NATIONAL GOVERNORS' ASSOCIATION

# Working Group on State Initiatives in Applied Research

Conference Proceedings
April 28-29, 1988

**Meeting Location:**
**Hall of the States**
**444 N. Capitol Street, N.W.**
**Washington, D.C. 20001**

**Organized By:**

**The State of Ohio**
**Governor Richard F. Celeste**
**NGA Lead Governor on Science and Technology,**
**in cooperation with the**
**National Governors' Association**

inlei

*ROUTING AND TRANSMITTAL SLIP*

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| 3. | SPECIAL ASSISTANT FOR EXECUTIVE DIRECTION | 3. | As Requested |
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THE SECRETARY OF COMMERCE
Washington, D.C. 20230

Honorable Joseph Ada
Governor of Guam
Agana, Guam 96910

Dear Governor Ada:

The Omnibus Trade and Competitiveness Act of 1988 calls for a nationwide study of state technology extension services and for a report of findings to the Congress along with recommendations on an appropriate Federal Government role in encouraging such programs. The study is being carried out by the Department of Commerce's National Institute of Standards and Technology in conjunction with the National Governors' Association (NGA).

The intent of the study is to document programs in your state that are involved in reaching out to help small and medium-sized businesses solve technical problems or to help them gain access to new technology. The study will also focus on the degree to which the officials administering these programs are aware of or use Federal programs having similar goals. In addition to meeting the Congressional mandate, the study will provide information for the NGA Task Force on Research and Technology, chaired by Governor John R. McKernan of Maine, which is examining the state role in expanding U.S. markets by capitalizing on emerging technologies. The Task Force is interested in identifying state policies and programs aimed at promoting the commercialization of new technologies.

A questionnaire requesting information on your state programs has been sent to your designee to the NGA Working Group on State Initiatives in Applied Research. Governor Dick Celeste of Ohio has taken a lead role in focusing Governors' attention on science and technology and the Working Group has been a very useful resource. Therefore, we are asking the members of the Working Group to serve as state coordinators, gathering data from the various state agencies that provide technological assistance to businesses.

We urge your support to assure that the study and the resulting report to Congress accurately reflect your state initiatives. Thank you very much for your cooperation.

Sincerely,

C. William Verity
U.S. Secretary of Commerce

Governor Gerald L. Baliles
Chairman, National Governors' Association

cc: State Designee to the Working Group

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STATE OF OHIO
**OFFICE OF THE GOVERNOR**
COLUMBUS 43266-0601

RICHARD F. CELESTE
GOVERNOR

# NATIONAL GOVERNORS' ASSOCIATION

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## <u>STATE INITIATIVES IN APPLIED RESEARCH</u>

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The following states do not have official representatives on the NGA Working Group on State Initiatives in Applied Research. The survey form was sent to the following people.

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RICHARD F. CELESTE
GOVERNOR

STATE OF OHIO
**OFFICE OF THE GOVERNOR**
COLUMBUS 43266-0601

SEP 26 1988

**M E M O R A N D U M**

TO: NGA Working Group on State Initiatives in Applied Research

FM: Chris Coburn

DT: September 15, 1988

RE: Enclosed Documents

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This packet contains information from our last NGA Working Group meeting and materials for our next meeting which will be held on September 29-30, 1988, in Washington, D.C.

The proceedings of our last meeting are bound in the enclosed document. Presentations were summarized either in the form of minutes or, in most cases, as reproductions of speakers' overheads and papers.

The second item is a copy of a letter that was sent from Governor Richard F. Celeste to your governor on June 14, 1988, encouraging your state's participation in the Federal Demonstration Project. As you will recall, the purpose of this project is to reduce bureaucratic red tape in the administration of research grants at U.S. universities.

For discussion at our next meeting, I have enclosed a summary of a draft proposed agreement between the Working Group and the National Science Foundation regarding ways to share Science and Technology Center proposal evaluations with the states. The subcommittee which was formed at our last meeting did an excellent job developing this agreement. Please look it over. A discussion on the proposal will be held during our meeting on Thursday, September 29, in the afternoon.

As a reminder, the meeting will be held in room 543 of the National Science Foundation building. If you have not already made your hotel reservation, the enclosed list of hotels are within walking distance of the NSF.

I look forward to seeing you on September 29.

# MECHANISMS TO INCREASE NSF/STATE COORDINATION AND COLLABORATION IN SCIENCE AND TECHNOLOGY CENTERS

As part of a broader effort to increase coordination and collaboration between the States and the National Science Foundation, this document outlines mechanisms to ensure optimal use is made of the information gleaned during the review of proposals submitted to NSF's Science and Technology Research Centers (STC) Program.

## Background:

There has been a significant increase over the past five years in both Federal and State investments in university-based organized research units (centers and institutes). At times State and Federal efforts have been well coordinated; at times they have not. Included among the costs of poor coordination has been duplication of effort in reviewing the same proposal sent to both Federal and State agencies. As NSF is completing the review of the first set of proposals submitted to its STC Program, we see a major opportunity to capitalize on that review process -- to maximize support for the best proposals and to minimize duplication of review efforts.

## Assumptions:

- NSF and the States share interests in promoting science, engineering, and technology research. The specifics of their interests, however, are not fully congruent. Therefore, NSF and the States will by necessity differ at times in which activities or fields they wish to support, even if everyone agrees on the absolute quality level of particular proposals.

- Tremendous effort and expense will have been expended in reviewing proposals submitted to NSF's STC Program, and much information will have been collected about specific proposals. NSF's sharing this information with the States could save a tremendous amount of duplicate effort.

- The major impediment to immediately sharing the outcome of the NSF STC review process is NSF's need to protect the confidentiality of proposers and proposals. Therefore, permission would have to be secured from proposers to share information about their proposals.

The Mechanism:

Step 1: States will have the option to remove themselves from the list for receiving information on the top (30%) STC proposals.

Step 2: Except for those states that have excluded themselves per step 1, NSF will contact the Principal Investigators (PIs) of all proposals rated in the top 30%, seeking permission to include their names, telephone numbers, and proposal titles on a list to be sent to the members of the NGA Working Group on State Initiatives in Applied Research and other potentional supporters.

When the NSF contacts the PIs (in writing), it will make clear that this process is to better insure the coordination of state and federal science and technology investments. There is no guarantee or expectation that states will be prepared to fund any of these proposals or future iterations of these proposals.

The NGA Working Group on State Initiatives in Applied Research will coordinate the transmittal of the list of PIs and proposal titles to the states. The state representative on the Working Group will receive this information unless the state identifies another individual to be the contact person. That individual is responsible for contacting the PI and for keeping copies of reviews received from the PI confidential, consistent with federal and state law.

With the identity of the reviewer removed, NSF peer reviews are automatically sent to the PI who has the discretion of providing them to the state representative.

Step 3: State officials will be responsible for contacting the PIs for further discussion or negotiation if they so choose. In the case of multistate STC proposals, the representative from the PI's state will be responsible for coordinating with his/her counterpart in other states that are major elements of the proposals.

-- Additional Suggestions --

## HOTELS IN WASHINGTON, D.C.

The following hotels are within a 15 minute walk of the National Science Foundation:

| | Government Rates Single | Double |
|---|---|---|
| **Lombardy**<br>2019 I Street, N.W.<br>202/828-2600 | $75.00 | $95.00 |
| **State Plaza**<br>2117 E Street, N.W<br>202/861-8200 | $75.00 | N/A |
| **Hampshire Hotel**<br>1310 New Hampshire Ave, N.W.<br>202/296-7600 | $75.00 | $85.00 |

RICHARD F. CELESTE
GOVERNOR

STATE OF OHIO
**OFFICE OF THE GOVERNOR**
COLUMBUS 43266-0601

June 14, 1988

The Honorable Joseph F. Ada
Governor
Territory of Guam
Office of the Governor
Agana, Guam 96810

Dear Governor Ada:

We have all been concerned with finding ways to enhance the environment for research within our universities. As Lead Governor for Science and Technology at the National Governors' Association, I write to ask you to take the leadership within your state to promote a federal activity designed to improve procedures for administering university research. This effort is consistent with the NGA's policy to increase governmental efficiency.

Federal agencies are now requesting proposals from universities on ways to eliminate unnecessary administrative burdens on sponsored research, thereby enhancing research productivity. A description of the program, called the Florida Demonstration Project, is enclosed. Proposals will be judged, in part, on a plan by the institution to improve its internal administrative procedures for research programs.

Over the past two years, federal R & D agencies joined with the Florida State University System and the University of Miami to demonstrate standardized and simplified approaches to the administration of sponsored research. As indicated in the attached memorandum from the Office of Management and Budget, all agencies now have the authority to use these simplified procedures in supporting research at colleges and universities throughout the United States.

I am urging each governor to bring together appropriate state and university officials to explore ways to improve state policies. In this way, you can build on the efforts already underway at the federal level. Since the due date for proposals is July 15, prompt action will be necessary.

The conduct of research in our universities will benefit from the improved procedures already implemented. The full benefit will come, however, only if federal requirements are extended and are accompanied by comparable changes at the state level. I encourage you to direct attention to this issue by using the Florida Demonstration Project as a model for action in your state.

Best regards,

Dick Celeste

RICHARD F. CELESTE
Governor

Enclosures

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF MANAGEMENT AND BUDGET
WASHINGTON, D C 20503

May 18, 1988

M-88-20

MEMORANDUM FOR THE HEADS OF EXECUTIVE DEPARTMENTS AND ESTABLISHMENTS

FROM: Joseph R. Wright, Jr.
Deputy Director

SUBJECT: Eliminating Unnecessary Administrative Burden on Sponsored Research

This memorandum provides guidance and instructions to reduce unnecessary administrative burden on sponsored research and to re-establish the Interagency Assessment Committee to oversee the Florida Demonstration Project to reduce overhead costs and increase research productivity.

The Federal Government has streamlined the administration of sponsored research through issuance of the Office of Management and Budget (OMB) Circulars A-21, "Cost Principles for Institutions of Higher Education," and A-110, "Grants and Agreements with Institutions of Higher Education, Hospitals and Other Non-profit Organizations." Nevertheless, grant accounting and administration remain relatively complex for a number of reasons, including the Federal Government's need to ensure public accountability and the financial pressures on universities to recoup all of the indirect costs associated with research. Overhead costs have gone up and productivity has gone down.

In March 1986, five agencies began the Florida Demonstration Project to see if this trend could be reversed. In March 1988, the Presidential Task Force on Regulatory Relief approved the expansion of the Project, beginning October 1, 1988, to include research contracts as well as grants, and to include universities and research facilities outside of Florida.

Agencies which sponsor research are authorized to make routine use, as appropriate, of the most successful subset of the Demonstration procedures:

1. Waive most cost related and other administrative "prior approvals" required by OMB Circulars A-21 and A-110, except actions which change the scope or objective of a project, change key personnel, require additional funding, or where specifically required in the award instrument.

2. Authorize grantees to incur pre-award costs at their own risk.

3. Authorize grantees the authority to initiate a one-time no-cost extension of up to 12 months.

4. Authorize grantees to carry forward unobligated balances to subsequent funding periods without prior agency approval.

Agencies will report to OMB by January 1, 1989, on experience using these procedures.

The Departments of Agriculture, Defense, Energy, and Health and Human Services, and the National Science Foundation will continue a Phase II of the Demonstration Project. Other Federal agencies are encouraged to participate as well.

The Interagency Assessment Committee composed of the senior policy officials of the participating agencies will continue to provide general guidance and oversight. Dr. William Raub, Deputy Director, National Institutes of Health, will continue as Chair and periodically report to OMB on the progress of the Demonstration and those developments that affect government-wide policy. Invitations will be extended to the President's Council for Management Improvement (PCMI), the President's Council for Integrity and Efficiency (PCIE) and the Chief Financial Officers (CFO) Council to provide ex-officio representation to the Interagency Assessment Committee.

The institutions currently in the Demonstration (the nine campuses in the State of Florida system and the University of Miami) will continue. The five institutions that participated in the ancillary costs studies (University of California, Columbia University, Johns Hopkins University, State University of New York, and the University of Virginia) will be eligible as well. Each of these institutions will specify their plans and methodology for continued participation.

An additional 10-15 university participants will be selected on a nationally competitive basis. Proposals will be due by July 1 and evaluation and selection by the Interagency Assessment Committee completed by September 1, 1988. The proposals must specify the area or topic for study, the methodology and evaluation criteria, including measurements for research productivity and costs savings.

For further information, contact Jonathan Breul, Financial Management Division, at 395-3050.

## NATIONAL SCIENCE FOUNDATION

### The Federal Demonstration Project (Formerly the Florida Demonstration Project); Phase II Solicitation

**AGENCIES:** National Science Foundation, National Institutes of Health, Office of Naval Research, Department of Energy, and Department of Agriculture.

**ACTION:** Notice.

**SUMMARY:** This Notice announces a solicitation to select organizations to participate in a Federal Demonstration Project (FDP) to eliminate unnecessary administrative burdens on sponsored research, thereby enhancing research productivity. The FDP constitutes Phase II of the current Florida Demonstration Project.

**DATES:** Evaluation and selection of organizations will be completed about August 15, 1988. Project organization and execution of Phase II agreements will be completed about October 1, 1988.

**FOR FURTHER INFORMATION CONTACT:** Geoffrey Grant, National Institutes of Health, 301-496-5967; William Kirby, National Science Foundation, 202-357-7880; Charles Paoletti, Office of Naval Research, 202-696-4601; Edward Sharp, Department of Energy, 202-586-8192; or Lyn Zimmerman, Department of Agriculture, 202-382-1304.

**SUPPLEMENTARY INFORMATION:**

### Background

In April 1986 NIH, NSF, DOE, ONR, and USDA joined with the Florida State University System and the University of Miami in a demonstration of a standard and simplified research support instrument.

The demonstration was developed by Federal officials with the encouragement of the Government-University-Industry Research Roundtable of the National Academy of Sciences.

The demonstration is testing the efficacy of standardizing and simplifying most Federal grant financial and administrative requirements as a means of enhancing research productivity and reducing administrative burden for Federal agencies and grantees.

The standard research grant being tested differs from the grants issued by most Federal agencies by eliminating most of the current requirements for Federal prior approval of certain expenditure items (foreign travel, permanent equipment, etc.) as long as pertinent grantee administrative systems are adequate. The terms of the Florida Demonstration Project also allow grantees the authority to incur pre-award costs up to 90 days before the effective date of the grant and to extend the period of the grant, if necessary, without Federal approval. Grantees may also determine that all Federally supported research of individual PI's is scientifically related and, if so, may charge available Federal funds to accomplish the work supported by each agency in the most effective way without detailed justifications of such allocations now required by Federal regulations. The Federal agencies continue to approve changes in the scope of the research or of the Principal Investigator.

Based on extensive review of the results of the project to date, an Interagency Assessment Committee recommended to the Office of Management and Budget that all research agencies be authorized to make routine use of most of the above features and that the Demonstration be continued with an enlarged scope and broader participation. On May 18, OMB issued a memorandum to all agencies making these authorities available for all agencies to apply to many research awardees, including contractors. The following solication is intended to implement the recommendation that the Demonstration be continued in an expanded form.

### Purpose and Scope

The purpose of this solicitation is to provide a mechanism to expand the scope of the Florida Demonstration Project and to broaden participation in demonstration activities.

Phase II will have the following basic purposes:

1. To refine and test further certain features of the Florida Demonstration Project.
2. To identify and test or review new features.
3. To serve as the basis for the continued development of a model policy for the administration of all fundamental research and related awards.
4. To serve as a catalyst for awardee organizations and state government participation in reducing unnecessary or redundant internal and state systems administrative burden.
5. To examine the potential effects of administrative requirements on research productivity and/or costs.

### Eligibility and Composition of Phase II

This solicitation is open to all organizations which perform or administer Federally sponsored research, or recognized representatives of such organizations. Up to 20 organizations may be selected. Those organizations that participated in Phase I that submit proposals and wish to participate under the same conditions outlined in this solicitation for Phase II will be included.

The selection or organizations is intended to be broadly representative of the research community, including primarily large and small public and private colleges and universities, and also possibly predominantly undergraduate institutions, non-profit research institutions, hospitals, and profit-making organizations. However, no commitment is made to select either a minimum number of organizations or to ensure representation by every organization type or other characteristics.

**Participation Conditions**

As a condition for participation in Phase II, the selected organizations will be required to agree to the following conditions:

1. To participate fully in the development and demonstration of Phase II activities; and in subsequent review and communication of Phase II results to appropriate officials and audiences.

2. To accept the General Terms and Conditions governing the current Florida Demonstration project, as revised for Phase II.

3. To conduct an assessment of its own internal systems and to report on and undertake appropriate organizational changes (including review and approval at organization system or state/local levels) to improve administrative systems by reducing unnecessary and redundant requirements.

4. To assess or measure actual or potential impact of changes on research productivity.

5. To defray the costs of participation without special awards or funding from the participating Federal agencies.

**Selection Criteria**

1. Proposed approach(es) to addressing required Phase II activities, including methodologies for assessing the impact of administrative changes on research productivity.

2. Evidence of organizational and top management commitment to full participation in Phase II.

3. Organization's proposed approach to its own internal systems assessment, including evidence of appropriate state system or agency agreement to engage in these or corresponding assessments.

4. Evidence of experience and leadership in improving research administration.

In addition to the above, equally weighted criteria, consideration will be given to achieving an appropriate representation of organizations, including organization type, size, extent of research support, geographic location, etc.

**Evaluation of Proposals and Selection Process**

Evaluation of proposals will be carried out by a panel comprised of Federal agency officials and representatives of the research community convened by the Government University Industry Research Roundtable (GUIRR). The panel will make its recommendations to an Interagency Assessment Committee, comprised of representatives of participating Federal agencies for final selection.

**Organization of Phase II**

Phase II will be organized around several major core activities and issues which will be addressed by the participating organizations and agencies. The emphasis of these activities will be on examining administrative requirements and processes which directly impact research productivity. The Federal agencies, in cooperation with the selected organizations, will assess policies and operational issues in the core areas; select appropriate issues for demonstration or testing purposes; develop demonstration protocol; and be the focal point for carrying out the activity and evaluating its results. Selected organizations must be involved in all the core areas. While the focus of the Phase II activities will be on Federal requirements and processes, selected organizations will be expected to make corresponding changes in internal systems, where appropriate and consistent with prudent stewardship of Federal or institutional resources.

**Phase II Activities**

The following core areas will be included in Phase II:

1. Terms, Conditions, and Award Instruments

The standard terms and conditions governing the original Florida Demonstration Project will be refined and modified, with particular emphasis on the issues of project relatedness, data rights and copyrightable materials, and issues related to different types of award instruments (grants, contracts, cooperative agreements). It is intended that, prior to the commencement of Phase II, the parties will ratify standard terms and conditions which will goven both the Phase II participation and awards made during Phase II. The period of the Phase II agreements will extend for 24 months.

2. Application Process

Issues pertaining to the administrative burden associated with the application process will be explored, with particular emphasis on the time, effort and paperwork required to comply with Federal application requirements. The goals of this core area will be to simplify the process for non-competing applications and funding and to develop uniform protocol and formats for application materials and electronic submission.

3. Reporting Requirements

Issues pertaining to the administrative burden associated with technical and financial reporting requirmenets will be explored. The focus of this core area will include contents of reports, standardization, and frequency, and electronic submission.

4. Audit Requirements

Alternatives to existing audit and systems review processes as a means of assuring appropriate accountability and proper stewardship of Federal funds will be explored.

**Other Areas**

In addition to the above core areas, selected organizations and participating agencies may agree to pursue additional administrative issues, including more limited studies and demonstrations which may not involve all participants. Examples of such activities could include developing standard certifications and assurances, addressing indirect cost negotiation and reimbursement issues, reviewing payment processes, etc.

**What to Submit**

Proposing organizations must submit fifteen (15) copies of a brief proposal (not to exceed 5 pages) which covers the following:

1. Phase II Narrative

A narrative describing: (i) the primary areas of organizational and staff expertise which the proposer would contribute to Phase II, with particular emphasis on the core activities; (ii) suggested approaches for addressing those areas; (iii) other suggested subject areas and features; (iv) expected benefits to organization and research community of organization's participation, including suggested methods or approaches for assessing the impact of changes on research productivity.

2. Commitment/Responsibility

A section indicating the organization's top management and working level willingness and commitment to fully participate in the Phase II activities. This discussion should also identify the person who will be responsible for coordinating the organization's participation and their qualifications. In the case of organizations representing university systems, a single contact is required.

3. Internal Systems Review

A brief description of what and how the organization would reveiw its internal systems and make or recommend changes. In the case of state institutions, how they will also seek review and appropriate changes at the system or state levels and evidence of appropriate state agency agreement to engage in such reviews.

4. Experience

A description of the organization's and its staff's experience and contributions in the area of sponsored research management.

5. Organization Profile

A brief summary of the organization's characteristics: type of institution/organization, size, Federal R&D funding for FY 85–87, by year and funding agency, etc.

**Proposal Submission and Deadlines**

Fifteen (15) copies of the organization's proposal must be received by C.O.B. July 15, 1988 at: Government—University—Industry, Reasearch Roundtable, National Academy of Sciences, National Academy of Engineering, Institute of Medicine, 2101 Constitution Avenue NW., Washington, DC 20418. Attention: FDP.

**Selection and Schedule**

Evaluation and selection of organizations will be completed about August 15, 1988.

Project organization and execution of Phase II agreements will be completed about October 1, 1988.

(OMB No. 3145–0080)

William S. Kirby,

*Head, Policy Office, Division of Grants and Contracts, National Science Foundation.*

[FR Doc. 88–12820 Filed 6–3–88; 10:11 am]

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STATE OF OHIO
**OFFICE OF THE GOVERNOR**
COLUMBUS 43266-0601

RICHARD F. CELESTE
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# NATIONAL GOVERNORS' ASSOCIATION

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# PROGRAM

Program

**Fifth Meeting of the**
**National Governors' Association**
**Working Group on State Initiatives in Applied Research**
April 28 - 29, 1988
Washington, D.C.

**THURSDAY, APRIL 28, 1988** — **Room 211, Hall of the States, 444 N. Capitol Street, NW**

| | |
|---|---|
| 8:30am - 9:00am | Registration and Coffee |
| 9:00am - 9:15am | Opening Remarks by Chris Coburn, Science and Technology Advisor to Ohio Governor Richard F. Celeste |
| 9:15am - 10:45am | **Updates on States' Program Evaluation Strategies** |
| | Michigan Strategic Fund<br>Jamie Kenworthy, Manager, Research and Technology Programs |
| | New York State Science and Technology Foundation<br>Graham Jones, Executive Director |
| | Ohio's Thomas Edison Program<br>Chris Coburn, Executive Director |
| 10:45am - 11:45am | **Evaluation Methods Used for the NSF Engineering Research Centers Program and Update on NSF Science and Technology Centers Program** |
| | Dr. Alan Leshner, Director, National Science Foundation Office of Science and Technology Centers Development |
| 11:45am - 1:00pm | Break for Lunch |
| 1:00pm - 2:00pm | **Hollings Centers Competition** |
| | Dr. Don Johnson, Director, Industrial Technology Services<br>National Bureau of Standards |
| 2:00pm - 2:30pm | **Status of Key R & D Issues in the Federal Budget: An Overview** |
| | Dr. Kenneth Wilson, Nobel Laureate in Physics, 1982 |
| 2:30pm - 5:00pm | **The National Science Foundation** |
| | Mr. Raymond Bye, Director, Office of Legislative and Public Affairs, National Science Foundation, "Overview of NSF Activities and Budget" |

| | |
|---|---|
| | Break |
| | Dr. Charles Brownstein, Assistant Director, Directorate for Computer and Information Science and Engineering, "Advanced Scientific Computing and Networking" |
| | Dr. Bassam Shakhashiri, Assistant Director for Science and Engineering Education, "Efforts in Science and Technology Education" |
| | Ms. Margaret Grucza, Study Director, Government Studies Group Division of Science Resources Studies |
| 5:00pm - 7:30pm | **Reception:** The Monocle on Capitol Hill, 107 D Street, N.W. |
| | Invited guests included selected Congressional staff, former speakers, federal R & D agency leaders and foreign science attaches. |

**FRIDAY, APRIL 29, 1988** **Room 211, Hall of the States**

| | |
|---|---|
| 9:00am - 9:15am | Coffee |
| 9:15am - 10:15am | **Enhancing the Economic Output of the Federal Laboratories: New Initiatives** |
| | Mr. Norm Peterson, Strategic Planning Group, Argonne National Laboratory, "Overview of Technology Transfer Legislation and Programs" |
| | Mr. Ray Gilbert, Manager, Applications Engineering at the National Aeronautics and Space Administration, Technology Utilization Division |
| 10:15am - 11:15am | **Foreign Trade Opportunities for State Technology Programs** |
| | Dr. Robert Yuan, Senior Advisor in Biotechnology to the U.S. International Trade Administration and Professor of Microbiology at the University of Maryland, College Park |
| 11:15am - 11:30am | Break |
| 11:30am - 12:00pm | NGA Committee on Economic Development and Technological Innovation - Announcements |
| | Mr. Richard Geltman, Staff Director |
| 12:00pm - 1:00pm | Future NGA Policy Recommendations/Activities: Open Discussion and Wrap Up |

# INTRODUCTION

**Christopher M. Coburn**
**Science and Technology Advisor**
**to Ohio Governor Richard F. Celeste**

August 29, 1988

Dear Working Group Member:

In late 1985, the National Governors' Association, having served as a forum for cooperation, interaction, and debate between the states for the past seventy-five years, established a Working Group on State Initiatives in Applied Research.

The group has met biannually since May of 1986 to share experiences and to discuss federal science and technology issues and legislation affecting the states. Meetings have focused on a wide range of topics and issues, ranging from federal initiatives to specific concerns at the state level.

In total, sixteen states have made presentations on various aspects of program design and development during the last five meetings. The group has also been briefed by and exchanged information with over seventeen federal programs, three international associations and ten U.S. Senators, Congressmen and their staffs. Private groups and individuals who are actively affecting national science policy and state science and technology activities have also participated at previous meetings.

This book is a compilation of the proceedings of the last meeting which was held on April 28-29, 1988, in Washington, D.C.

Nationally, there is a growing recognition that investments in science are necessary for long-term economic growth. States are committing significant resources to science in the context of a balanced, long-term plan. The Working Group lies at the point of intersection between the Federal research complex and state science and technology programs.

Future meetings will produce practical recommendations for cooperation. The first step is to ensure that the next administration becomes a partner with the states. Federal R&D programs direct enormous scientific resources that the states can draw upon, given the opportunity.

Second, the next administration must be directed to draw state science and technology programs into any national effort to increase U.S. global economic strength. States have learned the lessons -- economic competitiveness initiatives are a successful reality in the states and not just a promise of some action in the future. Together, the federal and state governments can implement a true national effort to increase America's economic competitiveness.

This agenda for cooperation will be the focus of our sixth meeting which will be held in Washington, D.C. on September 29-30, 1988. I hope you can attend.

Sincerely,

Christopher M. Coburn
Science and Technology Advisor to
Ohio Governor Richard F. Celeste

## SUMMARY OF PREVIOUS MEETINGS

The first meeting of the Working Group on State Initiatives in Applied Research was held in Washington D.C. on May 12-13, 1986. Structured around many informal panel sessions, discussion was focused on an agenda created by the participating states. The Working Group also touched on the need for better interaction between the federal government and the states.

At the end of the first meeting, the Working Group recommended that the National Governors' Association (NGA) pass a resolution supporting the reauthorization of the Small Business Innovation Research (SBIR) program, and that NGA's Center for Policy Research apply for funding from the National Science Foundation (NSF) for research on state science and technology programs. Both of these activities were implemented.

The second meeting of the Working Group was held in Washington on September 29-30, 1987. Highlights of this meeting included a presentation by the Science Counselor to French President Francois Mitterand on a new European Economic Community high technology group, a report on the SBIR Program by Congressman Nicholas Mavroules, Chair of the House Small Business Oversight Subcommittee, and a presentation on the process of innovation and the states.

The third meeting of the Working Group on State Initiatives in Applied Research was held on April 8-9, 1987. The Working Group produced another policy resolution on Increased Cooperation between Federal Competitiveness Programs and State Applied Research Initiatives which was adopted by the nation's governors at the NGA's annual meeting.

Discussions were also held on the proposed Superconducting Super Collider (SSC) and the National Center for Manufacturing Sciences (NCMS). Representatives Buddy MacKay and George Brown also talked about national economic competitiveness strategies and the role of state science and technology programs in economic development.

The fourth meeting of the Working Group was held on September 28-29, 1987. Competitiveness was the dominant theme. Claudine Schneider, Co-chair of the Congressional Competitiveness Caucus, spoke along with two Congressional staff members representing both the House Science, Space and Technology Committee and the Senate Commerce, Science and Transportation Committee. Two issues emerged as cornerstones of the Working Group's long-term agenda: cooperation with the National Science Foundation and the need for better program evaluation measures. Alan Leshner of the National Science Foundation discussed cooperation on Science and Technology Centers and the Government-University-Industry Research Roundtable (GUIRR) provided insights on possible measures of program performance.

The last meeting of the Working Group, which was held on April 28-29, 1988, continued to focus on the issue of evaluation -- looking at three state programs as case studies. Executive briefings on key aspects of the FY 89 Federal science budget were also provided, setting the stage for two discussions with the

National Bureau of Standards' Manufacturing Technology Centers Program and activities at the National Science Foundation. Foreign trade opportunities for state technology programs and the status of economic spinoffs from the federal laboratories were also discussed.

# PRESENTATIONS

# Updates on States' Program Evaluation Strategies: Michigan Strategic Fund

presented by

James Kenworthy, Manager
Research and Technology Programs

Summary of Remarks by

**James Kenworthy, Manager**
**Research and Technology Programs**

**Michigan Strategic Fund**

Mr. Kenworthy began by explaining how the Michigan Strategic Fund conducted their second round of funding for their technology centers program.

They first required each center to develop what he called a "strategic research plan." A strategic research plan is a five year plan similar to a business plan appropriate to the earlier stage of a research and development organization. The plan is analyzed competitively.

During the planning process, each center is asked to describe what services they provide which the existing marketplace or universities do not. In other words, the center must explain what technical gap they fill and why they can succeed as a business in that gap. Mr. Kenworthy pointed out that since most centers are research-driven and university-oriented, their plans need to demonstrate how they will work with industry and serve an economic development purpose.

After each center's market niche is identified, they are then asked to describe why their service is a public good. Each center's plan must specify types of technologies they will focus upon. They must also explain how the state can capture a national leadership position in their technology area(s) and how the center plans to disseminate technology through start-ups and licensing. In designing a center, the first test is how a non-profit business can succeed. The second test is how the state will capture benefits from that success.

Mr. Kenworthy noted that the process of developing a strategic research plan requires that his office work closely with each of the centers. The process has enabled him to establish very close working relationships with center directors and has created a sense of accountability from both sides. He expressed the opinion that the quality of the collaborative relationship between the state and the centers is a good indication of the center's success.

A grant between the state and the center is written which is similar to an NSF cooperative agreement. The state grant manager meets annually with a business advisory group that reviews the technical and economic development plan for the year and the benchmarks to be accomplished in the year ahead. Quarterly reports to the state reviews progress on those benchmarks. Investments in centers are reviewed by a non-partisan Research Advisory Board before action is taken by the Michigan Strategic Fund board.

One Working Group member asked Mr. Kenworthy what will happen when Governor Blanchard leaves office. He responded that centers were funded under a governor of another party and the program is building a base of support for the centers that will hopefully transcend political boundaries. They do this by involving business leaders from both parties in decision making and input.

# Updates on States' Program Evaluation Strategies: New York State Science and Technology Foundation

presented by

Graham Jones, Executive Director

## LEVELS OF EVALUATION

1. Basic Sanity Check
2. Are Contractual Requirements Met?
3. Are Program Objectives Achieved?
4. Does Society Benefit?

## PROGRAMS

Investment Program

R & D Grants Program

SBIR Program

Regional Outreach Program

Research Centers Program

## CORPORATION FOR INNOVATION DEVELOPMENT

Conserve Capital

Needs Test

True Innovation

Potential Benefit to Economy

Jobs

## R&D Grants Prg ram

### Objectives

- The main objective of the Program is to stimulate economic development in New York by supporting R&D projects, in universities and not-for-profit laboratories, that have a distinct potential for industrial application. The latter is expected to strengthen the competitiveness of New York firms and to expand opportunities for job developmen and expansion.

### Evaluation Procedures

- The evaluative steps reported here are to be distinguished from a comprehensive evaluation of the entire program. Rather, they describe evaluation of particular facets of a still maturing program, aimed at tracking and guiding the program's development into its initial full configuration.

- The evaluation of the Program is carried out on a regular basis by Foundation staff. It involves receipt and analysis of program and financial reports, personal visits to each project site, and completion of a formal monitoring review form for each project. In addition, it is required that each project report annually, for five years following completion of the project, accounts of patenting, licensing or other commercial application.

- The evaluation criteria applied in monitoring and review are:

  - commitment of firms to cooperation in R&D projects including financial support, provision of personnel, and use of equipment and material,

  - development of firms' revenues and jobs created as a result of the application of R&D results,

  - outcome of the planned R&D; actual and potential commercial application of the R&D results,

  - patents applied for and granted,

  - licenses granted,

  - financial support developed from other sources for R&D projects that resulted from the original one.

## Small Business Innovation Research Promotion Program

### Objectives

- To strengthen New York's "best and brightest" high tech companies with the support of "seed capital" at a critical stage of their new product development.

- To foster increased participation by New York State businesses in the Federal SBIR Program, highly leveraging federal money into technology-based economic development in New York.

## Regional Technology Development Organization Program

### Objectives

- To accelerate the creation and growth in New York of technology-based businesses, leading to increased job opportunities and a strengthened economy. This program allows each region the flexibility to adopt strategies and take actions in support of technology development. Accordingly, each Regional Technology Development Organization (TDO) is encouraged to undertake programs and activities specifically tailored to their region.

## Centers for Advanced Technology (CATs) Program

### Objectives

- Encourage excellence and relevance in academic research in technological areas of high priority to sustain the absolutely necessary intellectual base for the technologies that will keep New York industry competitive in the future.
- Accelerate technology transfer, the commercial application of the intellectual base (discoveries, inventions, and results of academic research) to help New York firms gain competitive advantage in new or established product lines.
- Prepare scientists and engineers familiar with industrial problems and priorities to provide the human resources required by New York firms to remain technologically competent and competitive.
- Promote communication and cooperation between industrial R&D and academic researchers so as to bring a new level of informed creativity to our industrial community.

## APPENDIX E

### New York State Science and Technology Foundation
### Centers for Advanced Technology Program

### Performance Criteria

The following questions represent criteria against which the performance of each Institution's Center for Advanced Technology will be evaluated. Each criterion tests a specific aspect of performance which is regarded by the Foundation as being either a necessary or a desirable ingredient of satisfactory performance under the contract. The criteria have different weights, and some weigh more heavily than others as the responses vary from positive to negative; no attempt is made to quantify this variation.

I. Management and Administration

- Is there a coherent organization and plan that coordinates all activities of the Center internally and also in relation to the Institution? Is the plan adhered to and updated?

- Is the management structure which selects and supervises the work of the Center well-designed to optimize the scope of activities undertaken?

- Are the projects which have been selected promising in terms of the introduction of significant innovation?

- Are the projects which have been selected promising in terms of their applicability to commercial products or processes?

- Does the management team of the Center have an active focus on the introduction of significant technological innovation and the maintenance of a high level of technical excellence?

- Does the management team of the Center have an active focus on the facilitation of technology transfer to the commercial community?

- Are university policies regarding contracts for sponsored research, faculty relationships with private companies, patents, proprietary data and related issues, conducive to the process of technology transfer?

- Are required reports complete and timely?

II. Performance and Results

- Has demonstrable progress been made toward the development of new or improved products or processes, or scientific or technological knowledge?

- Have demonstrable products or processes, or promising new patents, patent disclosures or copyrights resulted from the work at the Center?

- Have any of the results of this work been applied commercially in such ways as the improvement or creation of marketable products or processes or the creation or expansion of firms?

- Have any firms (or divisions of firms) relocated or retained their locations in New York in order to work with the Center or in close proximity to it?

- Have educational offerings (e.g. courses, workshops, conferences) been designed and offered to maintain a competent professional work force in the Center's area of technology? Have these offerings been well attended by the constituency they were designed to serve?

III. <u>Relationships</u>

- Do the industrial contributors participate in planning and project selection of the Center? Are they satisfied with the direction and results of the Center's programs?

- Do personnel from the industrial companies participate in the research and development work of the Center? Does faculty associated with the Center participate in the research and development work of industry?

- Are university policies related to promotion and tenure conducive to participation of faculty in activities of the Center? Does the Center attract the active involvement of the more highly-regarded members of the Institution's faculty?

- What levels of private and governmental, other than State, matching funds is the Center able to attract? What special support has the Center leveraged from these sources by virtue of its programs and accomplishments?

- To what extent do students participate in the work of the Center? Does the Center attract the better students?

- Has the Center been responsive to the needs of small companies and members of the general industrial community?

- Is any of the Center's work performed in cooperation with other academic or research institutions, including consortium members?

- Do the staff and investigators understand the mission of the Center, have a sense of common purpose, and enjoy a spirit of working together toward common goals?

# Updates on States' Program Evaluation Strategies: Ohio's Thomas Edison Program

presented by

Christopher M. Coburn
Executive Director

# OHIO'S THOMAS EDISON PROGRAM

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LINKING TECHNOLOGY and ENTERPRISE in OHIO

TO: EDISON TECHNOLOGY CENTER DIRECTORS

FROM: CHRIS COBURN

DATE: DECEMBER 9, 1987

RE: NEXT ROUND OF CENTER FUNDING

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We are developing a process to award center funding in August, 1988. The goal of this process is to further strengthen our nine existing centers. It is the goal of the state to support only the nine current centers--funding of new Edison centers is not anticipated at this time.

The purpose of this memo and of the Center Directors' meeting is to seek your input in the funding competition process and timeline. We plan to release final documents detailing the funding competition by January 1, 1988. Appropriate center comments and suggestions will be included in the final document.

<u>Summary of Funding Process</u>

Two separate center funding processes are proposed. One will be for the three newer centers (Edison Materials Technology Center, Edison Industrial Systems Center, and Edison Biotechnology Center). The other will be for the original six centers.

Each of the newer centers will be asked to prepare a short report detailing their progress and future funding needs. Like the proposals that the original six centers submitted in 1986, the reports will reference achievements of original milestones and accomplishments made in staffing, facilities, research and development, educational programs, marketing, and matching contributions. A ten-year budget and specific financial information will also be requested. Funding decisions will be made on the basis of financial need and of satisfactory progress in meeting Edison Program and individual center goals and milestones.

The original six centers may participate in a two-phase, competitive process. The goal of this competitive process is to award Edison funding based on performance and need for additional resources. Only those centers needing Edison funds during the next two years will be eligible for the competition. The first phase of the process is the peer reviews, which are being conducted currently. The second phase is center reports, which will include answers to a set of performance criteria and a narrative report of center accomplishments. Funding will be based on a center's ability to meet the performance criteria and to obtain matching funds. It is possible that a portion of the center pool may be divided equally among competing centers.

Funds Available for Centers

Between $18 and $20 million will be available for Edison Centers next August. A more exact figure will be determined in July or August. It is expected that $5 to $6 million will be available to newer centers, while about $12 to $15 million will comprise the competitive pool for the original centers. No funding has been recommended for the establishment of new centers.

Background

Several assumptions have shaped the development of the center funding process:

1. The original six centers have been in operation for three years and have technical, economic development, and management results which can be evaluated.

2. Since each center aspires to some common Edison goals, certain evaluation criteria may be applied to all six centers. However, the centers have different technologies, organizational structures, and clientele and therefore evaluation criteria unique to each center must also be applied.

3. As the Edison Technology Centers mature, results need to be quantified in order to make funding decisions on the basis of achievement of economic development and research goals and the need for additional state support. Representatives from all sectors are asking for results.

4. A limited amount of funds are available for the centers during the current biennium. When the legislature approved the state's budget for fiscal years 1988 and 1989, it included a cut in the Edison Program's budget from the previous biennium.

5. The three newer centers have not operated long enough to receive the same evaluation treatment as the original six.

With the exception of the last item, these assumptions point to a competitive funding process. Recognizing the importance of developing a fair and workable evaluation model for such a competition, the staff has worked with recognized national leaders from federal and state levels.

The review model found to be the most applicable is based largely on the experience of other state models. Some aspects were borrowed from the National Science Foundation. The main goal of the competitive process is to award funding on the basis of performance, but also to build in flexibility to allow for the differences between the centers. A competitive process allows for more objective decision-making and provides the centers with greater incentives to meet Edison goals, as well as their own individual goals. The competitive system in other states has helped centers optimize economic development, research, matching, technology transfer, and educational performance.

Proposed Competitive Center Funding Process

Each of the original six centers are currently participating in the peer review. The results of these reviews are to be used largely for the benefit of each center. Reviewers have been requested to provide suggestions for improved performance. The evaluations will also be read by Edison staff and ITEAB.

Centers requiring funding during the next two years and desiring to participate in the funding competition will be asked to complete a competitive funding proposal. The proposal will include a short narrative describing the center's progress since inception and addressing any concerns or suggestions of the peer reviewers. It will also include answers to a set of performance criteria. A draft of these criteria is attached.

The performance criteria list is intended to be very comprehensive. It is recognized that the detailed list will require a large effort by competing centers, but the data should lead to equitable decision-making and to a better understanding of each center. Some of the data, particularly that relating to job generation and impact on business, must be collected by the centers from individual companies. In recognition of the work required, each center will be allowed approximately six months to complete its report.

The list of performance criteria is subject to your comments, as well as those of ITEAB. The final list will include detailed instructions and definitions. It is important to recognize that many of the performance questions listed have no "right answers", because of the differences between centers. Other pieces of data will be important to understand the operations of a center, but will not be used as measures. All will provide information to make fair and equitable decisions.

Process Time-Line

It is recommended that the centers have a relatively long period of time to prepare their reports because of the proposed structure, the matching documentation required with the reports, and the time to needed to address independent reviewer comments. A shorter amount of time will be required for report evaluation. Therefore, the following time-line is proposed:

| | |
|---|---|
| January 1 | Final documents detailing funding processes for original and newer centers released |
| January 15 | Final peer review reports complete |
| July 1 | Original and newer center funding reports due from centers to Edison Program |
| August 8 | Edison staff evaluations complete, distributed to ITEAB |
| August 18 | ITEAB recommends funding levels |

Questions

If you have any questions or comments about the process described in this memo or the performance criteria, please feel free to discuss it at the center directors' meeting. If you have additional comments or questions after the meeting, please call me or Marianne Hudson. We look forward to your comments.

OHIO'S THOMAS EDISON PROGRAM

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LINKING TECHNOLOGY
and ENTERPRISE in OHIO

**STATE OF OHIO**
**DEPARTMENT OF DEVELOPMENT**
**THOMAS EDISON PROGRAM**
**1988**

**EDISON TECHNOLOGY CENTERS**

**THIRD ROUND FUNDING FOR CENTERS SELECTED IN JULY, 1984**
**1988 FUNDING GUIDELINES**

## I. INTRODUCTION

In 1988, Ohio's Thomas Edison Program wishes to provide continued funding support to qualifying Edison Technology Centers. The goal of such funding is to further strengthen the capabilities and effectiveness of centers designated as Edison Technology Centers in July, 1984. These include:

Applied Information Technologies Research Center (AITRC)
Cleveland Advanced Manufacturing Program (CAMP)
Edison Animal Biotechnology Center (EABC)
Edison Polymer Innovation Corporation (EPIC)
Edison Welding Institute (EWI)
Institute of Advanced Manufacturing Sciences (IAMS)

Funding awards will be made on a competitive basis. Grant amounts awarded will depend on each center's performance in meeting Edison Program goals and individual milestones, need for additional resources and the ability to match them. In order to qualify for third round funding, a center must demonstrate need for additional funding during the period beginning July 1, 1988 and ending June 30, 1990.

## II. EDISON TECHNOLOGY CENTER GOALS AND OBJECTIVES

The goals of the Edison Technology Center program remain similar to those of previous years which have been published in "General Guidelines and Application Instructions" and individual center grant agreements. These goals are:

1. Economic development--job creation and retention, as well as business development and expansion, in Ohio



Ohio Department of Development • David J Baker, Director

2. Increase the competitiveness and productivity of existing Ohio companies through technological innovation

3. Diversification of Ohio's economy--creation of new businesses and/or industries in Ohio

4. Formation of effective partnerships and consortia involving the private sector, colleges and universities, and government

5. Development of the highest possible technical competence given the field or area of technology

6. Development of financially and scientifically viable institutions

7. Establish and improve education and training programs to meet the needs of the workforce now and in the future

Progress in accomplishing these goals may be achieved by Edison Technology Centers through joint applied research and development projects, educational and training programs, technology transfer activities, and entrepreneurial development and assistance.

## III. FUNDS AVAILABLE FOR QUALIFYING CENTERS

Between $12 and $15 million will be available for third round funding. A more exact figure will be determined by July or August, 1988. The amount of the awards will vary according to center performance.

## IV. GRANT TIMELINE

The 1988 Funding Guidelines and Request for Proposals will be released to all six centers on or before March 8, 1988. Completed proposals are due to the Edison Program office no later than 5:00 pm, July 1, 1988. All proposals must be submitted by that date and time in order to be considered for funding. Ten copies of the proposal should be provided.

The proposal review and funding recommendation process will last about six weeks. Staff of the Edison Program will review each proposal and prepare a report for the Industrial Technology and Enterprise Advisory Board (ITEAB).

It is anticipated that ITEAB will make its funding recommendations at its August 18, 1988 meeting.

These recommendations will be carried to the Director of the Department of Development. The Director's decision will be forwarded to the State Controlling Board, which has final authority for the award of state grants. Every effort will be made to place the Department's grant recommendations on the Controlling Board's September 26, 1988 agenda.

## V. PROPOSAL REQUIREMENTS

The challenge grant program is structured to provide information on each center's progress in meeting the above-mentioned goals as well as individual center goals and milestones. There are three parts to a complete proposal: first, a narrative report detailing center accomplishments since July 1, 1986 and addressing each of the topics listed in the "Program Strategy and Progress Narrative" section, second, quantitative performance measure section, and third, documentation of new matching resources. More detailed information on each part of the proposal is included in the rest of these guidelines.

### A. Program Strategy and Progress Narrative

The narrative report should detail the center's accomplishments for the period July 1, 1986 through June 30, 1988 and outline plans to strengthen the center using additional state money. Progress should be identified and explained for each of the program areas listed below. If there are other areas in which significant progress or accomplishments have been made, please include them in the narrative. Where appropriate, please discuss the center's progress in addressing the comments of outside peer reviewers. With the exception of an executive summary of progress and lists of research projects and business participants, no specific format is required, as long as each area is addressed. The narrative should be ten to twenty pages in length, excluding three exhibits and a budget requested below.

a. Executive summary of the center's most important accomplishments during the period. The summary should be a maximum of two pages and cite progress in some of the areas listed below. Special emphasis should be placed on specific examples in which the center has directly impacted economic growth in Ohio. (This will not count against the narrative page limitation.)

b. Program milestones. List the major program milestones and projected dates of accomplishment set by the center during the period. Such milestones or goals should relate to research, business participation, revenues, staffing, education and training and other programmatic goals rather than to administrative matters. Has the center met each of these milestones at the projected time? Why or why not?

c. Activities and accomplishments in research and development. Summarize important research efforts and note significant awards or citations received by the center or center researchers for research excellence. In a chart formatted after Exhibit A, briefly explain each research project underway or completed during the period. To the extent possible, please do not include confidential information. Any such information that is included should be marked "Confidential".

d. Education, training and technology transfer activities and results. Describe significant training activities and their direct impact in meeting current or future industrial and community needs. Summarize the center's intellectual property policy and licenses granted by the center.

e. Private sector participation. As appropriate, describe progress made in obtaining business participants and programs developed to benefit them, including innovative programs to assist small businesses. Discuss programmatic and financial contributions made by participating companies. In order to be considered a participant, a company must provide documented matching resources to the center during the reporting period or must have received assistance from the center during that time. Please provide a list of all current industrial participants in a chart formatted after Exhibit B. Confidential information should be so marked.

f. Operational accomplishments. Discuss accomplishments made in the areas of staffing, facilities, marketing, obtaining matching resources, financial management, governing and technical boards, university-business cooperation, and administrative matters.

g. Community relations. Describe significant interactions with local government agencies, economic development agencies (separate from the Edison Program), chambers of commerce, federal government agencies or laboratories, elected officials, trade and professional associations, and other Edison Technology Centers and Incubators. Summarize important benefits to the center and its partners resulting from those interactions.

h. Updated budget and milestone plan. Summarize the center's updated operational strategy or business plan and discuss any additions, deletions, or modifications to plans presented previously. The strategy should include an updated projection of major programmatic goals and milestones during the next three years (July 1, 1988 through June 30, 1991). A budget, outlining the sources and uses of all center resources for each fiscal year, must also be included. The budget should be divided by fiscal year and must cover the period July 1, 1984 through June 30, 1993.

B. Documentation of Matching Resources

Centers desiring additional Edison funds must show an ability to match those funds on at least a one to one basis with resources from sources other than state government.

Please submit new matching resources with this proposal. As in the past, quality of match is important. Match quality will be assessed in the following order: cash, including research contracts, from industry and foundations; federal government grants to the center; new equipment; in-kind contributions; used equipment; and federal research grants or contracts to individual investigators. Resources from small companies (those with less than 50 employees or less than $5 million in annual sales) are valued more highly than resources from larger companies.

In order for new matching resources to be counted as match, satisfactory written documentation of commitment must be provided. Centers must submit a copy of a check, company purchase order and/or a letter, signed by an official with authority to commit resources from the organization, committing a specific amount of money to the center over a specific period of time. Letters committing equipment or non-monetary resources must include a statement detailing how the contribution was valued and how it is related to the center's activities. If claimed match is a research grant or contract, a copy of the contract or the grant information sheet from the awarding agency should be submitted. Equipment should be treated as it is for tax purposes and other non-monetary contributions should be valued at market rates. As in the past, an independent appraisal for all used equipment claimed at or above $5,000 must be submitted.

C. Program Progress Measures (Exhibit C)

A number of statistical tables, requesting quantitative data about the center's performance of economic development, research, and management goals is attached as Exhibit C. In general, the tables cover center progress from July 1, 1986 though June 30, 1988 (the "reporting period"), although some measures are marked differently. A response should be given for each measure and the center may attach appropriate additional information that will enhance the Edison Program's understanding of the center's response. If there are no results for a given measure, the form should read "none" or "0". If the request does not apply to the center, please briefly explain why not.

Instructions to complete each measure is listed below. Each number below corresponds with the tables in Exhibit C. Definitions for several terms are included in Section VI.

Increased Industrial Competitiveness

1. Number of companies associated with the center.
   Data in this section should summarize information included in Exhibit B. The combination of "total members" and "total non-members" should equal the number of companies listed in Exhibit B.

2. Dollar value of matching resources from participating companies.
   The table requests a breakdown of industrial matching resources provided by the companies counted in table 1. The table may include matching resources received since the center's inception, as long as the resource has been previously certified or is documented in the proposal. Please use the actual value of the match, rather than the weighted values listed in Section V.B. Do not double count among the categories. For instance, if a research contract is counted toward a particular company's membership, the contract may not be included in the Research category.

3. Growth in industrial participation.
   This table charts the annual growth of industrial participants and matching resources from industry for six years beginning fiscal year 1985.

4. Research projects.
   This table requests summary information on the number of research projects under the auspices of the center completed or underway during the reporting period. The chart should parallel Exhibit A.

Product or Productivity Improvement Impacts

5. Number of companies reporting that center efforts improved their "bottom line".

Provide the total number of companies who report that a center research project, training program, or other center service resulted in a cost savings, increased revenues, high return on investment or other "bottom line" improvement. All citations must be quantified in table 6. In all cases, the improvement must be directly related to a specific center activity and the company must be included in Exhibit B.

6. Quantify "bottom line" improvements
For the companies reporting improvements in table 5, quantify the improvements for the group as a whole. Several categories, including "other measures" are noted. More than one category may be used per company as long as there is no double counting. Return on Investment is generically defined at the present value of cash flows during the next five years directly resulting from the center effort divided by the company's investment into the project.

For each company reporting improvements, the center must have on file a statement from the company estimating the direct impact of the center on that company. These letters do not need to be attached to the proposal, but should be available to the Edison Program for review if a question should arise. This will allow for the total impact measures to include information of a confidential nature.

<u>Job Impacts</u>

7. Number of center employees.
In 7.A., provide the full-time equivalent number of personnel currently employed by the center. A full-time equivalent job is considered to be one of 35 or more hours. Only those people working at the center's headquarters or those who receive all of their compensation from the center should be included. In 7.B., provide the full-time equivalent number of college personnel (including faculty, students, and administrative personnel) who currently work directly on center activities. No positions may be included in both A and B.

The State of Ohio strongly encourages the employment of minority workers. Please note for both categories the number of full-time equivalent employees who are minorities as defined in the Definitions section. These figures should be included in the total job figures as well. Please attach the center's policy for affirmative action in employment.

8. Jobs created at participating companies.
9. Jobs retained at participating companies

For the categories in both tables, note the number of companies reporting job creation or retention and the number of current full-time equivalent jobs created or retained at participating companies as a direct result of center activities. Only those companies included in Exhibit B are eligible to be counted in the table. The reporting companies must show a reasonable and causal relationship between center research, education and training, or entrepreneurial assistance activities and jobs created or retained at the firm. Jobs created or retained at the company due to other reasons during the period may not be included in the table.

All of the data included in the tables must be documented to the center by the reporting companies. Letters reporting job impacts do not have to be included in the proposal, but the center must have them on file for possible review. Double counting of jobs created or retained is prohibited. Data included in the job creation table may not be included in the jobs retained table and vice-versa.

10. Number of start-up firms assisted.

Enter the number of start-up firms the center has assisted during the period. Start-up firms are those which have legally incorporated since January 1, 1985. Such assistance may include the "spin-off" of a technology developed at the center, educational or training assistance, prototype testing, consulting, or entrepreneurial assistance. All current employees, adjusted for full-time equivalency, of such start-up firms may be counted in part B of the table. The data in this table may be included in table 8.

## Center Technology

11. Center Patents.

Include patent information relative to those research projects listed in Exhibit A. Information related to other projects may also be included only if they are directly related to these projects, were conducted by personnel directly related to the center, and were completed during the period. For each patent application, disclosure, or award, please list the title and author.

12. Number of papers, theses, dissertations and official presentations by center personnel.

For those personnel directly related to the center only, total the number of the above activities taking place during the reporting period. Papers, theses, dissertations, and official technical presentations may only be included in the total when their primary purpose is to describe the results of research projects listed in Exhibit A.

13. Licenses.
The table is meant to measure center licensing activities. Only those licenses which cover technology developed and owned by the center and for which a fully signed licensing agreement exists may be counted in the data. In Part B of the table, please total the dollar value of royalties or other resources that the licensing companies have agreed to give to the center in return for the license. Such values must be included in the executed licensing agreements. Part C requests the total value of royalties or other resources that the center has actually received. Information about any potential licensing arrangements should be included in the narrative portion of the center's proposal.

14. Number of individuals directly conducting research.
Please provide a further breakdown of data in table 7, which summarizes the number of individuals who are currently engaged in center activities. In order to be counted in this table, an individual must currently be working on one of the research projects listed in Exhibit A. "Center research personnel" is defined in this table as those who work at center "headquarters" and receive all compensation from the center. Please provide the breakdown of researchers in terms of raw numbers and adjusted full-time equivalents.

15. Research grants and contracts from non-state sources.
Information about research grants or contracts separate from company memberships should be measured. Do not include research contracts that count toward a company's membership obligation. Please enter the data for applications made by the center for grants or contracts from the listed sources during the reporting period and the data for grants and contracts actually awarded (those awards for which the center has written notice).

16. Facilities.
Please provide information about the center's facilities and equipment. All information should be current. Information included under the "center" category should be for space and equipment at center

headquarters. University partner information should relate directly to center activities.

College/University Involvement

17. College/University resources supporting center.
    Indicate the dollar value of support to the center from participating colleges and universities. The "GRF" represents state General Revenue Funds--which include dollars allocated to state colleges and universities by the State of Ohio. "Non-GRF" funds would include funds given to the university by private organizations or individuals or resources from private universities. A division between GRF and non-GRF is made because only the resources from non-GRF resources may be considered as match to the Edison grant by state law. However, a school's commitment of its state resources may often be vital to the success of the center. Data in the "received" columns should include only those resources which were actually received by the center during the reporting period. Data in the "committed" category should include those resources committed by the college to the center which have not yet been received. Please attach documentation for all matching resources which have not been certified previously.

18. Total amount of space at academic institutions dedicated solely to center (in square feet).
    Do not include any space that may also be used for research projects that are not in Exhibit A.

19. Number of projects involving more than one academic institution.
    Cooperation among universities is strongly encouraged by the Edison Program. Joint research, training, or entrepreneurial assistance projects are appropriate programs for cooperation. Any of these kinds of joint center projects should be totaled under "All Projects". The "Research Projects" number should be a subtotal of all projects. Please discuss such joint research projects in the narrative portion of the proposal.

20. Center resources paid to academic institutions.
    For each academic partner, please provide the requested budget breakdowns for payments made during the reporting period.

Education, Training, and Technology Transfer

21. General education and training.
   Count the number of training classes or seminars held by the center, the number of individuals successfully completing such training, and quantify financial support of other groups for sponsorship of training programs. Financial support included in the table must be separate from membership resources.

Optional Data

22. (Optional) Number of companies reporting follow-up investment in technology developed in conjunction with center.
   One of the goals of the Edison Program is that companies will be interested in technologies developed at a center and decide to carry out the final product development work or other work necessary to put that technology on the market or in use within the company. How many companies reported investing their own resources (cash or in-kind) in product development, refinement, licensing, marketing, etc. in this activity?

23. (Optional) Dollar value of follow-up investment.
   Ask the companies reporting further work on center developed technology to estimate the amount of company resources invested in such activity during the reporting period.

24. (Optional) Number of companies relocating to Ohio acknowledging center efforts or activities as influencing their decision.
   The table should include companies reporting a relocation to Ohio from another state which resulted in part from center activities (research and development, contact with center membership, education and training, entrepreneurial assistance). For the jobs number, count only the full-time equivalent number of new jobs added at the Ohio site. Data in this table may be included in table 8.

25. (Optional) Number of graduate students involved in center activities hired by participating companies.
   Enter the number of graduate students formerly involved in carrying out center research projects (those listed in the narrative research descriptions) who were hired for full-time permanent research positions by participating companies during the reporting period.

## VI. DEFINITIONS

Ohio company: private enterprises which have established and continue to maintain operations and facilities in Ohio and are incorporated under Ohio law.

Minority: those persons belonging to the following ethnic groups: American Indian, Black, Hispanic, and Oriental (State of Ohio Affirmative Action guidelines).

Group Sponsored Project: research projects that are financially sponsored by two or more companies, for which research results are available to sponsoring companies only.

Single Sponsored Project: research projects sponsored by an individual company. Such projects are usually proprietary in nature and intellectual property rights belong to the contracting company only.

Generic Project: research projects for which results are available to all center business members.

Full-time Equivalent Jobs: jobs that are 35 or more hours per week.

## VII. EVALUATION CRITERIA

Each of the three sections of the proposal--narrative, matching documentation, and the quantitative measures-- are important in determining center funding levels.

When the third round funding proposals are reviewed, performance and progress in the following areas may be evaluated:

- impact on economic development and job creation
- ability to meet programmatic milestones
- quality and quantity of matching resources
- ability to attract business participants and increase their competitiveness and productivity
- development of high quality research programs and capabilities
- development of effective education, training, and technology transfer programs
- progress toward building financially and scientifically viable centers
- university support and commitment
- community support

# EXHIBIT A

## CENTER RESEARCH AND DEVELOPMENT PROJECTS

| Project Title | Type* | Company Sponsors | Universities or Subcontractors | Project Cost | Objective and Project Description |
|---|---|---|---|---|---|

* Type of Project
Group Sponsored Project = GSP
Single Sponsored Project = SSP
Generic or Core Project = Core

EXHIBIT B

PRIVATE SECTOR PARTICIPANTS

| Company Name and Address | Headquarters Location | Number of Employees | | Type of Participation* |
|---|---|---|---|---|
| | | Ohio | Worldwide | |

* Type of Participation
  Membership = M
  Contract Research = C
  Training = T
  Other = O

EXHIBIT C

## Increased Industrial Competitiveness

| | Total Members | Ohio Members | Total Non-Members | Ohio Non-Members |
|---|---|---|---|---|
| 1. Number of companies associated with center | ______ | ______ | ______ | ______ |
| 2. Dollar value of matching resources from associated companies | | | | |
| A. Membership (does not include equipment) | ______ | ______ | ______ | ______ |
| B. Equipment (membership and non-membership resources) | ______ | ______ | ______ | ______ |
| C. Research contracts (separate from membership resources) | ______ | ______ | ______ | ______ |
| D. Education and training (separate from membership resources) | ______ | ______ | ______ | ______ |
| E. Other (please define) | ______ | ______ | ______ | ______ |

| | 7/84 - 6/85 | 7/85 - 6/86 | 7/86 - 6/87 | 7/87 - 6/88 | 7/88 - 6/89 | 7/89 - 6/90 |
|---|---|---|---|---|---|---|
| 3. Growth in industrial participation | | | | | | |
| A. Total number of members | ______ | ______ | ______ | ______ | ______ | ______ |
| B. Total number of other participants | ______ | ______ | ______ | ______ | ______ | ______ |

| | 7/84 - 6/85 | 7/85 - 6/86 | 7/86 - 6/87 | 7/87 - 6/88 | 7/88 - 6/89 | 7/89 - 6/90 |
|---|---|---|---|---|---|---|
| C. Dollar value of resources from industry | ______ | ______ | ______ | ______ | ______ | ______ |

| | Dollar Number | Value |
|---|---|---|
| 4. Research Projects | | |
| Group Sponsored Projects | ______ | ______ |
| Single Sponsored Projects | ______ | ______ |
| Generic Projects | ______ | ______ |

Product or Productivity Improvement Impacts

| | Total | In Ohio |
|---|---|---|
| 5. Number of companies reporting that center efforts improved their "bottom line" | ______ | ______ |

| | Total | In Ohio |
|---|---|---|
| 6. Quantify "bottom line" improvements | | |
| A. Return on investment | ______ | ______ |
| B. Cost savings or reductions | ______ | ______ |
| C. Improvements in Operating Efficiency (improved productivity and product quality) | ______ | ______ |
| D. Increased profits or yields | ______ | ______ |
| E. Increased product sales | ______ | ______ |
| F. Other measures - please define | ______ | ______ |

Job Impacts (full-time equivalents)

| | Total | In Ohio | Minorities |
|---|---|---|---|
| 7. Number of center employees | | | |
| A. Directly employed by center | ______ | ______ | ______ |
| B. University personnel directly engaged in center activities | ______ | ______ | ______ |
| 8. Jobs created at participating companies | | | |
| A. Number of companies reporting job creation resulting from center developed technology or assistance | | | |
| i. Center technology resulting in a new product | ______ | ______ | |
| ii. Center technology or activity resulting in an improvement of an existing process or product | ______ | ______ | |

| | Total | In Ohio | Minorities |
|---|---|---|---|
| B. Number of jobs included in item 8.A.i. | ______ | ______ | ______ |
| C. Number of jobs included in item 8.A.ii. | ______ | ______ | ______ |
| 9. Jobs retained at participating companies | | | |
| A. Number of companies reporting job retention resulting from center developed technology or assistance | | | |
| i. Center technology resulting in a new product | ______ | ______ | |

| | Total | In Ohio | Minorities |
|---|---|---|---|
| ii. Center technology or activity resulting in an improvement of an existing process or product | ______ | ______ | |
| B. Number of jobs included in item 9.A.i. | ______ | ______ | ______ |
| C. Number of jobs included in item 9.A.ii. | ______ | ______ | ______ |
| 10. Start-up firms assisted by center | | | |
| A. Number of companies | ______ | ______ | |
| B. Number of jobs created | ______ | ______ | ______ |

## Center Technology

| | Total |
|---|---|
| 11. Center patents - attach general description of each | |
| A. Number of patent applications and/or disclosures filed | ______ |
| B. Number of patents granted | ______ |

| 12. Number of papers, theses, dissertations and official presentations by center personnel | Direct Center Employees | University Personnel Directly Engaged in Center Activities |
|---|---|---|
| A. Papers published in national or international scholarly journals | ______ | ______ |
| B. Papers to national or international technical conferences | ______ | ______ |
| C. Technical presentations to professionally sponsored conferences | ______ | ______ |

D. Ph.D. dissertations and Masters theses ______ ______

13. Licenses

| | Total | Ohio Companies |
|---|---|---|
| A. Number of licenses awarded | ______ | ______ |
| B. Total dollar value of licenses | ______ | ______ |
| C. Dollar value of royalties returned to center | ______ | ______ |

14. Number of individuals directly conducting research

| | Total Number | Minority | Full Time Eqvlnt. | FTE Minority |
|---|---|---|---|---|
| A. Center research personnel | ______ | ______ | ______ | ______ |
| B. University professors | ______ | ______ | ______ | ______ |
| C. University graduate students | ______ | ______ | ______ | ______ |
| D. Subcontractor personnel - please define | ______ | ______ | ______ | ______ |
| E. Other - please define | ______ | ______ | ______ | ______ |

| | Company | Federal | Foundation | Other |
|---|---|---|---|---|
| 15. Research grants and contracts from non-state sources | | | | |
| A. Number of applications for research grants/contracts | _____ | _____ | _____ | _____ |
| B. Number of research grants/contracts awarded | _____ | _____ | _____ | _____ |
| C. Total dollar value of research grant/contract applications | _____ | _____ | _____ | _____ |
| D. Total dollar value of research grants/contracts awarded | _____ | _____ | _____ | _____ |

| | CENTER | | UNIVERSITY PARTNERS | |
|---|---|---|---|---|
| | Total Space Available | Space in Use | Total Space Available | Space In Use |
| 16. Facilities | | | | |
| A. Square footage of space for center | _____ | _____ | _____ | _____ |
| B. Cost per square foot | _____ | _____ | _____ | _____ |
| C. Current value of equipment | _____ | _____ | _____ | _____ |
| D. Replacement value of equipment | _____ | _____ | _____ | _____ |

## College/University Involvement

| | Non-GRF Resources | | GRF Resources | |
|---|---|---|---|---|
| | Received | Committed | Received | Committed |
| 17. College/University resources supporting center | | | | |
| A. Cash | ______ | ______ | ______ | ______ |
| B. Facilities and equipment | ______ | ______ | ______ | ______ |
| C. In-kind donations (including personnel) | ______ | ______ | ______ | ______ |
| D. Reduced overhead charges | ______ | ______ | ______ | ______ |
| E. Other (please define) | ______ | ______ | ______ | ______ |

18. Total amount of academic institution space dedicated solely to center (in square feet) ______

| | All Projects | Research Projects |
|---|---|---|
| 19. Number of projects involving more than one academic institution | ______ | ______ |

| | Edison Funds | Matching Resources |
|---|---|---|
| 20. Center resources paid to academic institutions: | | |
| A. Research personnel | ______ | ______ |
| B. Equipment | ______ | ______ |

| | Edison Funds | Matching Resources |
|---|---|---|
| C. Services (training programs and testing) | ________ | ________ |
| D. Overhead | ________ | ________ |
| E. Other | ________ | ________ |

* NOTE: If payments were made to more than one university, please provide figures for each university.

## Education, Training, and Technology Transfer

21. General education and training

A. Number of classes or seminars held ____________

B. Number of people attending center classes or seminars ____________

C. Dollar value of sponsorship (cash) ____________

D. Dollar value of sponsorship (donated service, in-kind) ____________

Optional Data

| | Total Members | Total Ohio Members | Ohio Non-Members | Non-Members |
|---|---|---|---|---|
| 22. (OPTIONAL) Number of companies reporting follow-up investment in technology developed in conjunction with center | | | | |
| 23. (OPTIONAL) Dollar value of follow-up investment | | | | |

| | Total | In Ohio | Minorities |
|---|---|---|---|
| 24. (OPTIONAL) Number of companies relocating to Ohio acknowledging center efforts or activities as influencing their decision | | | |
| A. Number of jobs resulting from #24 | | | |

| | Total | Ohio Companies |
|---|---|---|
| 25. (OPTIONAL) Number of graduate students involved in center activities hired by participating companies | | |

PROJECT OBJECTIVES

AND METHODOLOGY

## BACKGROUND

Ohio's Thomas Edison Program was initiated in 1983 by Governor Richard F. Celeste and the Ohio General Assembly. It is a $232 million effort created to stimulate technological innovation in Ohio through university/industry partnerships. The three components of the program are the Edison Seed Development Fund (SDF), the Edison Incubators and the Edison Technology Centers. The purpose of this project is to evaluate the Edison Seed Development Fund, which represents over $21 million in state and non-state investments. Since Janaury 1984, 92 SDF grants have been made to Ohio companies (see attached Portfolio). Of these, the research of 46 of the grants has been completed. This project seeks to compile and evaluate the results of the completed 46 SDF grants.

## OBJECTIVES

This evaluation seeks to provide detailed information on the performance of the Seed Development Fund (SDF) to determine: program impact, analysis of findings and next steps. This evaluation is intended to describe the impact of each research project both from the company's and the university's standpoint, give an overview of the 46 completed SDF projects, the current status of the companies involved with these projects, the status of the technology investigated, and the administrative aspects of the program.

## METHODOLOGY

The project manager, Jane Kirksey, has initiated a survey of the industries and their respective academic partners with completed Seed Development Fund projects. An Industry Interview Questionnaire has been developed to elicit information concerning: company performance, technology application and utilization, employment level and participants critique of the Seed Development Fund program. A second questionnaire, a University Interview Questionnaire, tracks the interaction with the partner industry, research results, publications and presentations, final status of the research, and participants critique of the Seed Development Fund program.

This survey will be executed through mailings, telephone interviews and selected on-site visits. The industries and universities will be initially contacted by mail (cover letter and survey attached). The format of the mailing will be structured to elicit comprehensive information on all completed projects. This data gathering will be enhanced by selective, in-depth individual project analysis. Personal on-site visits will be made to over 50% of all involved businesses to derive more thorough, extensive information on individual experiences with the Seed Development Program.

An overview of the program with findings and recommendations will be provided using the results of this evaluation, relying on responses to the questionnaire and general comments.

# INDUSTRY INTERVIEW QUESTIONNAIRE

## SEED DEVELOPMENT FUND
## COMPLETED PROJECTS

Date:____________

**CONTACTS**

Project:______________________________________________ Number:_______________
______________________________________________
______________________________________________

Company:________________________________________ Telephone: ___________________

Address:_____________________________________ President:_____________________
_____________________________________
_____________________________________ Project
_____________________________________ Director: _____________________

University:____________________________ Project Manager:_________________________

**COMPANY AND JOB IMPACT** _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Based on your Seed Development Fund (SDF) application you had _____ employees in Ohio when applying. What is your current number of Ohio employees?_____. If there has been a change since your application, how many jobs resulted from the SDF project? ______.

Are you projecting any additional jobs at your facility related to the SDF research:
- o within the next year? y / n. Number: __________.
- o within the next 3 years? y / n. Number: __________.

Have you relocated any personnel or facilities from out-of-state since inception of the SDF project? y / n. If yes, how many __________ Did the SDF research influence this relocation? y / n. In what ways?

Can you identify any spin-off jobs (jobs in other firms) as a result of research or technology development in this project?

Have any university personnel involved in this project become employees of the company? y / n. If so, how many? ________

Were any reductions in staff avoided as a result of this SDF project? y / n. If so, how many employees were retained?_______.

How long has your company been in business? _______ years.

Gross annual sales when applying were: $___________.
What are current gross annual sales? $___________. Can any of this difference be attributed to the SDF project? y / n. Please elaborate:

Have you filed any patents? y / n. How many? _________ Number granted? _______

Have any licenses been granted? y / n To whom: ___________________________
Value $___________

Amount of royalties paid to the state $ ________. (Class II only).

Current square feet of facilities used or owned in Ohio:
Manufacturing __________ Research/Development __________ Office __________

Has your company garnered external funding from such sources as SBIR, venture capitalist companies, other private sources etc.? y / n. Please describe type, amount and if used as matching funds for this SDF grant:

| Type | $ Amount | Used for Match? |
|---|---|---|

Has your company committed additional funding to developing the SDF product or process? y / n. If yes, please elaborate:

How would you characterize your company's interactions with academic institutions in the past 4 years? Please indicate the appropriate description.

Greatly decreased _______ About the Same _______ Greatly increased _______
Decreased _______ Increased _______

Has the Ohio Thomas Edison Program influenced the level of interaction with academia?
y / n.

TECHNOLOGY

Did the research completed under this project result in a process or a product? y / n.
Describe:

How would you classify the current status of your product or process (check appropriate description):

_______ Being actively marketed
_______ Anticipate marketing within the next _______ years
_______ Awaiting additional development
_______ Being developed by another firm
_______ Deemed economically or scientifically marginal: will not be marketed
_______ Will not be marketed for other reasons
Please elaborate:

Have you utilized Edison Incubator resources? y / n . If yes, in what way?

Have you utilized Ed'son Center resources? y / n . If yes ,in what way?.

Was SDF funding adequate for completing the needed esearch? y / n . If not, what levels would you suggest for Class I projects $_______________
for Class II $__________.

Was the time alloted for the SDF project adequate to complete the research?. y / n . If not, how many additional months did you need? _________.

ADMINISTRATIVE _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
Did you have any difficulties with the SDF application approval process?. y / n . Do you have any suggestions for improvements?

Do you have any comments or suggestions on the quarterly reporting procedures? Do you have any suggestions for improvements?

Do you have any comments in regard to university/industry relationships (contracts, technical interactions, proprietary rights, equipment loans or purchases, etc)?

Have you continued to interact with the University since completing the SDF project? y / n . In what capacity?

MISC _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _
From an overall standpoint, do you consider your Seed Development Project to have been successful. y / n . What were the most positive and negative aspects of the program?

Are there restrictions in the Edison program that prohibit it from being utilized more by industry?

Any other comments you have are most welcome.

# UNIVERSITY INTERVIEW QUESTIONNAIRE

## SEED DEVELOPMENT FUND
## COMPLETED PROJECTS

Date:__________

CONTACTS

Project:______________________________ Number:__________

Company:____________________ Telephone: __________________

Address:____________________ President:__________________

Principal Investigator:__________________

University:____________________ Telephone: __________________

Address:____________________ Project Manager: __________________

Adminis-trator: __________________

PRINCIPAL INVESTIGATOR

What university staff were engaged in this project?

| Type | Total # Involved | Full Time Equivalent |
|---|---|---|
| Professors | | |
| Graduate assistants | | |
| Other | | |

Number of publications submitted pertaining to research completed for this project:________
(Please give title, journal, date and any other pertinent information).

Number of presentations made: __________ ( Please give title, conference, date, etc.)

Has research led to obtaining other research funding? If so, please specify, type and amount .

Equipment used for this project was (check all pertinent descriptions):

________ bought for the project with SDF funds
________ retained by the university
________ supplied by partner industry
________ retained by partner industry
________ available at university at onset of project
________ other (describe)

Was SDF funding adequate to complete the research? y / n. If not, what levels would you suggest:

o for Class I projects? $____________________
o for Class II projects? $ ____________________

Was the time allocated for the SDF project adequate to complete the research? y / n.
If not, how many additional months did you need? __________.

Did research completed result in a process or a product? y / n.

Did you receive adequate financial and technical support from partner industry? y / n.
Please elaborate:

Have you continued to interact with the partner industry since completing the SDF project? y / n. If so, in what capacity?

**Any comments or suggestions on reporting procedures?**

**From an overall standpoint, do you consider this Seed Development Project to have been a successful experience for the university? y / n.**

**Any other comments you have are most welcome.**

## ADMINISTRATION

Any comments in regard to university/industry relationships (contracts, technical interactions, proprietary rights, equipment loans or purchases, etc.)

Any remarks in regard to the university/state relationship (contracts, reporting procedures, overhead charges, billings, etc.)

How would you characterize your university's interactions with industry in the past 4 years?

| | | |
|---|---|---|
| Decreased ________ | | Increased ________ |
| Greatly Decreased ________ | About the same ________ | Greatly Increased ________ |

Has the Edison Program influenced this interaction? y / n Please elaborate:

Do these relationships with industry differ from previous interactions? y / n. If yes, in what way?

What restrictions prohibit greater use of the SDF program by the university?

Any other observations you have are most welcome.

# Evaluation Methods Used for the National Science Foundation Engineering Research Centers Program

## and an

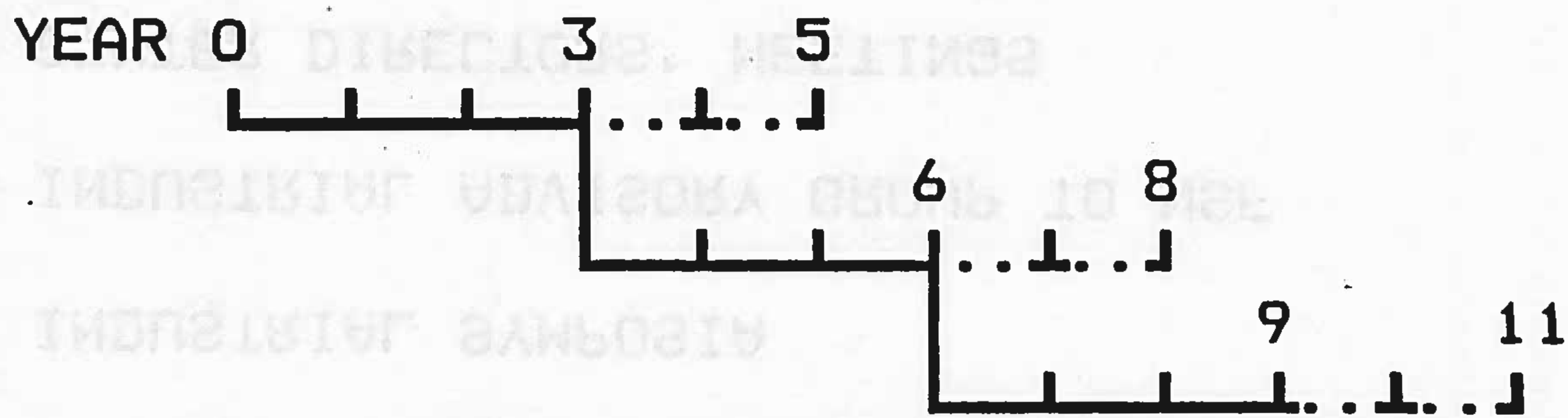
## Update on the NSF's Science and Technology Centers Program

presented by

Dr. Alan Leshner, Director
National Science Foundation
Office of Science and Technology Centers Development

# THE LIFE CYCLE OF AN NSF/ERC

MAY 9 1988




<< LEGEND >>

——: FULLY FUNDED PERIODS

3,6: RENEWAL EVALUATION

...: PHASE-OUT PERIODS BUT ELIGIBLE TO COMPETE WITH NEW PROPOSALS

PRODUCED USING BY LEHMAN

# ERC OVERSIGHT AND MANAGEMENT

## VEHICLES

- ANNUAL REVIEWS (TAC TEAM VISITS)
- OTHER VISITS AND ADVISORY MEETINGS
- INDUSTRIAL SYMPOSIA
- INDUSTRIAL ADVISORY GROUP TO NSF
- CENTER DIRECTORS' MEETINGS
- THIRD-YEAR RENEWAL EVALUATION

## ERC THIRD-YEAR REVIEW

## SITE TEAM COMPOSITION

- 5 TO 7 ACADEMIC/INDUSTRIAL REVIEWERS

  * TECHNICAL FIELDS OF EXPERTISE
  * MANAGEMENT OF RESEARCH TEAMS
  * INDUSTRIAL RESEARCH/DEVELOPMENT
  * ENGINEERING EDUCATION
  * ORIGINAL PROPOSAL REVIEWER(S)

- NSF TECHNICAL ADVISORY COMM. CHAIR

- NSF ERC PROGRAM DIRECTOR - TEAM CHAIR

# OVERALL FACTORS

HAS ERC MET ITS GOALS AND ERC PROGRAM GOALS?

IS ERC COHESIVE WITH SHARED GOALS?

IS IT AN ERC OR IS IT BUSINESS AS USUAL?

WHAT HAS ERC ACHIEVED THAT COULD NOT BE ACHIEVED THROUGH INDIVIDUAL GRANTS?

# ERC THIRD-YEAR REVIEW

## EVALUATION CRITERIA

- RESEARCH
- EDUCATION
- INDUSTRIAL COLLABORATION
- KNOWLEDGE/TECHNOLOGY TRANSFER
- OUTREACH
- LEADERSHIP
- STRATEGIC PLANNING
- INSTITUTIONAL ENVIRONMENT/SUPPORT

# FUNDAMENTAL RESEARCH

IMPORTANT FOR COMPETITIVENESS

COHERENT PLAN WITH SYSTEMS VIEW

HIGH QUALITY EXPLORATORY RESEARCH
RELEVANT TO TECHNOLOGICAL ADVANCES

PROJECTS FOCUSED ON ACHIEVABLE ADVANCES
IN TECHNOLOGY

CROSS-DISCIPLINARY TEAMS

INSTRUMENTATION PROMOTES EXPERIMENTATION

# EDUCATION

INVOLVE UNDERGRADUATE AND GRADUATE STUDENTS IN RESEARCH

BETTER PREPARE STUDENTS FOR ENG PRACTICE
- TECHNOLOGY-DRIVEN RESEARCH
- EXPOSURE TO INDUSTRIAL VIEWS
- VIEW OF ENGINEERING SYSTEM
- CROSS-DISCIPLINARY TEAM RESEARCH

DEVELOP COURSE MATERIALS BASED ON ERC

# INDUSTRIAL COLLABORATION

ONGOING INVOLVEMENT IN GUIDING/ASSESSING

DIRECT INVOLVEMENT IN JOINT RES/EDUC

SUPPORT BASE LARGE ENOUGH TO SIGNIFY A COMMITMENT FROM INDUSTRY

# KNOWLEDGE TRANSFER TO INDUSTRY

EFFECTIVE METHODS DEVELOPED

CONTINUING EDUCATION FOR PRACTICING ENG

POTENTIAL OR ACTUAL IMPACT ON
TECHNOLOGICAL CHANGE

# OUTREACH

WILL ERC INVOLVE STUDENTS/FACULTY FROM OTHER SCHOOLS?

IS ERC VIEWED AS A LEADER IN ITS FIELD?

# STRATEGIC PLANNING

DETERMINE VISION

DEFINE TECHNOLOGICAL GOALS
- ERC'S IMPACT ON GAPS IN KNOWLEDGE BLOCKING TECHNOLOGICAL ADVANCE

DEFINE MANAGEABLE THRUSTS
- EXPLORATORY RESEARCH NEEDED FOR SIGNIFICANT ADVANCES IN KNOWLEDGE
- FOCUSED RESEARCH NEEDED FOR ADVANCES IN PROCESSES, DEVICES, ETC.

# LEADERSHIP

VISION OF CENTER

INTEGRATES INDIVIDUAL FACULTY INTO A TEAM AROUND COMMON OBJECTIVES

BALANCES INDUSTRIAL NEEDS WITH ROLE OF UNIVERSITY IN FUNDAMENTAL RESEARCH

INTEGRATES ERC INTO CAMPUS CULTURE AND GAINS SUPPORT FOR INNOVATIVE ERC

SETS UP STRONG MANAGEMENT SYSTEM

# INSTITUTIONAL ENVIRONMENT

COMMITTED FACULTY PARTICIPATION

SUPPORT TO ERC FROM UNIVERSITY

UNIVERSITY CLIMATE SUPPORTS CROSS-DISCIPLINARY RESEARCH

- DOES TENURE SYSTEM VALUE ERC EXP?
- DOES ERC DIRECTOR HAVE TENURE INPUT?
- DOES UNIVERSITY SUPPORT/ASSIST ERC?

# NSF S&T RESEARCH CENTERS PROGRAM OBJECTIVES

- *Exploit opportunities in fundamental science and technology*
- *Increase transfer of knowledge from discovery to application and among sectors of society*
- *Provide special educational opportunities for future scientific and technical workforce*

# NSF S&T RESEARCH CENTERS
# MAJOR FEATURES

- Science to be done will determine the size, structure and organization

- Common features:
  * *University based*
  * *Educational components*
  * *Knowledge transfer components*
  * *Linkages to other sectors*

# NSF S&T RESEARCH CENTERS
## PROGRAM FEATURES

- All Fields
- Single competition
- No predetermined topics
- Both Centers awards and Planning grants
- Institutions may submit multiple proposals, but not on the same topic
- Central coordinating office; review and management in NSF substantive divisions

# Unexpected Benefits of Fundamental Research

- *High-temp. superconductors*
- *Frog skin antibiotics*
- *Lasers*
- *NMR*
- *Biological pest control*
- *Fisheries manag. techniques*
- *Solar collectors*
- *Spell checkers*
- *Tunneling electron microscopes*
- *Critical minerals mining techniques*
- *BASIC*
- *Biotechnologies*
- *Fiber optic communications*
- *Artificial intelligence*
- *Artificial biol. membranes, organs*
- *Retroviruses*

# NSF S&T RESEARCH CENTERS PROGRAM
## PROPOSAL STATISTICS

- *Full STC Proposals* = 323

  Total Requested (5 years) = $4.1B
  Average Request (5 years) = $12.6M
  First-Year Average = $2.4M

- *Planning Grant Proposals* = 258

- *Number of Institutions* = 205

- *Number of States* = 48 (+ D.C., P.R.)

3/14/88

# REVIEW PROCESS
# MULTI-TIER

- NSF S&T Centers Office
  - *Review and/or classification*
- NSF - STC Technical Coordinators
  - *Mail and/or panel review*
- Site Visits
- NSF Assistant Directors
  - *Priority lists*
- Single multidisciplinary committee
  - *Balance among fields*
  - *Competitiveness*
- National Science Board

# NSF S&T RESEARCH CENTERS PROPOSAL REVIEW CRITERIA

- Intrinsic merit of the theme and research
- Research performance competence
- Utility or relevance of the research
- Appropriateness of the center approach
- Appropriateness of institutional and management plans and arrangements
- Effect of the Center on the infrastructure of science
- Quality of educational and training components
- Form and strength of linkages and knowledge transfer efforts

# NSF S&T RESEARCH CENTERS PROGRAM
## REVIEW CATEGORIES

- Mathematics
- Computational Science and Engineering
- Cogn. and Inform. Sci./Art. Intell.
- Computer Science and Engineering
- Condensed Matter/Superconductivity
- Electronic and Optical Materials/ Interfaces
- Surface Science, Catalysis & Synthesis
- Polymers/Micro. and Nano. Structures
- Engineering
- Social and Behavioral Science
- Biological Science
- Molecular Sciences
- Others Physics/Astronomy
- Geosciences

2/16/88

# NSF S&T RESEARCH CENTERS PROGRAM
## PROPOSALS PER REVIEW CATEGORY

| | |
|---|---|
| Mathematics | 21 |
| Computat. Sci. & Eng. | 12 |
| Cog. & Inf. Sci./A.I. | 32 |
| Computer Sci. & Eng. | 17 |
| Cond. Matter/Supercon. | 21 |
| El., Op. Mats./Interf. | 27 |
| Surfaces/Catal./Synth. | 25 |
| Polymers/Structures | 17 |
| Engineering | 12 |
| Other Physics/Astron. | 29 |
| Geosciences | 46 |
| Molecular Sciences | 19 |
| Biological Sciences | 29 |
| Social & Behav. Sci. | 14 |

2/18/88

# NSF BUDGET SUMMARY
## FY 1987–1988
(DOLLARS IN MILLIONS)

| | FY 87 APPROP | FY 88 APPROP | CHANGE AMOUNT | FY88/87 CHANGE |
|---|---|---|---|---|
| RESEARCH AND RELATED ACTIVITIES | 1,406 | 1,453 | 48 | 3% |
| U.S. ANTARCTIC PROGRAM | 117 | 125 | 8 | 7% |
| SCIENCE AND ENGINEERING EDUCATION | 99 | 139 | 40 | 40% |
| TOTAL, NSF | $1,622 | $1,717 | $ 96 | 6% |

# IMPACT ON FY 1988 RESEARCH APPROPRIATION

- Protect: Mathematics
  Minority Programs
  Women's Programs
  Graduate Students
- Slower growth of undergraduate activities

------------

- Deferral of S&T Centers Initiative
- Facilities stretched out; No new starts
- No increase in grant size/numbers
- Fewer new PYIs

# NSF BUDGET SUMMARY

## FY 1988–1989

(DOLLARS IN MILLIONS)

| | FY 88 APPROP | FY 89 REQST | CHANGE AMOUNT | FY89/88 CHANGE |
|---|---|---|---|---|
| RESEARCH AND RELATED ACTIVITIES | 1,453 | 1,603 | 150 | 10% |
| SCIENCE AND ENGINEERING EDUCATION | 139 | 156 | 17 | 12% |
| U.S. ANTARCTIC PROGRAM | 125 | 141 | 16 | 13% |
| SCIENCE AND TECHNOLOGY CENTERS | 0 | 150 | 150 | N/A |
| TOTAL, NSF | $1,717 | $2,050 | $333 | 19% |

# NSF S&T RESEARCH CENTERS PROGRAM
## FY 1989 PLAN

- New $150 million appropriation
- Up-front, full funding (4-5 years) for about 15 Centers
- Projected award size: $1-5M per year for up to five years
- Slow outlay pattern (over 7-8 years)

2/18/88

# NSF S&T RESEARCH CENTERS PROGRAM
## RATIONALE FOR THE SEPARATE APPROPRIATION

- Clearly separate funding of STC activity from individual investigator support
- Provide reliable, stable support for the STC's first years
- Demonstrate to potential partners the Foundation's long-term commitment
- Take advantage of slow outlay rate

# Hollings Centers Competition

presented by

Dr. Don Johnson, Director
Industrial Technology Services
National Bureau of Standards

# NEW PROGRAMS AND DIRECTIONS

# AT THE

# NATIONAL BUREAU OF STANDARDS

**March 1988**

## New Programs and Directions at the National Bureau of Standards

### Introduction

The rapid loss of competitiveness of U.S. industry in international markets is an extremely serious problem with wide-ranging consequences for our material well-being, our security, and our political influence. Its causes are many, but among them certainly are the slow rate at which new technology[1] is embodied in commercial products and processes, and the lack of attention paid to manufacturing. We need to compete in world markets with high-value-added products, incorporating the latest innovations, manufactured in short runs with flexible manufacturing methods. We need research, management, and manufacturing methods that support change and innovation.

Congress and the Administration have called upon the National Bureau of Standards to carry out a program of technology development and transfer in collaboration with industry, universities, other federal government agencies, and with state and local governments. The National Bureau of Standards (NBS) is the one federal government agency that already supports industry and commerce directly with infratechnology services. Its contributions are vitally needed now to support rapid commercialization of technical innovations. NBS's leverage on innovation in industry and commerce has been significantly increased, and additional roles have been assigned to NBS to more fully use this unique government resource.

NBS is a small agency and its resources are quite small compared to the industrial and federal investment in research and development, or with the investment of $800 million by the various states in technology transfer and support programs. The new programs being developed by NBS will be collaborative, highly leveraged, and serve as examples to be followed by others with greater resources.

### National Institute of Standards and Technology

The legislative package for the Technology Competitiveness Act currently before the Congress, will assign four new major programs to the National Bureau of Standards and also change the name to National Institute of Standards and Technology. Not all facets are in place but the direction of change and the ensuing programs can be predicted. The long-standing mission of the National Bureau of Standards to provide for the measurement standards and data needs of the U.S. economy remains unchanged in the new legislation. However, the proposed new assignments will cast NBS in a new and different role working with a different constituency such as state and local economic development organizations and such federal agencies as the Small Business Administration, Economic Development Agency, and the International Trade Administration.

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[1] Technology is defined as technical information applicable to products and processes.

Many ideas originating in the American scientific and technical community are being commercially exploited in other parts of the world. We, as a nation, have been slow to capitalize on new technology developed from our own intellectual capability and to improve our manufacturing capability. In the past, small and mid-size companies have led U.S. industry in innovation. We must now determine how the federal government can support such companies in the development of improved manufacturing capabilities and the marketing of new, competitive products.

The NBS Director has decided to establish a new program at NBS (to become NIST) called "Industrial Technology Services (ITS)." This program will include the four proposed major activities: (1) Centers for the Transfer of Manufacturing Technology, (2) Industrial Extension Services, (3) an Advanced Technology Program, and (4) the Clearinghouse for State Technology Programs, which will be carried out by the Secretary's Office with support from NIST. Short descriptions of these four new programs follow.

## Centers for the Transfer of Manufacturing Technology

The aim of the first part of the Industrial Technology Services (ITS) program is to bring modern automated manufacturing technology to small and mid-size manufacturing firms, that cannot compete in the international markets because their resources for research or technological improvement are insufficient. ITS will work with the state and local organizations, universities, and also with industry to develop twelve regional centers to achieve the transfer of modern manufacturing technology to these constituents. The program focuses on technologies appropriate to small businesses, e.g., automation of existing facilities with off-the-shelf equipment within the reach of the personnel, finance, and engineering capability of such companies. The program will be a cost-sharing partnership where the funding provided by ITS will be matched by funds from other sources such as state governments, industry, and academic institutions. The location and function of each transfer center will be coordinated with the needs of the local or regional industry.

The program emphasizes "hands-on" experience. Senior managers will be invited to the center to observe and participate in demonstrations of automatic equipment that will be advantageous to their companies. They will be assisted in choosing the proper equipment, in selecting a reputable supplier, and in acquiring and training the staff that will operate the equipment. The program will encourage a partnership with academic institutions, with special focus on training of workers that could be provided by community colleges or vocational schools. ITS will provide funding of up to $3 million per year, ramped in years 4, 5, and 6, to be matched dollar for dollar from other sources. At the end of three years, each center will be reviewed to determine if its transfer of technology to industry justifies its continuation. At the end of six years, government funds will drop to zero, and the center should be self-sustaining. Two regional centers will come on line this year. ITS will make available engineers trained in industrial manufacturing and familiar with the Automated Manufacturing Research Facility (AMRF) at NIST to help start and operate the centers.

## Industrial Extension Services

The second part of the Industrial Technology Services program involves ITS in Industrial Extension Services, with the intent to make federal technology available to small and mid-size businesses through existing state and local extension activities. A number of federal agencies now sponsor extension programs of various kinds; the Economic Development Administration oversees about 40 centers; the International Trade Administration operates its trade assistance adjustment centers for companies disadvantaged by imports. Most extension services, of which there are thousands, do not deal with sophisticated technology but concentrate their efforts on business advice and business applications. For the most part, organizations providing extension services have neither the technically trained personnel nor the technical resources needed to help a small company just entering the high technology field. The role of ITS will be to provide the central federal coordination for extension services, working with federal agencies and federal laboratory consortia to carry out technology transfer throughout the extension program. ITS will also organize an invention evaluation service that will test the technical and economic feasibility of inventions. ITS will provide help in structuring workshops and will bring businesses of similar interest into networks for the joint solution of problems. A pilot effort to network local biotechnology companies and supporting firms has been operating successfully at NBS for a year. Experience gained from this pilot program will benefit the NIST efforts in other technologies.

## Advanced Technology Program

The third part of the Industrial Technology Services program will accelerate the commercial development of technology. This program will function quite differently from the others and will address a different but related constituency. In the Advanced Technology Program, ITS will provide funding to and will encourage formation of industry consortia aimed at developing generic technology and improving manufacturing processes. This program will focus on developing new products and in making major improvements in existing manufacturing processes. This program therefore complements the Small Business Innovative Research Program (SBIR) which addresses research and development up to the prototype stage. The formation and funding of consortia under this program will be similar, except in size, to a project recently proposed to DOD by the semiconductor industry, where 51 companies have formed a research consortium to find ways of improving the manufacture of semiconductor chips.

## Clearinghouse for State Technology Programs

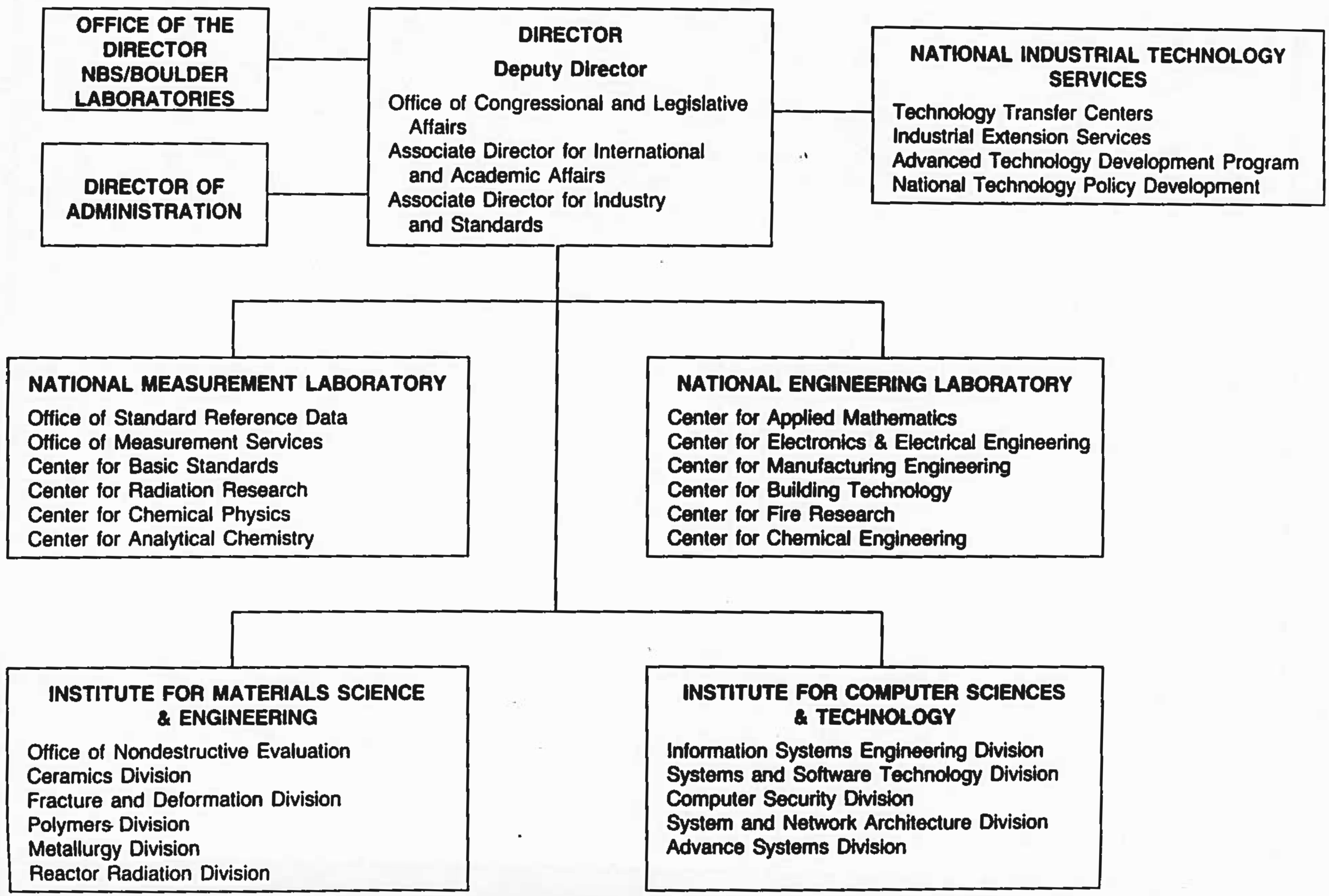
The fourth part of the Industrial Technology Services program deals with policy. Despite much debate there is little likelihood that a national industrial policy will be developed. However, a de facto technology policy is being developed at the state and local level by governors, county executives, and mayors. These leaders establish policy when they allocate public funds to particular development projects. The total investment is large and the influence on the overall direction of U.S. high technology firms and, hence, their impact on the nation's balance of trade is substantial. Under the new program ITS will provide technical and analytical support to state and local governments as they decide future investments in technology programs. The effort will be a shared assignment between the Department of Commerce (DOC) and ITS working through the Office of Intergovernmental Affairs.

ITS will develop a network of technical contacts within the state and local policy level staff, and will collect information on current programs and provide a technical analysis. A first report to Congress is scheduled for January 1, 1989. Meanwhile dialogue will continue and workshops will be offered in an effort to make federal resources available to aid in this decision-making process.

For further information, write or call:

Industrial Technology Services
National Bureau of Standards
Gaithersburg, MD 20899
301-975-2122

# U.S. DEPARTMENT OF COMMERCE
## National Institute of Standards and Technology



# Status of Key R & D Issues in the Federal Budget: An Overview

presented by

Dr. Kenneth G. Wilson
Nobel Laureate in Physics, 1982

**The National Science Foundation in the 1990's**
**by Kenneth G. Wilson**

I am writing this paper to urge increased support for the NSF based on my own past benefits from government support and the urgent need of today's brightest young scientists.

The National Science Foundation has acquired many new responsibilities related to economic development over the last two decades. Equally important, many simultaneous revolutions in science are competing for support from NSF. The budget for the NSF is woefully inadequate to meet demands on it, in part because it does not have as strong political support as does the NIH, the Department of Defense, or domestic social programs. While all agencies supporting basic research (NIH, DOE, NASA, DoD) need some growth for their basic research, NSF is especially visible right now because of the proposal to double its budget.

I became a scientist because my father (E. Bright Wilson, Jr.) was a scientist; he was one of the leaders of the scientific support for defense during World War II. I was a graduate student in the late 50's, at the time of the launch of Sputnik. I started my Nobel Prize winning research as a graduate student (supported by an NSF graduate fellowship), and pursued that research for fifteen years through the 1960's -- a golden age for U.S. science. I went on to publish the two papers cited by the Nobel committee in 1972.

The focus on science following Sputnik got me started on an extraordinary career. I urge that a new boost be given to science over the next few years. I urge this so that the scientists of today will have the same opportunity to compete for Nobel Prizes that I was given in the 1960's.

I will describe briefly the scientific quest that I was privileged to be part of, due to the extraordinary government support of science in the 1960's. When I began my research, the basic constituents of matter were known to be electrons, protons, and neutrons. These constituents combine to make up atoms, the basic units of the chemical elements. It was already known that protons and neutrons have complex structures, but the nature and causes of this structure were a mystery. Then during the 1960's, a world-wide community of high energy physicists unravelled the secrets of the proton and neutron. Countless experimental discoveries at particle accelerators created new puzzles to unravel. Attempts to understand these experiments led initially to fragmentary and seemingly contradictory explanations.

By the middle 70's the proton's structure had become clear; it and the neutron are made up of three objects called quarks, held together by a microscopic version of string. Equations of motion for both quarks and string had been established. The discovery of quarks and string, and the equations describing them, is as basic a scientific discovery as the discovery of Newton's Laws in the 1600's or the Laws of Electricity in the 1800's.

I was fully involved in these discoveries. Moreover, this was followed by my trip to Sweden to receive the Nobel Prize and the extraordinary respect from scientists and laymen alike that this award brings.

Many young scientists in the 60's received their graduate training by participating in research such as mine; these scientists today are faculty members at universities in every state in the U.S. The scientific opportunities awaiting them and their graduate students today are even more spectacular than when I started out. Telescopes and satellite observatories have completely altered our view of the universe, uncovering explosive events that consume entire galaxies of stars, or tiny pulsars that send pulses to earth with greater regularity than any earthbound clock. The current excitement over high temperature superconductors is only a tiny indication of a vast revolution in materials ranging from polymers and optical fibers to drugs and catalysts. This revolution is entering a new stage due to microscopes which can see individual atoms, and new techniques (such as molecular beam epitaxy) for building new materials, atom by atom. The continuing unfolding of the molecular basis of life was illustrated most recently in the search for the gene responsible for cystic fibrosis. Critical for human survival is the growing investigation of the global environment and climatic change.

Moreover, the accelerating computer revolution is profoundly extending the scope of science. It used to be that the most fundamental question asked by scientists was "What is this object made of"? Now, an equally important question is "How does this system work"? For example, scientists first learned that proteins (crucial components of life) are made up of amino acids. Now the exciting question is "How do entire proteins fold to achieve their biologically active structure"? The most powerful computers (supercomputers) are needed to manage all the data that such questions involve. The vast challenge of computer-aided design, engineering and manufacturing, is to understand and control the life history of all kinds of products -- from manufacture to final disposal as waste -- before they leave the drawing board. Computer networking is creating a revolution in communications as profound as the invention of printing 500 years ago, leading to instantaneous national and global scientific collaborations and the instantaneous capability to selectively search man's entire storehouse of knowledge.

The last twenty years has seen the emergence of regions of high technology economic development such as "Route 128" or "Silicon Valley" where world class universities provide highly trained manpower and the fruits of basic research to a mix of large and small companies. A major challenge to the next President is to encourage high technology growth throughout the country in collaboration with state Governors and their high technology economic development programs. I believe that many more high technology zones can be identified than are presently recognized, each with a different range of specialties benefitting from the many scientific and engineering revolutions now underway. At the heart of almost every such region there are university faculty of high quality with potential Nobel Prize-winning research goals. Their research can inspire successive generations of students to the creativity a modern high technology regions requires.

Unfortunately, the budget of the NSF is now far too small to meet the needs of even the most outstanding research projects. Scientists from all parts of the country prepare proposals for new research investigations, proposals that NSF program directors are eager to fund but either reject outright, or drastically underfund because of budget shortfalls. It is especially difficult for young scientists starting their careers, or scientists outside the most prestigious Ivy League or California universities to compete against the highly productive ongoing research programs at these universities, although even Nobelists at Ivy League schools, working on high temperature superconductivity, are being cut back too.

The difficulties at the NSF reflect a dramatic rise in budgetary pressures at the NSF over the past two decades. The sources of these pressures are, first, the transfer of major defense-funded programs to the NSF (such as the Materials Science Centers). Then, there was the growth of engineering research and graduate training programs in critical areas like electrical engineering and computer science to rival the science programs at NSF. Then, there was an explosive growth in the cost of research instrumentation, fueled by a rapidly growing industrial market for scientific instruments. Then, there was the continuing growth in the power of computers and the need to supply and update computers of all kinds for research. Most recently, the NSF has started its programs of engineering research centers, supercomputer centers, and the proposed science and technology centers, all of which are essential to support interdisciplinary groups studying complex systems.

The Reagan administration has proposed that the NSF budget be doubled over the next five years. I believe what is needed is to triple, not just double, the NSF budget.

This goal is, of course, very difficult to accomplish in an era of massive deficits. There is broad but shallow support for the NSF in Congress. There is a growing awareness of the NSF among state governors as they focus on needs for high technology development within their own states. However, there has been no powerful political voice supporting NSF in Congress in comparison with the support heard for the NIH, or defense, or major social programs. The university scientists and engineers who are supported by NSF are a minute fraction of the body politic, fragmented and politically naive. The role of these university faculty in economic development is poorly understood by the scientists themselves, as well as most laymen. Even the Congress is skeptical, being very concerned about the ease with which competitors abroad take advantage of U.S. research results.

There are obvious and valid concerns about the effectiveness of technology transfer from U.S. universities to U.S. industry, especially in the face of the massive trade deficit. It is, I believe, extremely dangerous to starve U.S. science because of these concerns. First, virtually the entire product offerings of U.S. industry are redesigned over a period of a decade or two, and the technology base for these designs is vastly different today than it was twenty years ago. Given the scientific revolutions underway in such key areas as materials and biotechnology, the advances in industrial technology worldwide over the next twenty years could be even more dramatic and the dangers if the U.S. falls behind are, I believe, extreme even by comparison to today's deficits. Second, there are areas where university/industry technology transfer works well, for example, technology transfer to U.S. military industries. Third, as Erich Bloch (Director of the NSF) has emphasized, whatever the causes of U.S. competitive failures in high technology -- from the overpriced dollar to the conservatism of middle management in large U.S. companies, to actions by our competitors abroad -- one has to look to university faculty to take the entrepreneurial lead in improving technology transfer to U.S. civilian industries. Starving U.S. science so that there is no technology to transfer is not, I think, the best strategy to pursue.

The scientists throughout the U.S. are ready; the time is ripe and many revolutionary research possibilities await them. All that is missing is the political will to provide them with support. This support is amply justified by the need to accelerate high technology growth surrounding research universities throughout the country. Economic growth is now the key to deficit reduction as well as continued global leadership by the U.S.

I have set aside half of my time to work on science policy issues over the next few years. I am moving from Cornell to the Ohio State University, partly in hopes of being more involved in the many practical issues of high technology advance. I am ready to help in any way I can to bring about another Sputnik-like advance in the support of science.

# The National Science Foundation
# "Overview of NSF Activities and Budget"

presented by


Mr. Raymond Bye, Director
Office of Legislative and Public Affairs
National Science Foundation

# NGA PRESENTATION

April 28, 1988

Chart 1: NSF Budget Summary FY 1988-1989

The FY 1989 Budget Request is $2.05 billion, an increase of more than 19 percent over FY 1988. It includes a proposed new appropriation for Science and Technology Centers. The request reaffirms the Administration's commitment to double support for NSF, primarily for academic basic research.

CHART 1

# NSF BUDGET SUMMARY
## FY 1988–1989
(DOLLARS IN MILLIONS)

| | FY 88 APPROP | FY 89 REQST | CHANGE AMOUNT | FY89/88 CHANGE |
|---|---|---|---|---|
| RESEARCH AND RELATED ACTIVITIES | 1,453 | 1,603 | 150 | 10% |
| SCIENCE AND ENGINEERING EDUCATION | 139 | 156 | 17 | 12% |
| U.S. ANTARCTIC PROGRAM | 125 | 141 | 16 | 13% |
| SCIENCE AND TECHNOLOGY CENTERS | 0 | 150 | 150 | N/A |
| TOTAL, NSF | $1,717 | $2,050 | $333 | 19% |

<u>Chart 2: NSF Budget Estimates, FY 1981 - FY 1993</u>
**This chart shows the planned doubling of the current budget by FY 1993, a return to the plan put forth by the Administration last year.**

CHART 2

# NSF BUDGET ESTIMATES
## FY 1981 – FY 1993

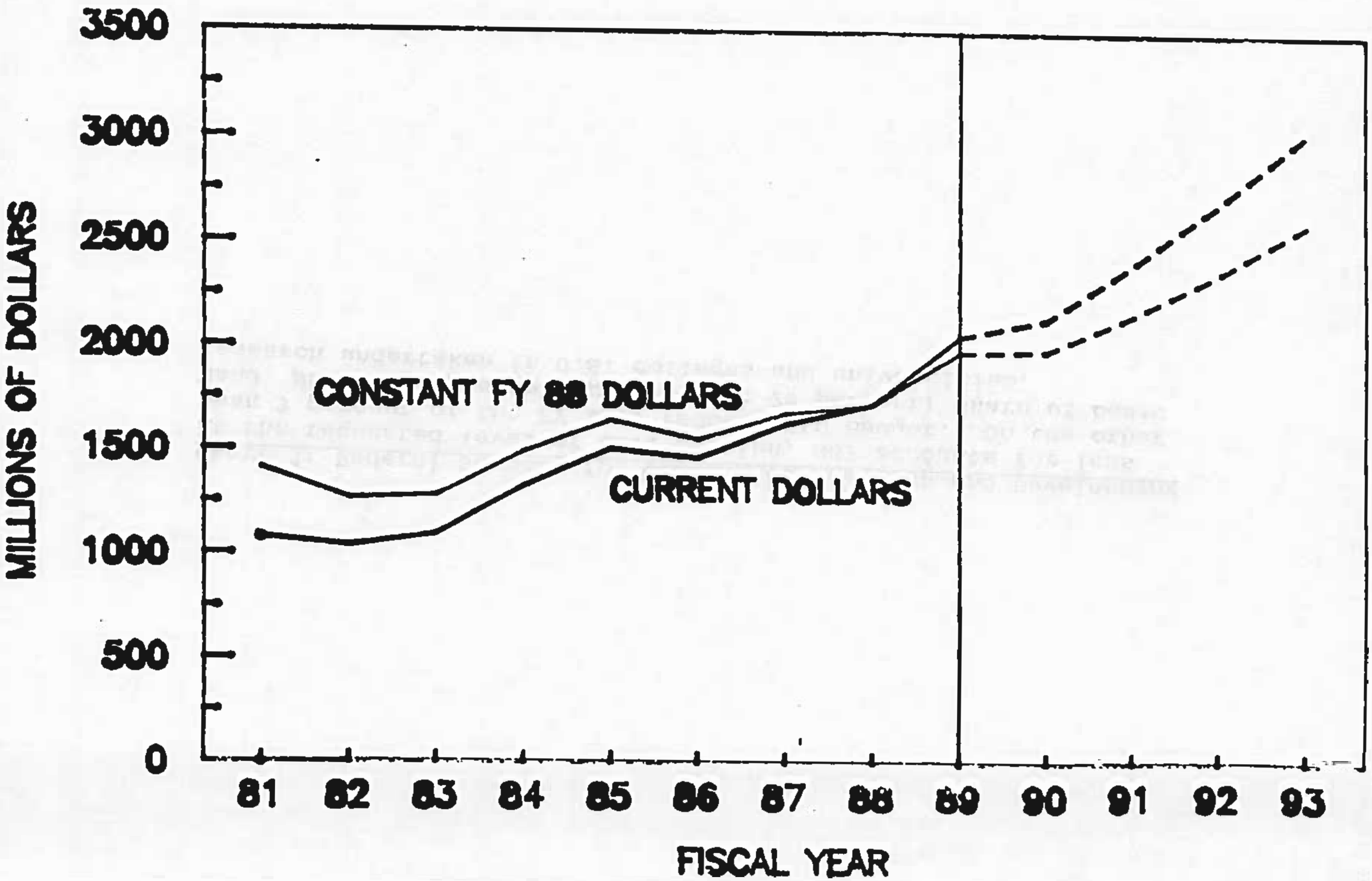


Chart 3: Federal Support for Conduct of Research and Development

At the requested level of $2.1 billion, NSF accounts for less than 3 percent of the FY 1989 Federal R&D Budget. On the other hand, NSF funds a significant (about 28 percent) share of basic research undertaken in U.S. colleges and universities.

# FEDERAL SUPPORT FOR CONDUCT OF RESEARCH AND DEVELOPMENT NSF SHARE, FY 1989

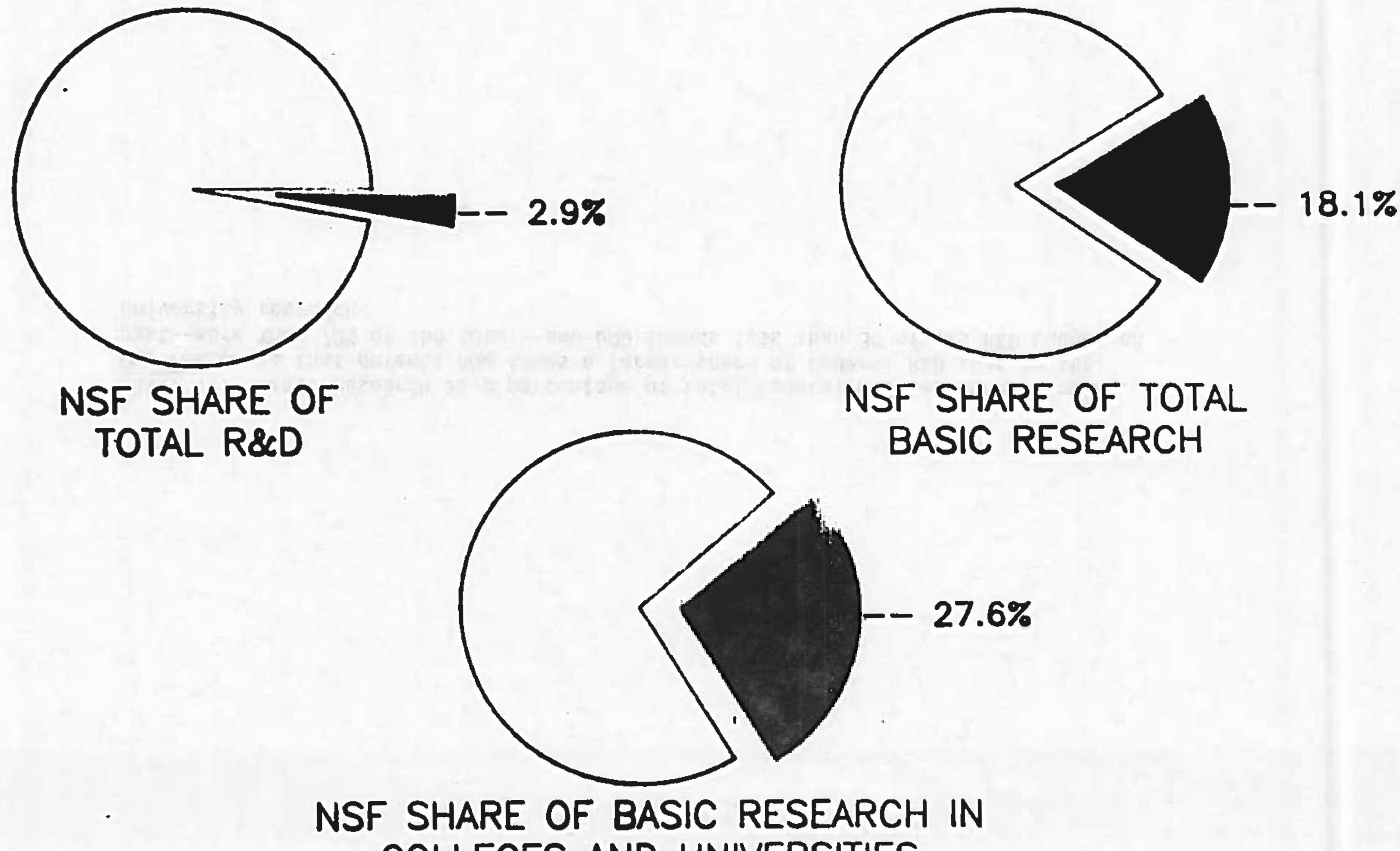
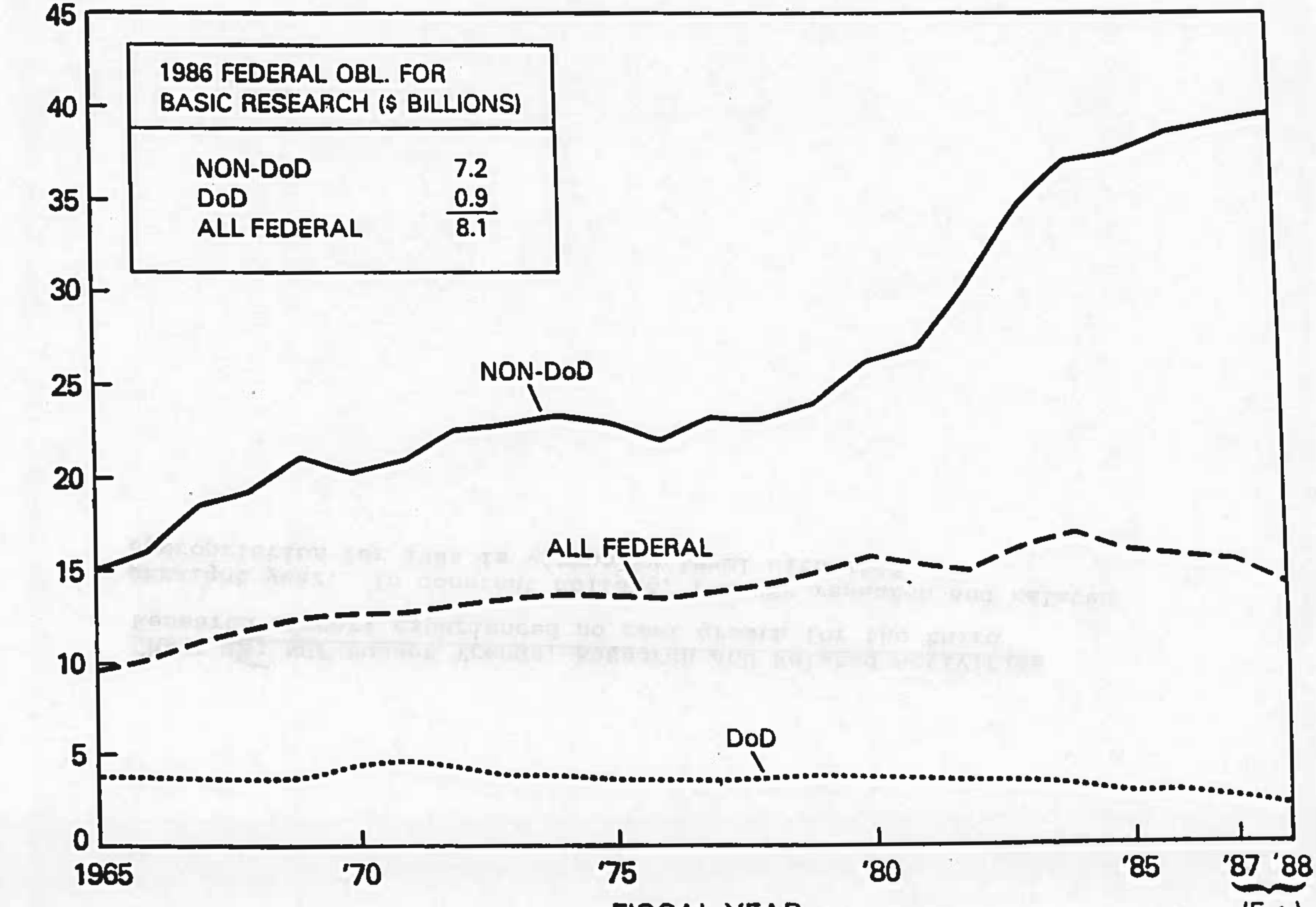


CHART 4 : 3asic research as a percentage of total Federal R&D has been dropping. One reason is that defense now takes a larger share of Federal R&D than in the past--more than 70% of the total--and DOD spends less than 3% of its R&D budget on university research.

# FEDERAL BASIC RESEARCH AS A PROPORTION OF TOTAL FEDERAL R&D, BY CATEGORY



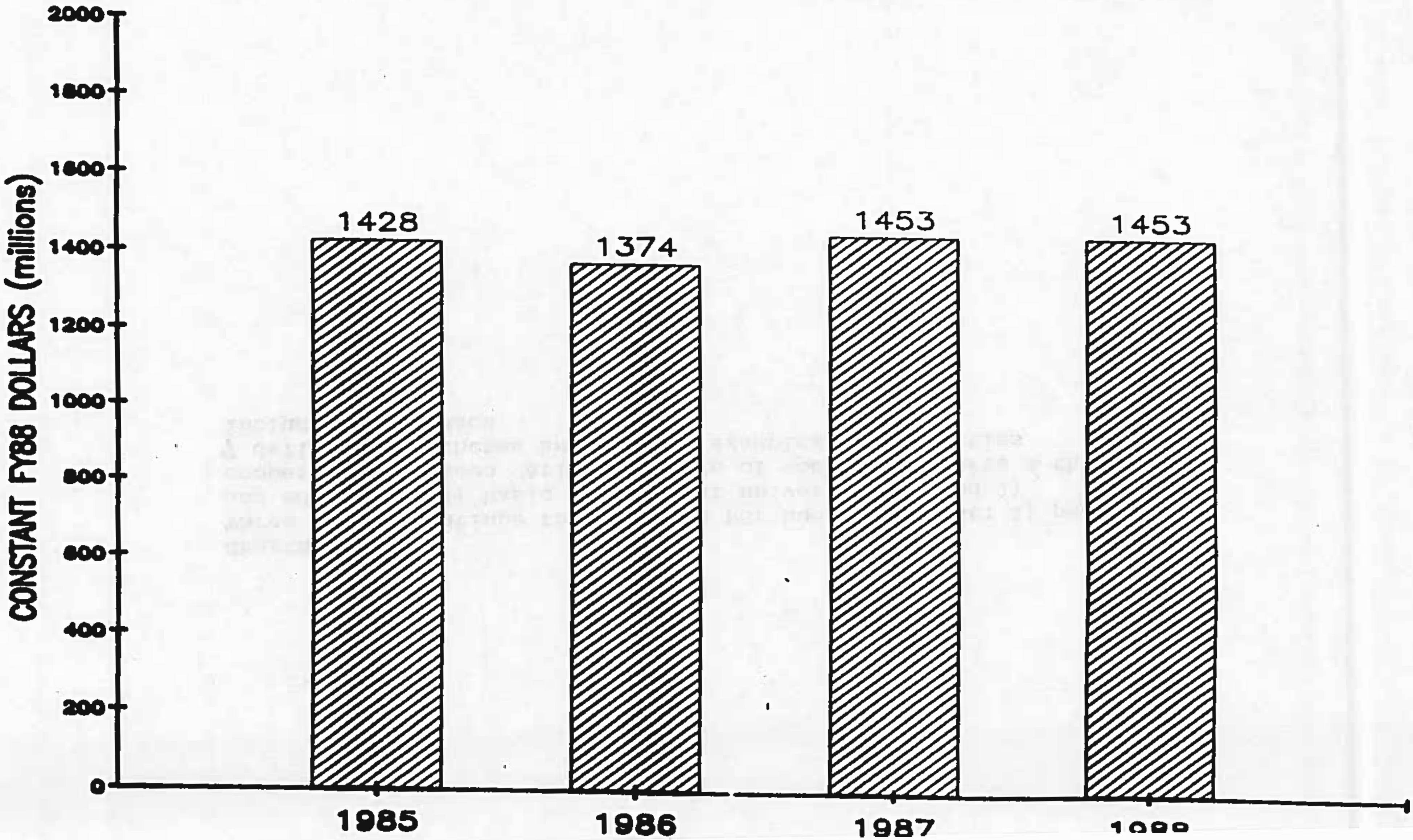

SOURCE: DIVISION OF SCIENCE RESOURCES STUDIES

Chart 15: NSF Budget Trends, Research and Related Activities

Research support experienced no real growth for the third straight year. In constant dollars, the NSF research and related appropriation for 1988 is virtually level with 1985.

CHART 5

# NATIONAL SCIENCE FOUNDATION
## BUDGET TRENDS
## RESEARCH AND RELATED ACTIVITIES



**Charts 6-9**

Three themes continue to shape the NSF budget request: 1) people and education; 2) basic research at universities; and 3) cooperation between various sectors of society. Charts 6 through 9 define these themes and provide examples of activities included under each.

CHART 6

# FY 1989 STRATEGIC THEMES

- o Education and Human Resources
- o Disciplinary Research and Facilities
- o Centers and Groups

CHART 7

# EDUCATION AND HUMAN RESOURCES

- Two Main Aspects:
  - Increasing supply of scientists and engineers for future
  - Broadening participation
    - Women, minorities, disabled
    - Institutions
    - Geographic regions
- Crosses all Foundation organizations
- Examples: Graduate Fellowships
  Presidential Young Investigators
  Minority Research Initiation
  Research Opportunities for Women
  Minority Scholars
  Special Postdoc Programs
  Research Improvement in Minority Institutions
  EPSCoR

# DISCIPLINARY RESEARCH & FACILITIES

- o Increase Grant Size and Number:
  - Support of students and postdocs
  - Instrumentation

- o New or Expanded Research Areas:
  - Superconductivity
  - Materials chemistry
  - Biological communication
  - Manufacturing systems
  - Parallel computing
  - Cosmology

- o National Facilities
  - National Supercomputer Centers and NSFNET strengthened
  - VLBA construction continues
  - Physics facility upgrades at Michigan State, Cornell and Indiana come online
  - Antarctic –– research ship, laboratory space, aircraft refurbishment

# CENTERS AND GROUPS
## FY 1989

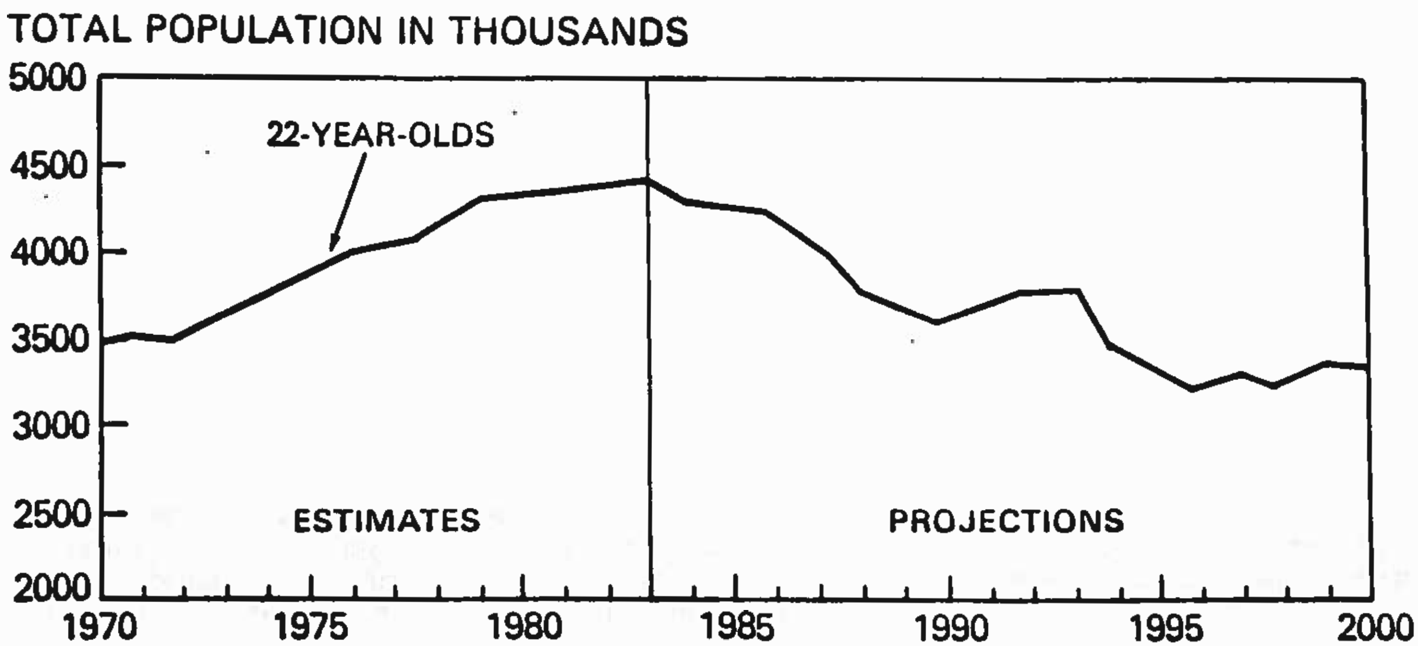
- Continuing Centers
  - Materials Research Laboratories
  - Engineering Research Centers
  - Interagency Plant Science Centers

- Groups
  - Materials, mathematics
  - Global geosciences
  - Biotechnology, ecology
  - Emerging engineering technologies

- Separate S&T Centers Initiative

CHART 10: Concerns about the future supply of scientists and engineers are to a large degree attributed to the fact that the number of 22-year-olds has been dropping steadily. Unless more undergraduates are attracted to S & E fields, the number of S & E degrees must decline also.

# ESTIMATES OF 22-YEAR-OLDS IN THE U.S. POPULATION



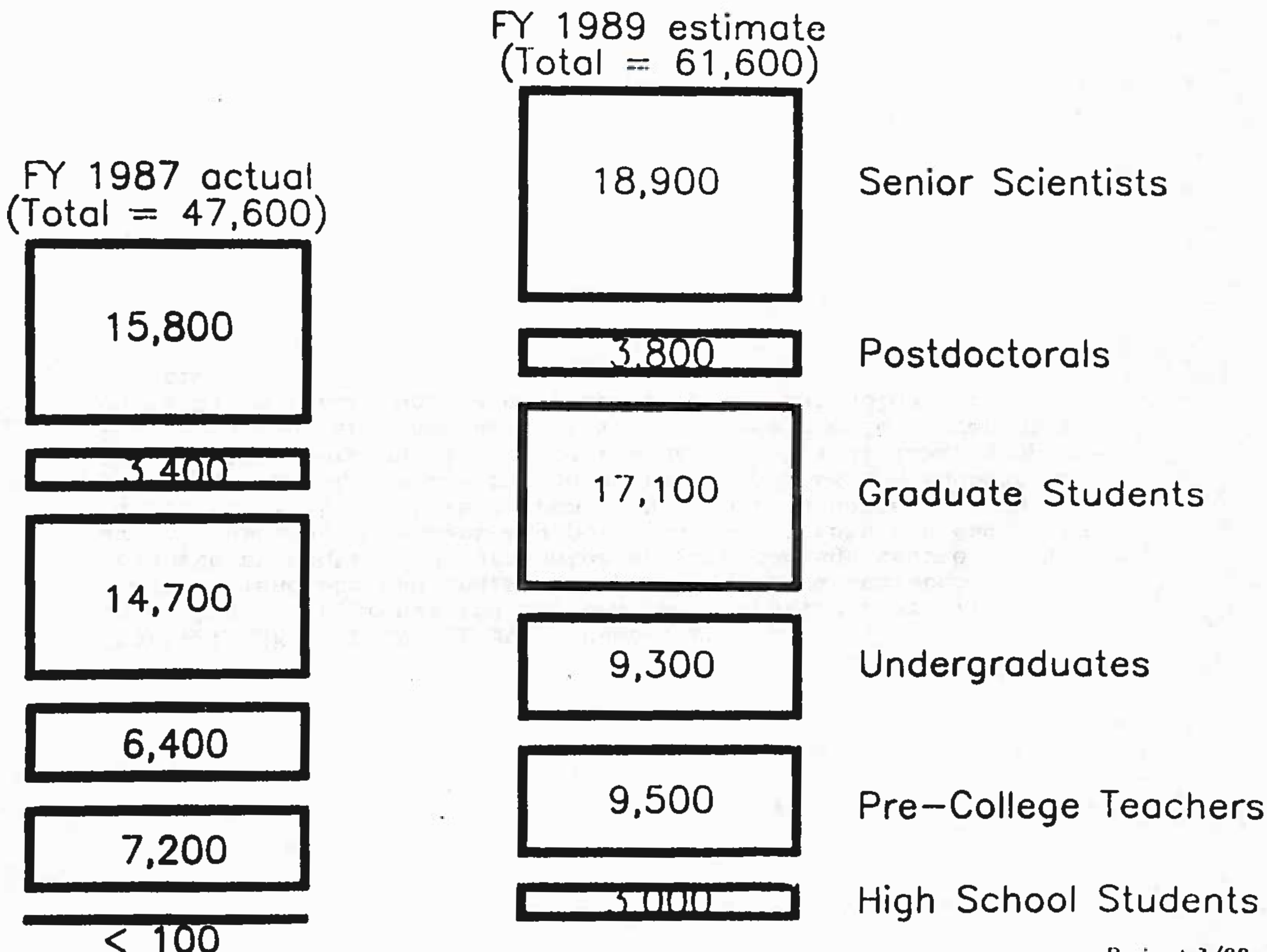

SOURCE: BUREAU OF THE CENSUS

**Chart [illegible]: NSF Support for Human Resources**

In FY 1987, NSF grants and fellowships supported over 47,000 senior scientists and engineers, postdoctoral associates, graduate students, undergraduates and pre-college teachers. The actual numbers of current and potential scientists and engineers supported -- at all levels from high school students through senior scientists -- are rising sharply. Across the Foundation, the FY 1989 increase will support over 14,000 additional people -- a 30 percent increase over FY 1987. These people represent the current and future source of scientific and technological creativity.

CHART #1

# NATIONAL SCIENCE FOUNDATION
# SUPPORT FOR HUMAN RESOURCES




Revised 3/88

CHART 12: The four appropriation accounts in the FY 1989 Request are: Research and Related, Science and Technology Centers, the U.S. Antarctic Program, and Science and Engineering Education.

This chart provides a breakout of our largest account, Research and Related Actvities.

CHART #2

# NSF BUDGET SUMMARY
# FOR
# RESEARCH AND RELATED ACTIVITIES
# FY 1988—1989

(DOLLARS IN MILLIONS)

| | FY 88 APPROP | FY 89 REQST | FY89/88 CHANGE |
|---|---|---|---|
| MATHEMATICAL AND PHYSICAL SCIENCES | $ 473 | $ 503 | 6% |
| GEOSCIENCES | 291 | 321 | 10% |
| BIOLOGICAL, BEHAVIORAL AND SOCIAL SCIENCES | 266 | 289 | 9% |
| ENGINEERING | 171 | 195 | 14% |
| COMPUTER AND INFORMATION SCIENCE AND ENGINEERING | 124 | 149 | 20% |
| SCIENTIFIC, TECHNOLOGICAL AND INTERNATIONAL AFFAIRS | 44 | 51 | 16% |
| PROGRAM DEVELOPMENT AND MANAGEMENT | 84 | 95 | 13% |
| RESEARCH & RELATED ACTIVITIES | $1,453 | $1603 | 10% |

Chart 12: U.S. Antarctic Program

Scientific research continues to be the principal expression of U.S. national interest and policy in Antarctia.

# U.S. ANTARCTIC PROGRAM
## FY 1989

- o Increases from $125 M in FY88 to $141 M
- o Research program strengthened
- o Continue with acquisition of ice—breaking research ship
- o LC—130 refurbishment program continues
- o Science enhancement at McMurdo

Charts 14&15: Science and Engineering Education

With the FY 1989 budget request, NSF funding for precollege education will have increased tenfold since FY 1983 (Chart 15). We estimate that in FY 1989 NSF will support over 12,000 pre-college teachers and high school students in programs designed to increase their ability to teach and learn science and mathematics. This emphasis on pre-college education addresses the growing awareness that America is not competitive in the areas of primary and secondary school science and mathematics training.

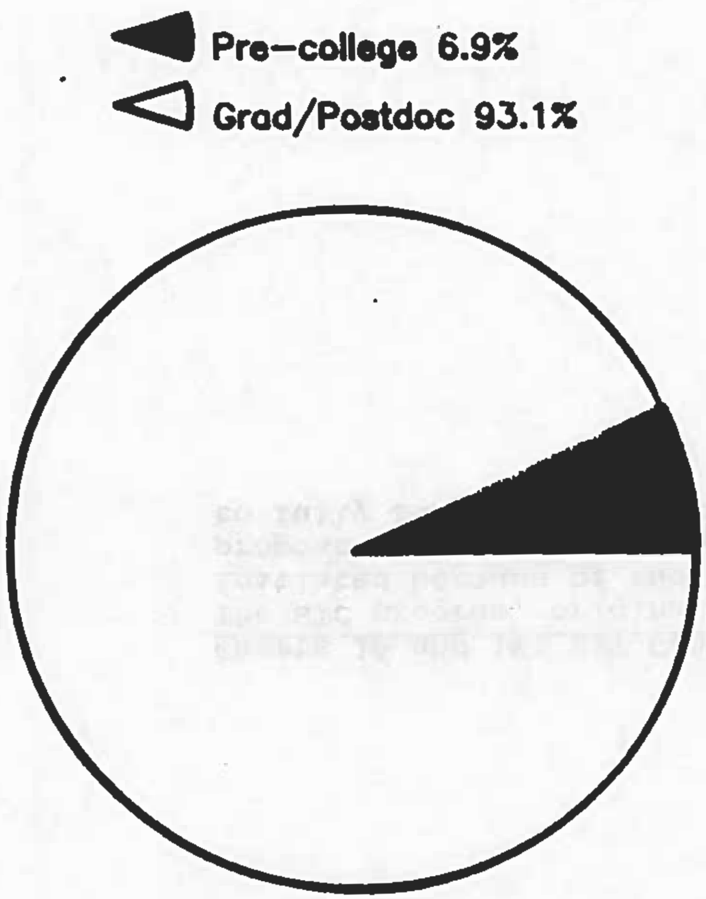
# SCIENCE AND ENGINEERING EDUCATION
## (FY 1989)

- Increases from $139 million to $156 million
- Summary by level:

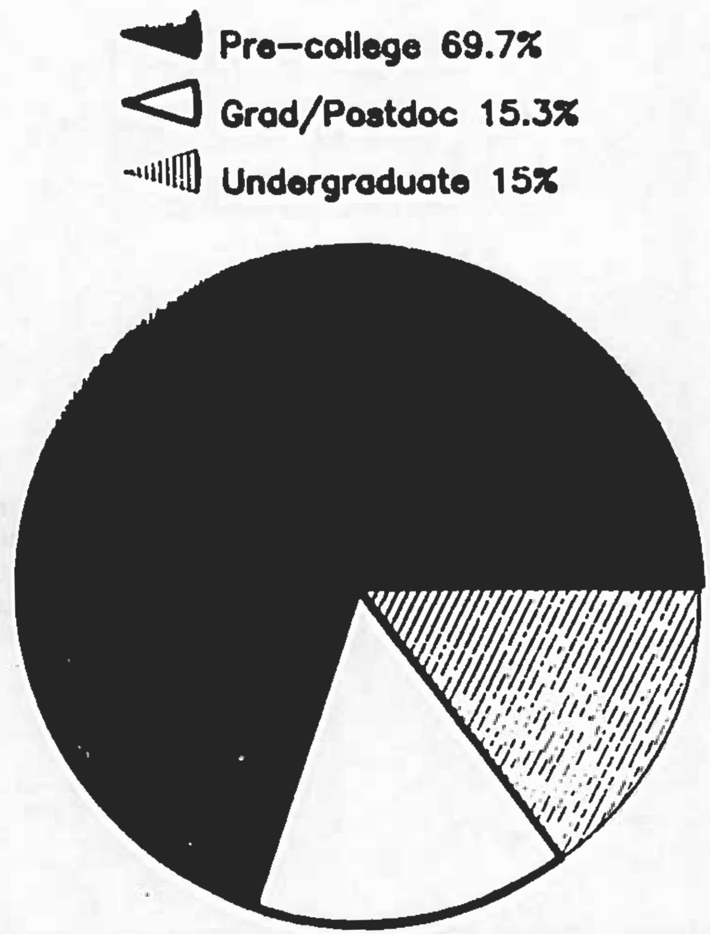
| | |
|---|---|
| Precollege | $108 M |
| Undergraduate | 24 M |
| Graduate | 24 M |

- 100 Additional New Graduate Fellows (Increased from 760 to 860)
- Double support for Comprehensive Regional Centers for Minorities
- Instructional Materials for Middle School Mathematics

# SCIENCE AND ENGINEERING EDUCATION SUPPORT BY EDUCATIONAL LEVEL FY 1983 – FY 1989




FY 1983 (TOTAL = $16.09 MILLION)




FY 1989 (TOTAL = [illegible])

__Charts 15 and 16: S&T Centers__
The STC program, originally proposed for FY 1988 funding, was not initiated because of the severely constrained appropriation. We propose a new appropriation in FY 1989 of $150 million for STCs, to fully fund 12 to 15 centers for up to five years.

# S&T CENTERS
## FY 1989

- New $150 Million Appropriation in FY 1989
- Up–front, fully funded Centers
- Slow outlay pattern
- Initiate 12 to 15 centers in FY 1989
- Projected award size: $1–5M per year for up to 5 years
- Merit review
- Topics not targeted by NSF in advance

# S & T CENTER PROPOSAL STATISTICS

Receipt Date: January 15, 1988

Proposals Received: 325

Number of Institutions: 122

Number of States: 42

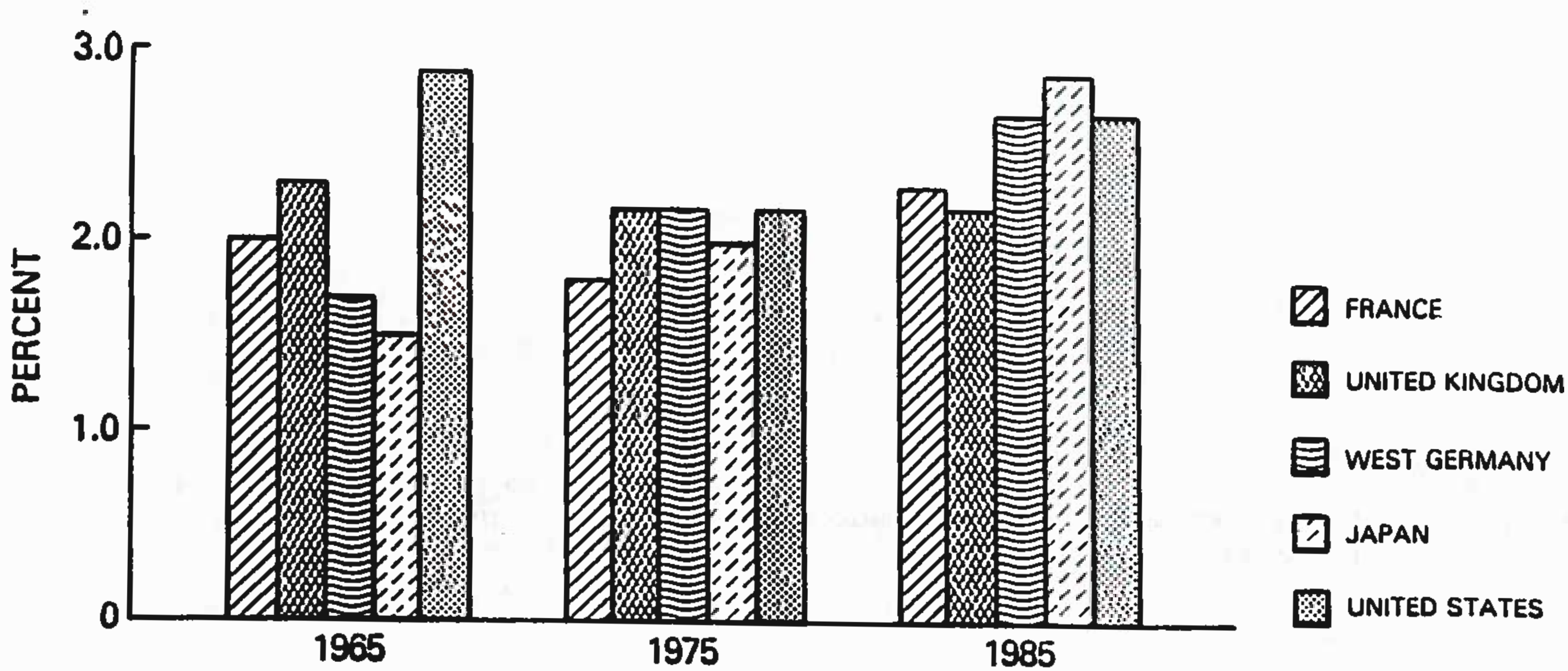
Total Requested: $4.1 Billion (for 5 years)

Average Total Request: $12.6 Million

First Year Average Request: $2.4 Million

CHART 18: In constant dollars, U.S. R&D spending rose 65% between 1970 and 1986. But in the same period German spending doubled and Japanese spending tripled.

## R&D EXPENDITURES AS A PERCENT OF GNP FOR SELECTED COUNTRIES: 1965, 1975, AND 1985




SOURCE: NATIONAL SCIENCE FOUNDATION.

# The National Science Foundation
# "Advanced Scientific Computing and Networking"

presented by

Dr. Charles Brownstein, Assistant Director
Directorate for Computer and Information
Science and Engineering

# NATIONAL SCIENCE FOUNDATION SUPERCOMPUTER AND NETWORKING ACTIVITIES: OVERVIEW

DR. CHARLES N. BROWNSTEIN

ACTING ASSISTANT DIRECTOR,
COMPUTER AND INFORMATION
SCIENCE AND ENGINEERING
NATIONAL SCIENCE FOUNDATION

NATIONAL GOVERNOR'S ASSOCIATION
WORKING GROUP ON STATE INITIATIVES
IN APPLIED RESEARCH

APRIL 29,1988
WASHINGTON D.C.

# NSF SUPERCOMPUTING AND NETWORKING ACTIVITIES

- **NATIONAL SUPERCOMPUTER CENTERS**

  JVNC (PRINCETON)
  CNSF (CORNELL)
  PSC (PITTSBURGH)
  SDSC (SAN DIEGO)
  NCSA (ILLINOIS)

- **NSFNET**

  NSFNET BACKBONE (MERIT) AND INTERNET

# SUPERCOMPUTER CENTERS/ NSFNET

- Multi-Institutional Partnerships

  (Federal/State/Industry/University)

- Services to Researchers

- Multiple Goals, Motivations, Needs, Resources

- Matrix of Relationships Shapes Policy, Action, Outcomes

# HISTORY:

## Phase I - FY84-87

**Goal -** Access to Supercomputers for NSF Grantees through PDs

**Method -** NSF bought blocks from Boeing, Minn., Purdue, Bell, CSU, Digital Prod.

**Result -** 932 Projects, 21K CPU hours

**Cost -** $23M

# CURRENT EVENTS:

## Phase II - FY85-90

Goals - Continue Access and Impact Science
Train/Educate
Stimulate US Computer Industry

Methods - Establish dedicated Centers (5)
Highly leveraged
Leading edge machines
National Network
Open to all researchers
Encourage: Innovation,
Parallelism, Tools,
Industry/University
collaboration,
Multi-disciplinary research

Results - About 150K CPU hours/year
6000 researchers on 2000 projects
3000 trained
1000 papers and growing
Growth in high-end academic
computing

Cost - $40-50M/year (NSF alone)

# National Supercomputer Centers

## Affiliated Institutions

| SDSC | NCSA | CNSF | PSC | JvNC |
|---|---|---|---|---|
| Agouron Inst. | Clemson | CUNY | CMU | Brown |
| Cal Tech | CSU | Clarkson | Case Western | Columbia |
| NCAO | Gallaudet | Duke | Drexel | Harvard |
| Scripps | GWU | Johns Hopkins | Duke, | Inst. for Adv. Study |
| Salk Inst | Georgia Tech | Lousiana St. | Florida | MIT |
| San Diego St. | Harvard | NYU | Georgia Tech | NYU |
| Stanford | IIT | N. Carolina St. | Johns Hopkins | Penn State |
| Hawaii | Indiana | Northwestern | Lehigh | Princeton |
| Maryland | New Mexico St. | Penn St. | Maryland | Rutgers |
| Michigan | NYU | RPI | Michigan | Arizona |
| USC | N. Dakota St. | Rockefeller U. | Michigan St. | Colorado |
| Utah | Northwestern | SUNY | N. Carolina St. | Penn |
| Washington | Notre Dame | Syracuse | Northwestern | Rochester |
| Wisconsin | Oklahoma St. | Texas A&M | Ohio St. | NJ Inst. of Tech. |
| U. Calif.(9 campuses) | Oregon St. | UCLA | Penn | Stevens Inst. of Tech. |
| Sw Fisheries Ctr | Penn St. | Delaware | Penn St. | Med. & Den. of NJ |
| | SIU | Florida | Pittsburgh | |
| | Stanford | Illinois | Rochester | |
| | Vanderbilt | Massachusetts | Temple | |
| | Alaska | Nebraska | N. Carolina | |
| | Arkansas | N. Carolina | Tennessee | |
| | U. Calif. | Rochester | Virginia | |
| | Chicago | Tennessee | Washington U. | |
| | Colorado | Virginia Poly. | W. Virginia | |
| | Delaware | Washington St. | Wisconsin | |
| | ⋮ | | Yale | |

# ALLOCATIONS

- o Open to all researchers, NSF and others
- o Serves the national research community, with no set-aside for local researchers
- o All allocations are done at the five NSF centers, not at NSF
- o Panels of scientists from many disciplines make decisions
- o Research institutions can request block time for small start-up research or education/training purposes

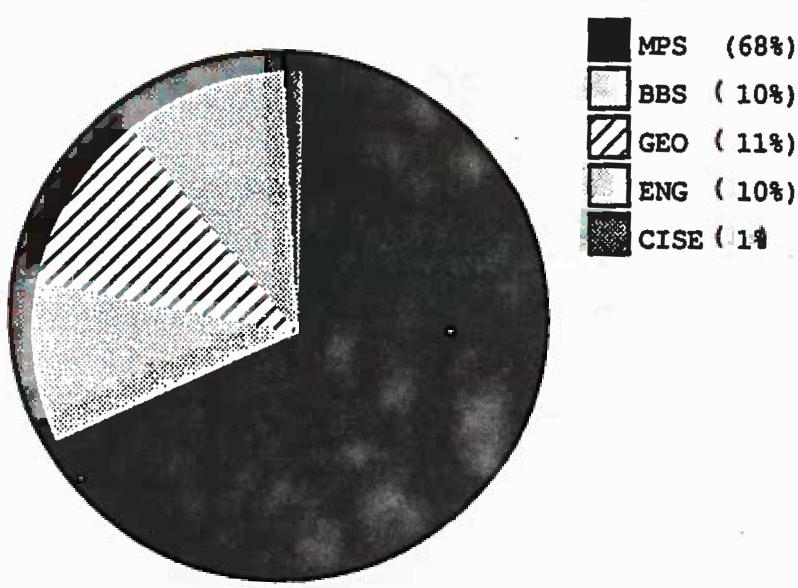
# OVERVIEW AND STATUS OF SUPERCOMPUTING CENTERS

Five National Centers
Fully Operational and Utilized

Since 1986:

- 6000 accounts authorized
- 2000 projects completed
- 105 training sessions (2743 participants)
- 107 research workshops (2831 participants)
- 677 attributed published research papers

Disciplinary Distributions of Use (by NSF Directorate)



# TRAINING AND EDUCATION

TRAINING AT CENTERS

- 2-3 DAY BEGINNER COURSES
- SPECIALIZED COURSES - GRAPHICS, WORK-STATIONS, NETWORKS, ETC.
- OFF-SITE AT ACADEMIC AFFILIATES, CON-SORTIUM MEMBERS
- ON-LINE TRAINING
- TO DATE, OVER 100 OF THESE COURSES TRAINING NEARLY 3000 RESEARCHERS

# SUPERCOMPUTER SUMMER INSTITUTES

INSTITUTES IN FY85 (3), FY86 (6), FY87 (8), NSF AND OTHER AGENCIES HAVE FUNDED ~$1.5M

COMPETITIVE SOLICITATION

AWARDS TO NATIONAL CENTERS AND OTHERS

2 WEEK INTENSIVE TRAINING/EDUCATION FOR YOUNG RESEARCHERS

RAISING OF AWARENESS

600 ATTENDEES TO DATE

STUDENT TRAVEL/PERDIEM PAID BY NSF

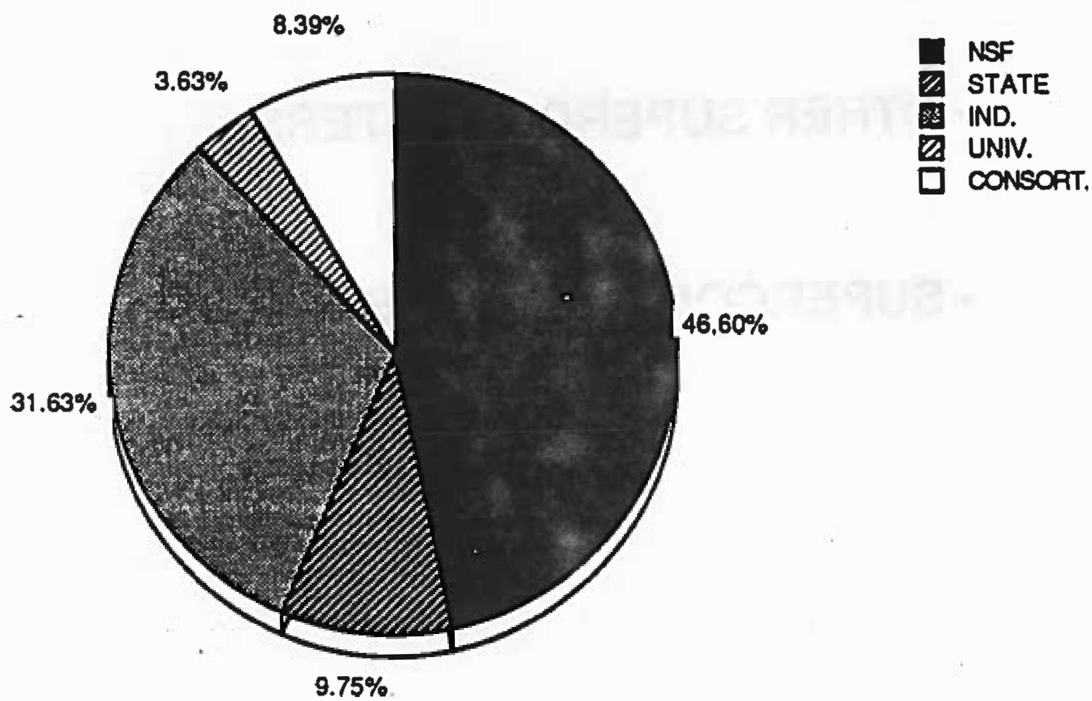
EMPHASES

- SCIENCE/ENGINEERING APPLICATIONS
- PARALLEL AND VECTOR TECHNIQUES
- LIBRARIES
- GRAPHICS
- NETWORKING

EACH STUDENT RECEIVES ADEQUATE SUPER-COMPUTER TIME TO FINISH A PROJECT. MOST BRING WORKING FORTRAN CODES FOR CONVERSION AND OPTIMIZATION.

# SUPERCOMPUTER CENTER COST SHARING

## (% OF TOTAL OF $88.2M IN FY 1988)



# SUPERCOMPUTING ISSUES

- ASSESSMENT
- UPGRADES (CHOICE/COST)
- NEW GENERATION MINI-SUPERS
- OTHER SUPERCOMPUTERS
- SUPERCOMPUTER RESEARCH

# OVERVIEW AND STATUS OF SUPERCOMPUTING PROGRAM

## General Directions

- Maintain NSF Centers
- Make up deferred acquisitions in FY 1989
- Begin upgrades in FY 1990
- Improve program balance
    - increase research on computational methods
    - support use of new technologies
- focus on highest capability
- focus on greatest research needs

# OVERVIEW AND STATUS OF NETWORKING PROGRAM

## PROGRAM GOALS

- BROADEN ACCESS TO RESEARCH RESOURCES
  (Initially Supercomputer Centers, now
  to unique computing and data resources,
  other researchers)

- BROADEN ACCESS TO TEACHING RESOURCES

- INCREASE EFFICIENCY OF FEDERAL RESEARCH NETS

- ADVANCE STATE-OF-ART OF NETWORK TECHNOLOGY

- ADVANCE STATE-OF-ART OF NETWORK APPLICATIONS AND SERVICES

# NETWORK COMPONENTS

- PEOPLE
- COMPUTERS
- SOFTWARE
- DATA RESOURCES/ INFORMATION
- LANS, CANS, RANS
- LINKS AND SUBNETS
- NATIONAL INTERNET BACKBONE
- INTERNATIONAL LINKS

# OVERVIEW AND STATUS OF NETWORKING PROGRAM

## NSF NET STRATEGY

- PROVIDE RESEARCH SERVICES
  (Using professional manager)
- CONDUCT ADVANCED RESEARCH
- SHARE FEDERAL AGENCY RESOURCES
  (Promote Internet)
- ADVANCE STANDARDS
- LEAD AS PER FCCSET RECOMMENDATIONS

# OVERVIEW AND STATUS OF NETWORKING PROGRAM

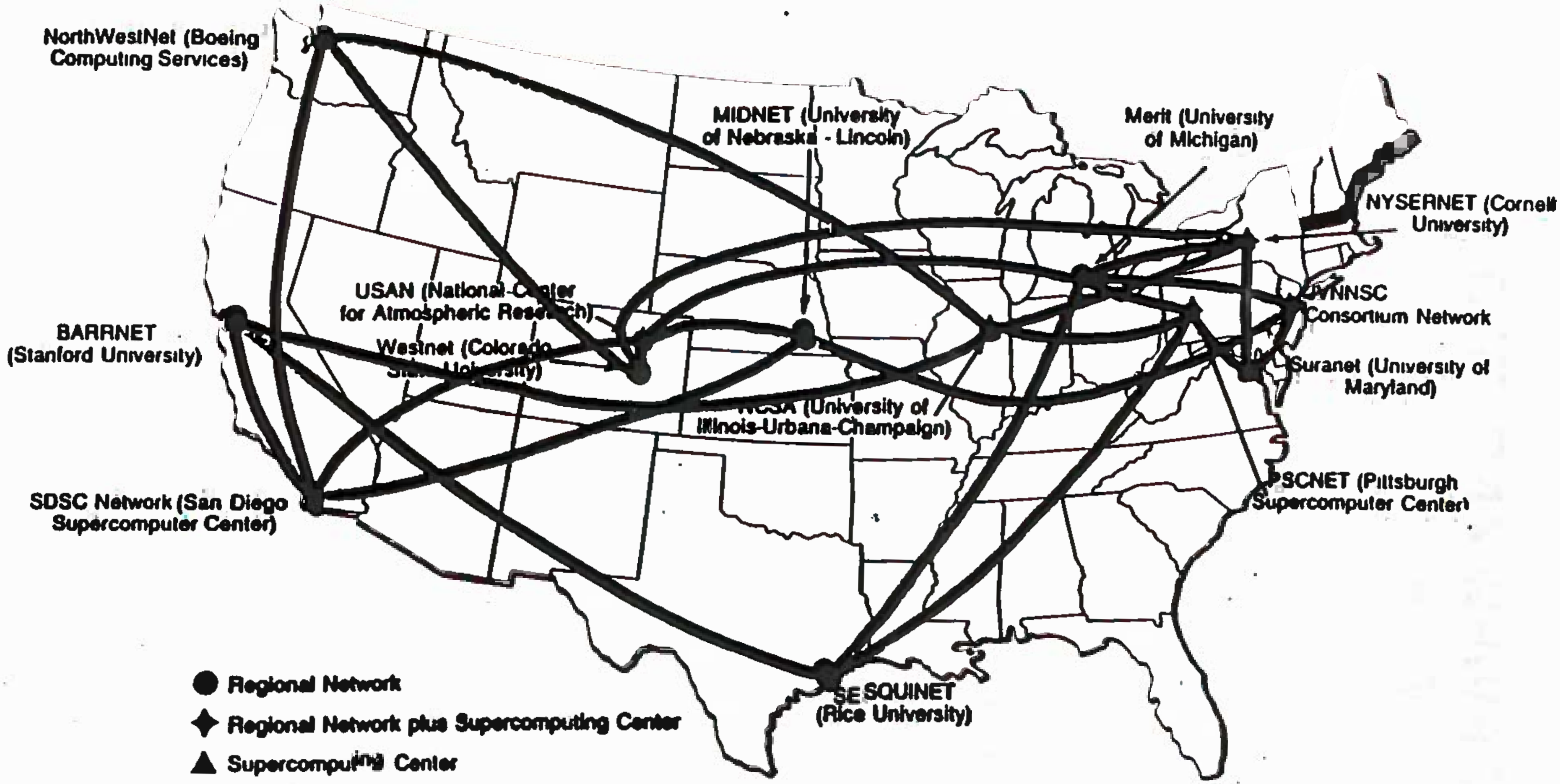
NSFNET ORGANIZATION

THREE-LEVEL HIERARCHY

- NSFNET BACKBONE
- SUPERCOMPUTER CONSORTIUM NETS,

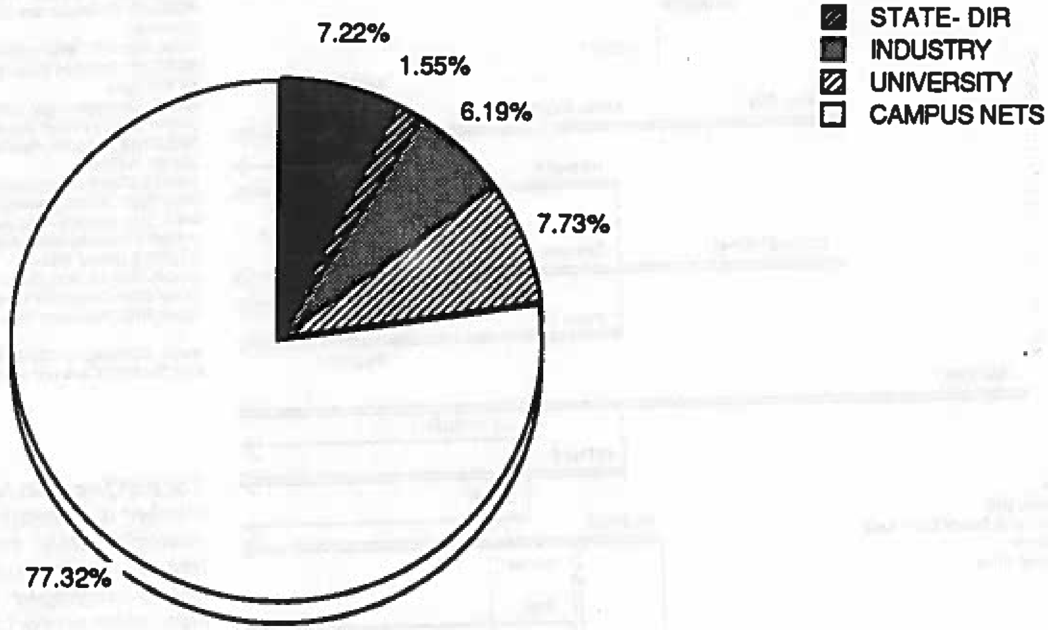
  REGIONAL, DISCIPLINE NETS
- CAMPUS NETS

# NSFNET

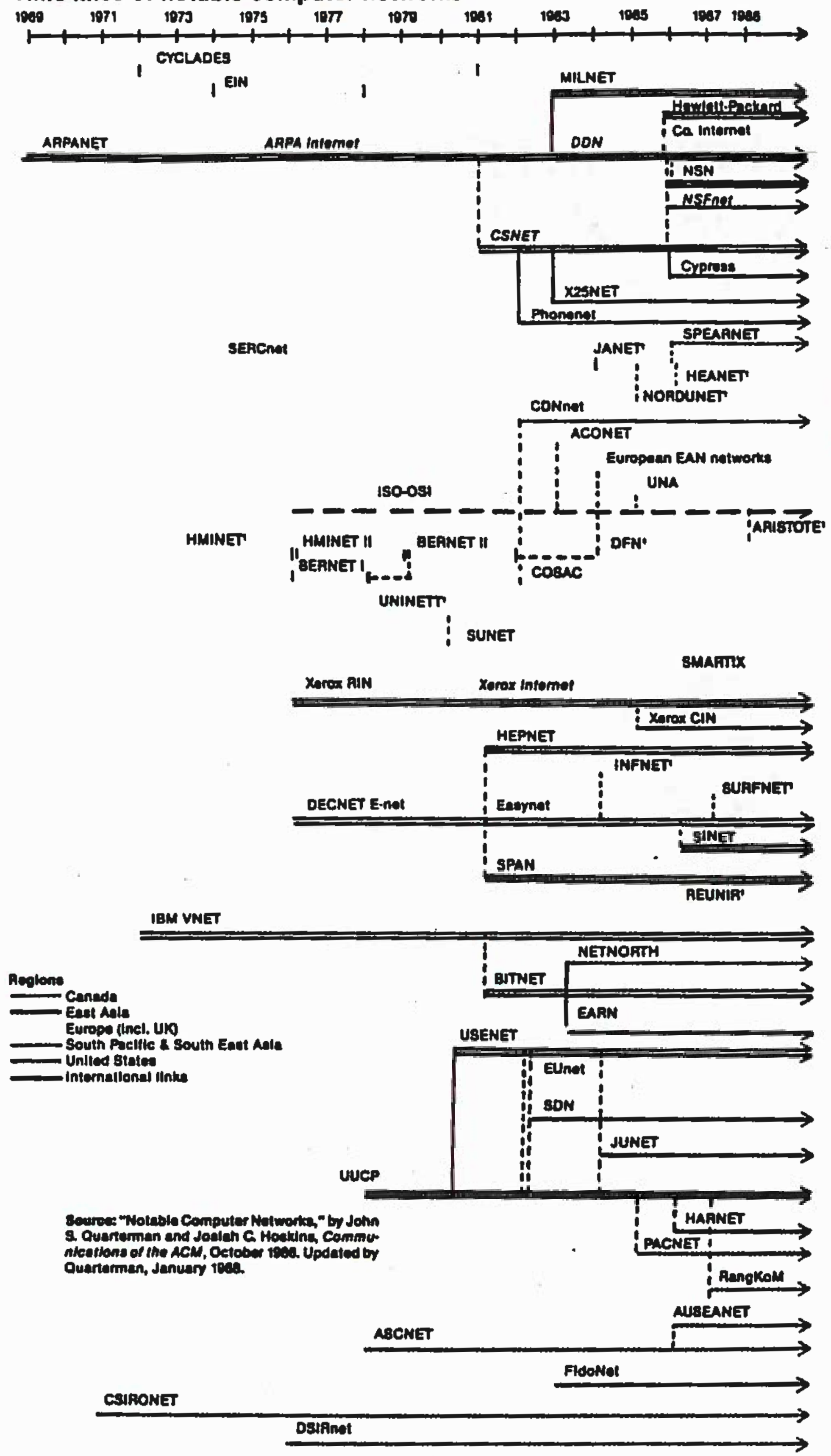

NorthWestNet (Boeing Computing Services)
MIDNET (University of Nebraska - Lincoln)
Merit (University of Michigan)
NYSERNET (Cornell University)
USAN (National Center for Atmospheric Research)
JVNNSC Consortium Network
BARRNET (Stanford University)
Westnet (Colorado State University)
Suranet (University of Maryland)
NCSA (University of Illinois-Urbana-Champaign)
SDSC Network (San Diego Supercomputer Center)
PSCNET (Pittsburgh Supercomputer Center)
SESQUINET (Rice University)
Regional Network
Regional Network plus Supercomputing Center
Supercomputing Center

# NSFNET/INTERNET COST SHARING

## (% OF TOTAL OF $ 97 M IN FY 1988)



## Time lines of notable computer networks




Source: "Notable Computer Networks," by John S. Quarterman and Josiah C. Hoskins, *Communications of the ACM*, October 1986. Updated by Quarterman, January 1988.

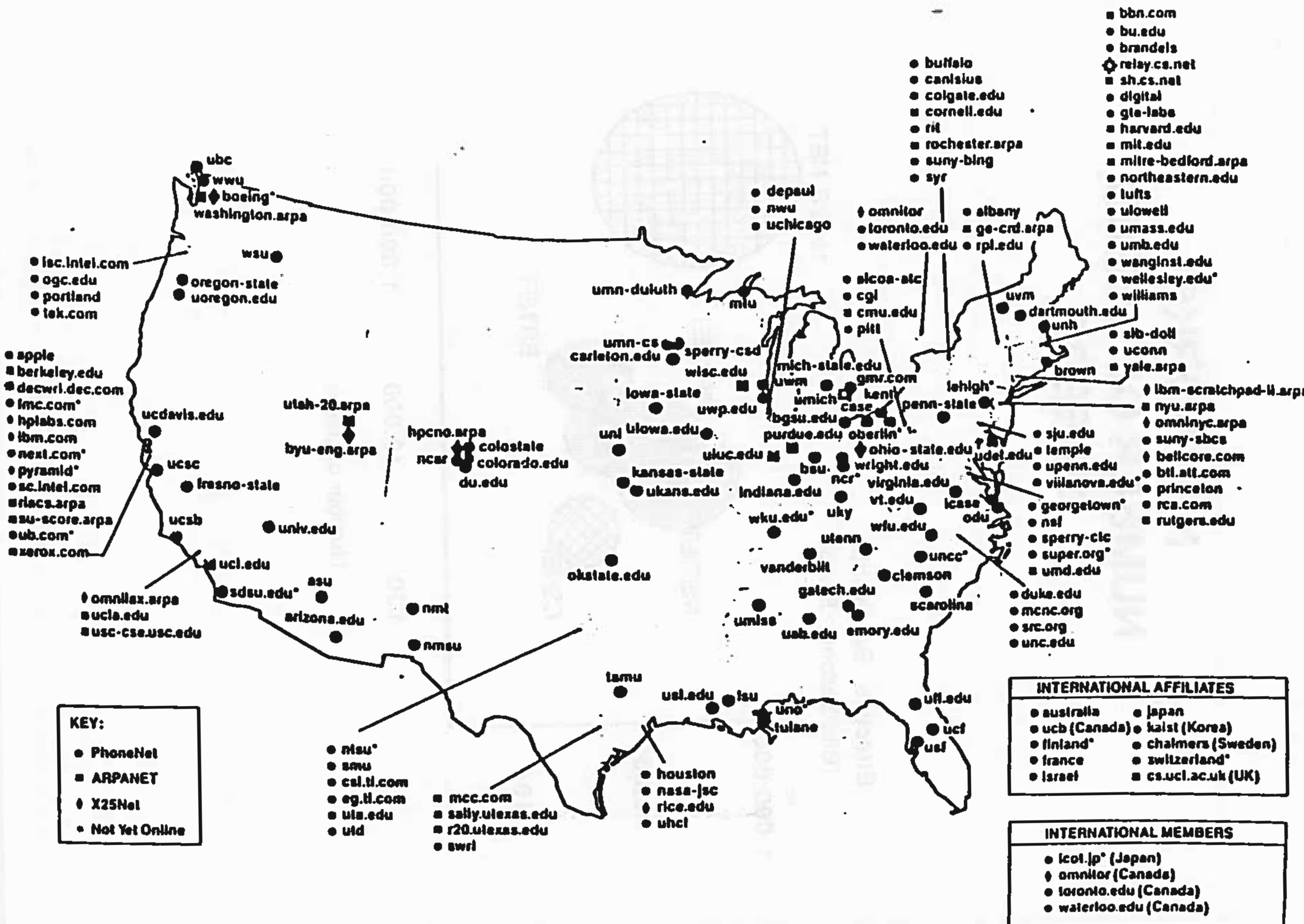
¹Participants in the Réseaux Associés pour la Recherche Européenne network (RARE)

**ACONET:** Akademisches Computer Netz
**ARISTOTE:** Association de Réseaux Informatiques en Système Totalement Ouvert et Très Elaboré
**ARPANET:** Advanced Research Projects Agency Network
**ASCNET:** Australian Computer Science Network
**AUSEANET:** Austroasian Network
**BERNET I, II:** Berlin Network
**BITNET:** Because It's Time Network
**COSAC:** Communications sans Connections
**CSIRONET:** Commonwealth Scientific & Industrial Research Organization Network
**CSNET:** Computer Science Network
**DDN:** Defense Data Network
**DECNET E-net:** DEC Engineering Network
**DFN:** Deutsche Forschungsnetz
**DSIRnet:** Government network in New Zealand
**EARN:** European Academic Research Network
**EIN:** European Informatics Network
**EUnet:** European Unix Network
**HARNET:** Hong Kong Academic & Research Network
**HEANET:** Higher Education Authority Network
**HEPNET:** High Energy Physics Network
**HMINET I, II:** Hahn-Meitner Institut
**IBM VNET:** Virtual Network
**INFNET:** Istituto Nazionale Fisica Nucleare
**ISO-OSI:** International Organization for Standardization–Open Systems Interconnect
**JANET:** Joint Academic Network
**JUNET:** Japanese Unix Network
**MILNET:** Military Network
**NORDUNET:** Nordic University Network
**NSFnet:** National Science Foundation Network
**NSN:** NASA Science Network
**PACNET:** Pacific Network
**RangKoM:** Rangkaian Komputer Malaysia
**REUNIR:** Réseaux des Universités et de la Recherche
**SDN:** System Development Network
**SERCnet:** Science Engineering Research Council Network
**SINET:** Schlumberger Information Network
**SPAN:** Space Physics Analysis Network
**SPEARNET:** South Pacific Education and Research Network
**SUNET:** Swedish University Network
**SURFNET:** Dutch university network
**UNA:** Universitäts-Netz Austria
**UNINETT:** Nordic university network
**USENET:** Users' Network
**UUCP:** Unix to Unix Copy
**Xerox CIN:** Corporate Internet
**Xerox RIN:** Research Internet

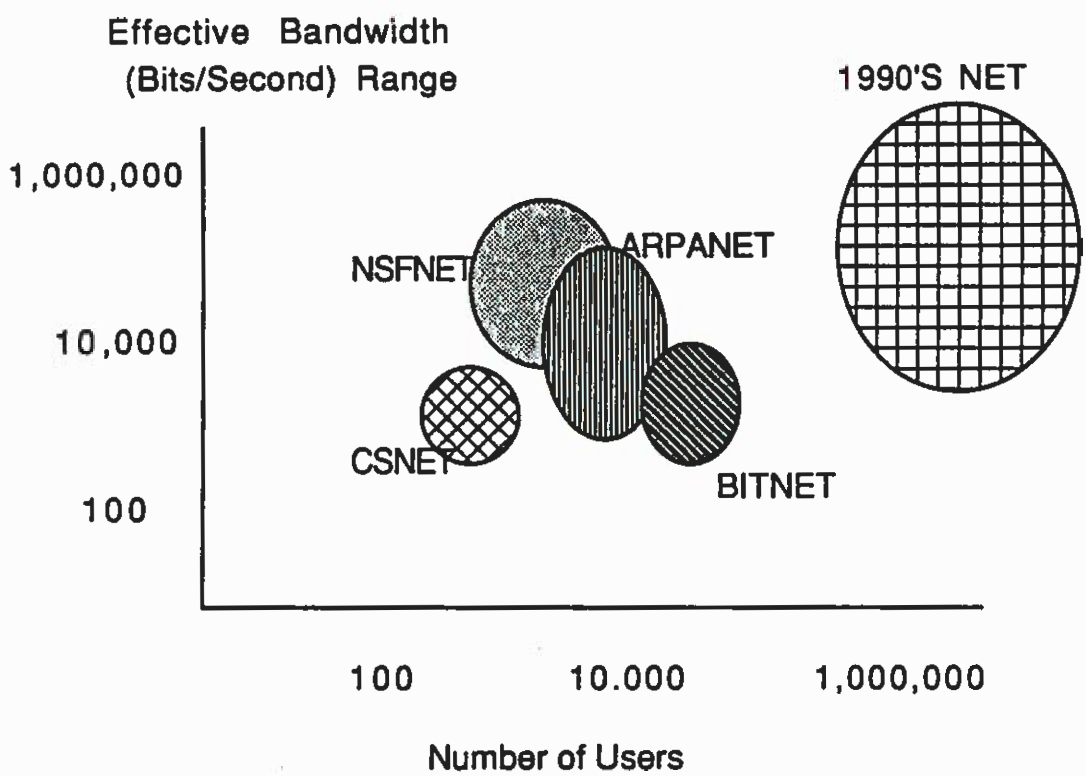
Note: CDNnet, CYCLADES, EAN, NETNORTH, and SMARTIX are not acronyms.

*The past five years have seen the number of networks soar dramatically. Many initially used transmission protocols and technology developed by one or more older networks; these are indicated by the vertical dashed lines connecting networks. (More recently, some networks have begun to use other protocols, particularly ISO-OSI and Arpanet standards.) Solid vertical lines between networks indicate systems under closely related administrations. Dashed horizontal lines indicate protocols or demonstration systems, rather than operational networks. Networks in italics are internets—several networks tied together that use the same transmission protocols.*

# CSNET Geographic Map, July 15, 1986



# NETWORKS, NUMBER OF USERS, SPEEDS



# A RESEARCH AND DEVELOPMENT STRATEGY FOR HIGH PERFORMANCE COMPUTING

Executive Office of the President
Office of Science and Technology Policy
November 20, 1987

# NATIONAL RESEARCH NETWORK

| | |
|---|---|
| Stage 1 | Expand interagency collaboration; interconnect networks; upgrade to 1.5 mb/s |
| Stage 2 | Expand (interagency) network; 45 mb/s trunking; 1.5 mb/s to 200-300 institutions |
| Stage 3 | 1-3 gb/s trunking; 1.5-45 mb/s to 1000 institutions |

# CURRENT ACTIVITY: NETWORKING

NATIONAL RESEARCH INTERNET
ACCEPTED

NSF IS LEAD AGENCY
- AGREEMENTS AMONG
  NSF, DARPA, DOE, NASA

"FRICC" CREATED AND OPERATING

"PHASE 1 BEING ACCOMPLISHED FROM
FY 1988 RESOURCES

ADVANCED "T-3" (45 MB) BACKBONE
PLANNED AND STARTED VIA
DARPA/DOE/NASA SUPPORT TO NSF

HIGH SPEED NET RESEARCH
- BEGUN BY NSF/ARPA/INDUSTRY

# MORE CURRENT ACTIVITY: NETWORKING

"GIGABIT" NET ADVISORY COMMITTEE ESTABLISHED BY DARPA

"POLICY BASED ROUTING" ISSUE IDENTIFIED

UNIFORM NET SERVICES WORKING GROUP ESTABLISHED BY NSF

ARPANET/NSFNET "RATIONALIZATION" INITIATED

FY 89, 90 BUDGET COORDINATION

INTERNATIONAL POLICY DEVELOPING

TRANSITION TO COMMERCIAL NET OPERATION ESTABLISHED AS GOAL

# The National Science Foundation
# "Efforts in Science and Technology Education"

presented by

Dr. Bassam Shakhashiri
Assistant Director for Science and
Engineering Education

NATIONAL SCIENCE FOUNDATION

news

Elizabeth Tait
Office: (202) 357-9498
Home: (703) 527-6938

FOR RELEASE:
February 29, 1988
NSF PR 88-11

# INTERNATIONAL SURVEY GIVES U.S. A FAILING GRADE IN SCIENCE EDUCATION

Students at the 5th, 9th, and 12th grade levels in the U.S. perform poorly in science subjects compared to their counterparts around the world, according to the results of an international science achievement survey reported today by the National Science Foundation (NSF).

"For a technologically advanced country, it would appear that [in the United States] a reexamination of how science is presented and studied is required," concludes the preliminary report of the Second International Science Study, conducted by the International Association for the Evaluation of Educational Achievement (IEA), an association of research centers.

U.S. fifth grade students ranked 8th among 15 countries. At the 9th grade level, U.S. students placed 15th in a field of 17 nations, with only Hong Kong reporting poorer performance. Among high school seniors pursuing a second year of study in biology, those considered to be "advanced placement" students and science specialists, the U.S. placed last with an average mean score of 37.9 percent. Advanced chemistry students in the

-more-

U.S. placed 11th out of 13 countries. Second-year American physics students ranked 9th of 13 countries.

"These findings emphasize again the troubled state of science education in the United States. We need a continual flow of talented and well educated people in order to maintain and improve the strength of the U.S. scientific and technological workforce," commented NSF Director Erich Bloch. "The critical question is whether we will be able to provide the high quality science and engineering personnel essential to meet the challenge of both our own domestic needs and those of the international marketplace.

"America's future as a world technological and economic leader and the quality of life we enjoy depend on confronting the real problems in science education with vigor, determination and a sense of urgency."

During the period 1983 to 1986, international tests based on science curriculum studies in each participating nation were administered to some 204,308 students at 7581 schools in 24 countries. The report released today contains preliminary results for the 17 countries for which data is now available: Australia, Canada, England, Finland, Hong Kong, Hungary, Italy, Japan, Korea, the Netherlands, Norway, the Philippines, Poland, Singapore, Sweden, Thailand, and the United States.

Three academic levels were selected for testing within each educational system: near the end of primary school, around the age of 10 years, typically grades four or five; the point in secondary school when education in most systems is still full-time and compulsory, 14-year-olds, or grades 8 and 9; and the terminal year of secondary school, 12th grade. These are the same populations sampled in the first IEA science achievement survey of 19 countries in 1970.

Among 10-year-olds, students in Japan, Korea, and Finland were the top performers with mean scores of 15.4 and 15.3 out of a possible 24 correct answers to test items. Singapore, Hong Kong, and the Philippines are at the bottom of the scale, and the U.S. is in the middle with a mean score of 13.2.

At the intermediate level, Hungarian, Japanese, and Dutch 9th graders demonstrated the highest achievement, correctly answering 19.8 to 21.7 out of 30 questions. American 14-year-olds ranked third to the last with 16.5 items correct, ahead of Hong Kong and the Philippines. In Thailand, whose score equalled that of the U.S., only 32 percent of this age group is in school, as opposed to 100 percent in the United States.

The bottom 25 percent of the fourteen-year-olds performed particularly badly in England, Hong Kong, italy, Singapore, and the U.S. The lowest-scoring children were scoring at chance level, indicating that, from the test's point of view, they were scientifically illiterate, according to the report.

The United States did not administer a test to high school seniors not taking science in conjunction with this study, so only data on biology, chemistry, and physics specialists is available for international comparison. In general, Hong Kong, England, and Singapore, where advanced secondary students may be studying only mathematics and science, were the highest scoring nations at the 12th grade level. Canada, Italy, Finland, and the U.S. recorded the lowest marks overall.

"The data paint a dismal picture of science education in the United States today. But American children have just as much native curiosity and capacity for learning about science as children in any nation," said Bassam Z. Shakhashiri, NSF Assistant Director for Science and Engineering Education.

"We must develop quickly the national will to improve the effectiveness of science education in American schools. All segments of our society must work together to nurture our children's curiosity and to provide for them teachers, materials, and surroundings that help them to learn science. The NSF is supporting the development of new curriculum materials for students in grades K-12, and the training of elementary school teachers is a high priority also in our efforts to improve science education."

The survey measured also the differences in science achievement between the sexes. In grades five and nine, in all countries reporting, boys had higher scores than girls. In Grade 12, in biology, chemistry, and physics, boys performed better than girls except in biology in Australia, Hong Kong (Form 7 level), and Sweden. In the U.S., the higher the grade level, the greater the discrepancy between boys and girls. Female students who were taught science by female teachers did not perform better than those taught by male teachers.

The report of the the Second IEA Science Study released today is an interim presentation of some selected international achievement score results intended to provide initial information from cross-national comparisons. Three comprehensive reports will be published in 1989. The first will concern science education and curriculum in 24 countries. The second will present basic descriptive statistics and explanatory analyses of between and within country differences in science education achievement in the 24 countries. The third will compare science education and achievement in the ten countries which participated in the IEA science studies in 1970 and 1983-1986.

Each participating school system collaborated in the research, and each was responsible for its own funding, data colection, data analysis, and preparation of national reports. Funding of approximately $1.25 million was provided by NSF. Additional international support came from the Japanese Shipbuilding Industry Foundation, the Center for Statistics of the U.S. Department of Education Office of Educational Research and Improvement, the Bank of Sweden Tercentenary Fund, and the Swedish National Board of Education.

The Australian Council for Educational Research in Melbourne serves as the international coordinating center for the study. Subsequent data processing and analyses are being undertaken at the Institute of International Education at the University of Stockholm and at the Institute of Comparative Education of the University of Hamburg.

Single copies of the report are available from the Office of Studies and Program Assessment, National Science Foundation, 1800 G Street, N.W., Washington, D.C., 20550. Telephone (202) 357-7425.

The U.S. coordinators are both at Teachers College, Columbia University: Richard N. Wolf, (212) 678-3355, and Willard Jacobson, (212) 678-3382.

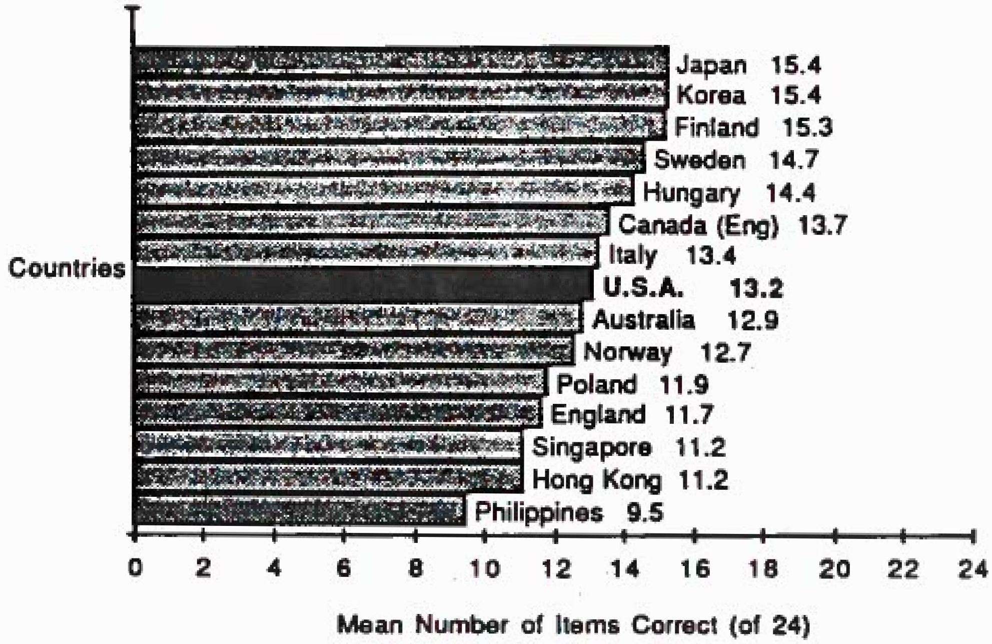
-end-

[Graphs and charts follow]

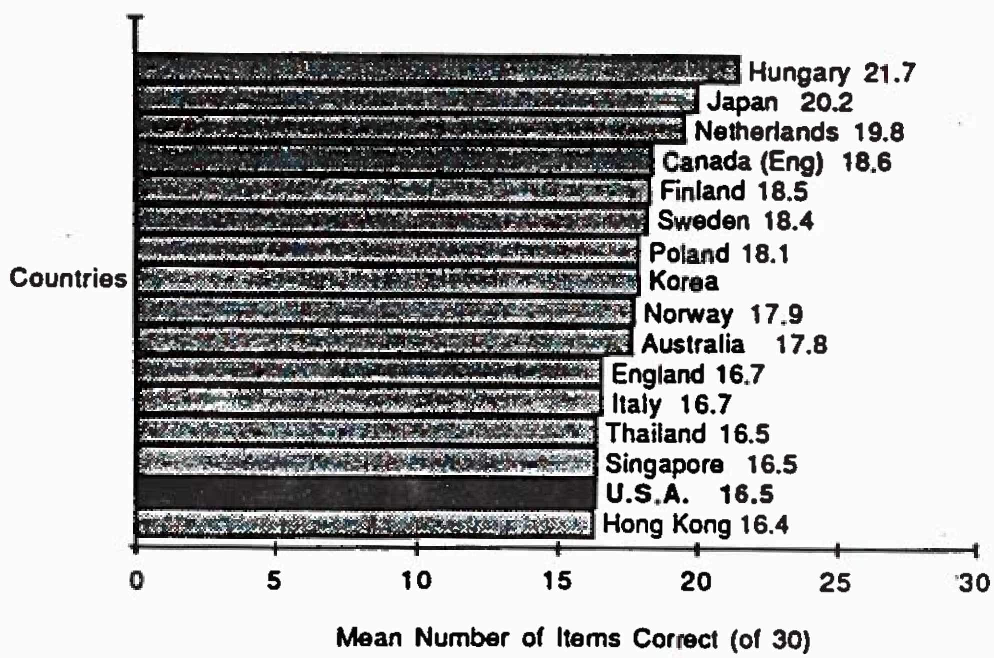
RANK ORDER OF NATIONS FOR EACH POPULATION LEVEL

| | 10 yr. olds Grade 4/5 | 14 yr. olds Grade 8/9 | Grade 12/13 Bio. | Chem. | Phys. | Non Science Students |
|---|---|---|---|---|---|---|
| Australia | 9 | 10 | 9 | 6 | 8 | 4 |
| Canada (Eng) | 6 | 4 | 11 | 12 | 11 | 8 |
| England | 12 | 11 | 2 | 2 | 2 | 2 |
| Finland | 3 | 5 | 7 | 13 | 12 | - |
| Hong Kong | 13 | 16 | 5 | 1 | 1 | - |
| Hungary | 5 | 1 | 3 | 5 | 3 | 1 |
| Italy | 7 | 11 | 12 | 10 | 13 | 7 |
| Japan | 1 | 2 | 10 | 4 | 4 | 3 |
| Korea | 1 | 7 | - | - | - | - |
| Netherlands | - | 3 | - | - | - | - |
| Norway | 10 | 9 | 6 | 8 | 6 | 3 |
| Philippines | 15 | 17 | - | - | - | - |
| Poland | 11 | 7 | 4 | 7 | 7 | - |
| Singapore | 13 | 14 | 1 | 3 | 5 | 6 |
| Sweden | 4 | 6 | 8 | 9 | 10 | - |
| Thailand | - | 14 | - | - | - | - |
| U.S.A. | 8 | 14 | 13 | 11 | 9 | - |
| Total No. of Countries | 15 | 17 | 13 | 13 | 13 | 8 |

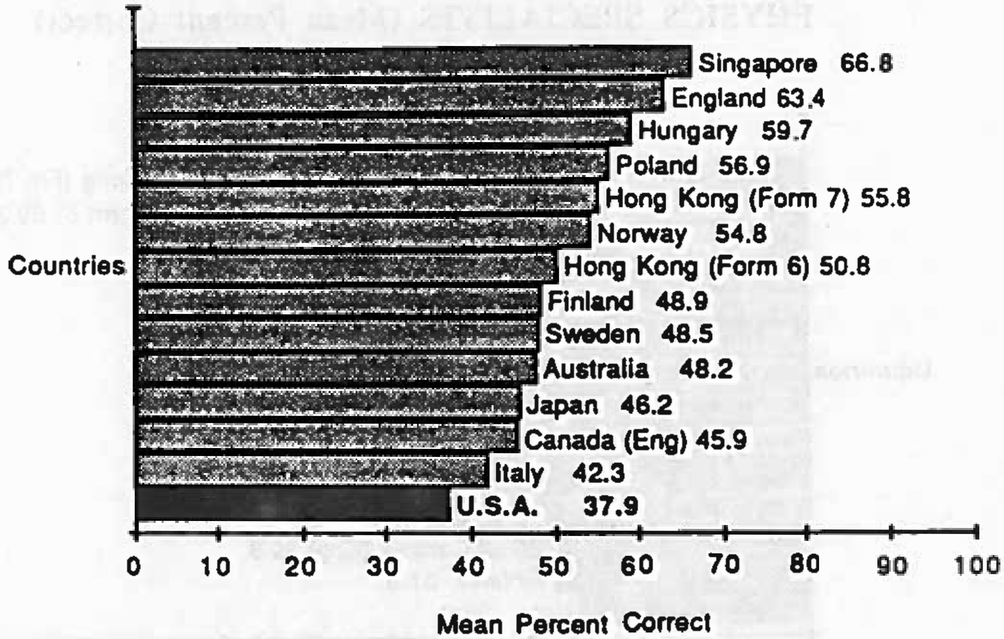
## Grade 5 Science Achievement in 15 Countries



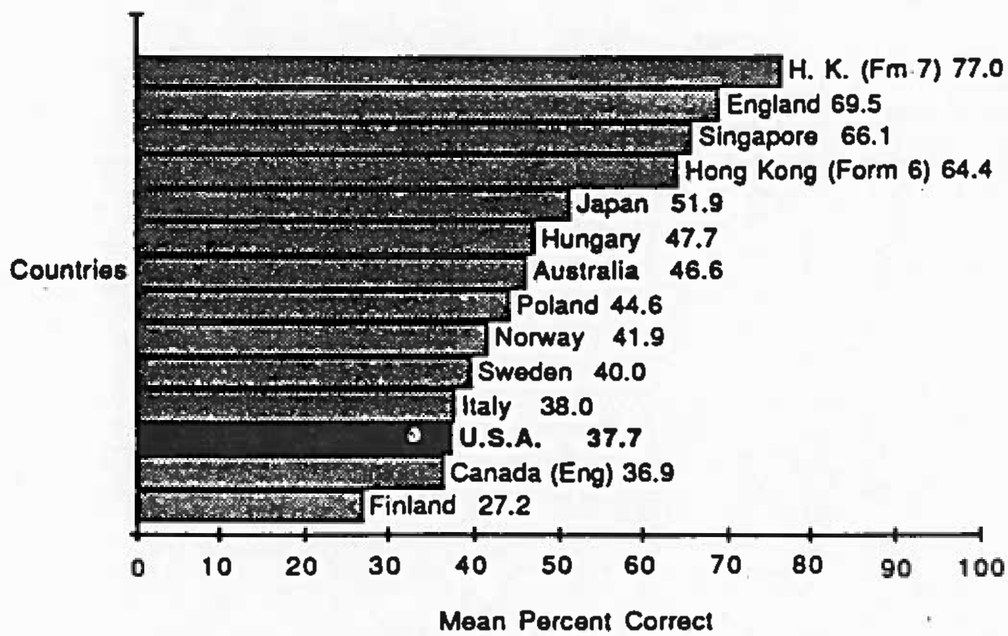

## Grade 9 Science Achievement in 16 Countries



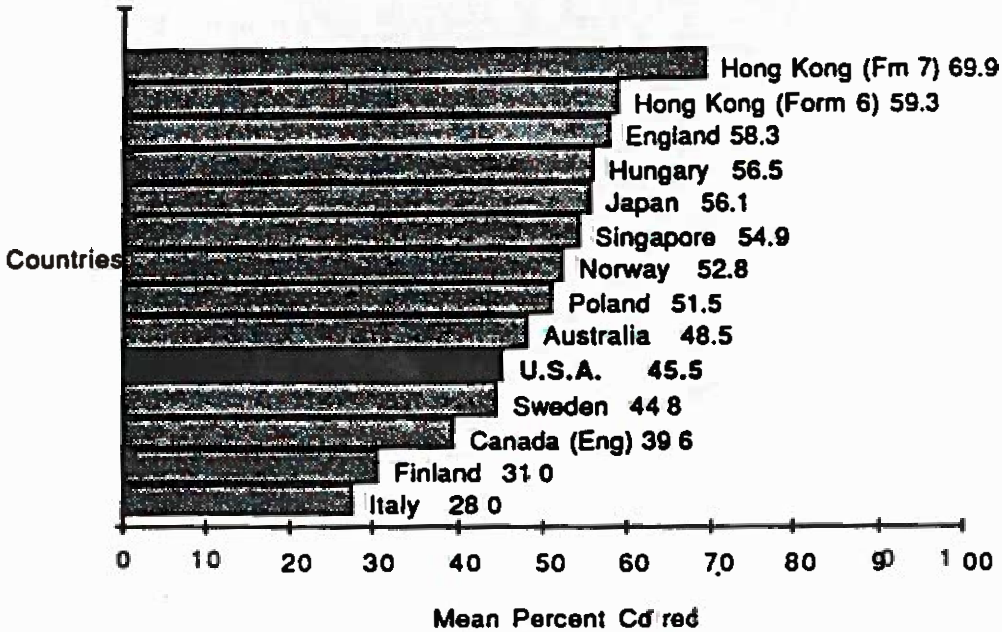
BIOLOGY SPECIALISTS (Mean Percent Correct)




CHEMISTRY SPECIALISTS (Mean Percent Correct)



PHYSICS SPECIALISTS (Mean Percent Correct)



# The National Science Foundation
# "State Science and Technology Program Data"

presented by

Ms. Margaret Grucza, Study Director
Government Studies Group
Division of Science Resources Studies

SCIENCE RESOURCES STUDIES HIGHLIGHTS

NATIONAL SCIENCE FOUNDATION WASHINGTON, D.C. 20550 FEBRUARY 19, 1988 NSF 88-303

# Real Increase in 1988 National R&D Funds Estimated at Lowest Rate in Eleven Years

## Highlights

• The Nation is expected to spend $132 billion on research and development in 1988, or 7 percent more than the amount estimated to have been spent in 1987. After adjusting for expected inflation, this represents a 3-percent increase,[1] the lowest rate of real research and development (R&D) growth since 1977.

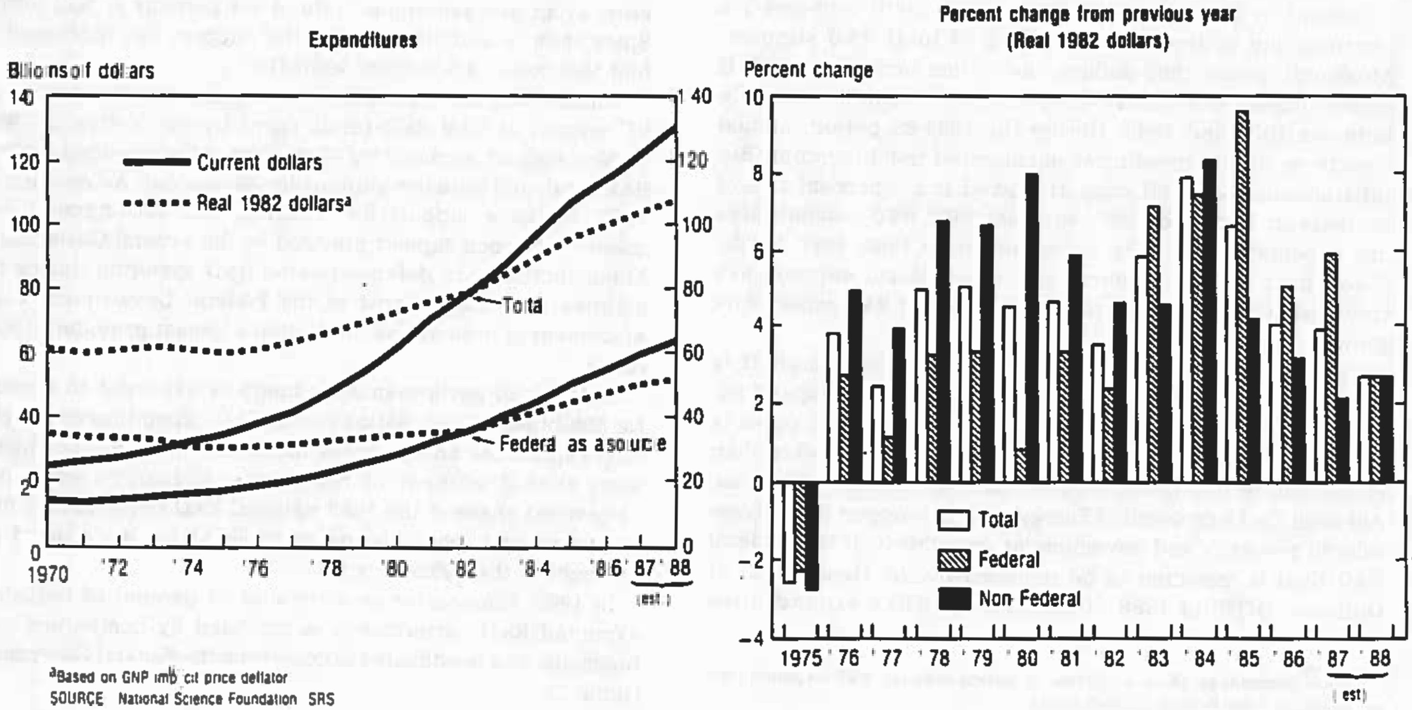
• Between 1977 and 1982, national R&D expenditures increased 4.5 percent annually in real-dollar terms. Between 1982 and 1985, real R&D growth increased to 6.8 percent annually, before slowing to 4 percent in both 1986 and 1987 (chart 1).

• It is expected that about 68 percent of the Nation's total R&D expenditures will be spent on development activities in 1988, a fraction that has increased gradually from a level of 64 percent in 1982. This shift toward development is primarily a result of major increases in Federal spending on defense R&D activities, which is about 90 percent development.

• The proportion of U.S. gross national product (GNP) spent on R&D activities is estimated at 2.7 percent for 1988; the ratio has remained relatively unchanged since 1985. Between 1978 and 1985, the U.S. R&D/GNP ratio increased from 2.1 percent to 2.7 percent. The U.S ratio will continue to exceed or approximate that of other market-oriented, industrialized

[1] The estimated 1987-88 growth in real R&D expenditures is based on an assumed 4-percent change in the GNP implicit price deflator as estimated by the Office of Management and Budget.

Chart 1. National R&D expenditures

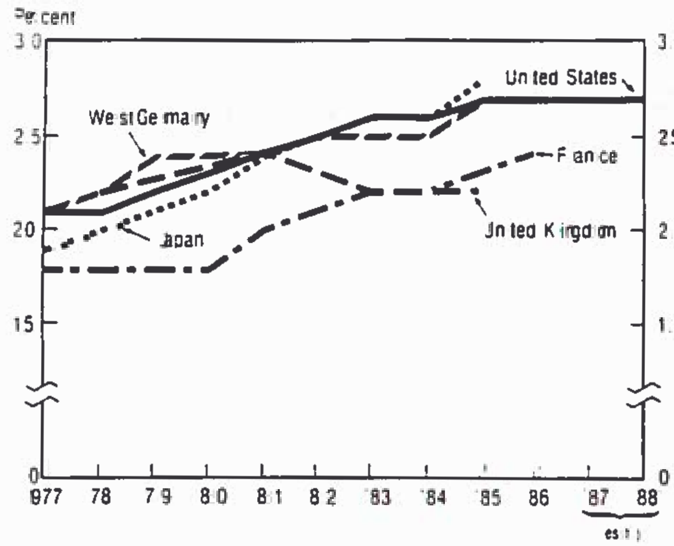



[a]Based on GNP implicit price deflator

SOURCE: National Science Foundation, SRS

Prepared in the Economic Analysis Studies Group, Division of Science Resources Studies nations (chart 2). If civilian (nondefense) R&D expenditures are compared to GNP, however, the U.S. ratio is substantially lower, and has stayed at 1.8 percent throughout the 1983-88 period. By comparison, according to the latest data available, the civilian R&D/GNP ratio for Japan was 2.8 percent in 1985 and 2.7 percent for West Germany in 1986.

**Chart 2. International R&D/GNP**




NOTE: Data for the United Kingdom are available only for 1978, 1981, 1983, and 1985.
SOURCES: National Science Foundation and Organisation for Economic Co-operation and Development

## National R&D Expenditure Trends

Although national R&D expenditures are expected to increase 7 percent in 1988 to $132 billion, this growth represents a continuation in the recent slowing of total R&D support. Measured in real 1982 dollars, the Nation increased its R&D expenditures at a steady 4.5-percent average annual rate between 1977 and 1982. During the 1982-85 period, annual growth in such expenditures accelerated to 6.8 percent. But inflation-adjusted R&D support slowed to a 4-percent rate of increase in 1986 and 1987, and real 1988 R&D expenditures are expected to be only 3 percent more than 1987 levels. Slackening in both Federal and non-Federal support has contributed to this 3-year slowing in national R&D-expenditure growth.

Since 1980, most of the gain in national R&D support is attributable to major increases in Federal defense spending. Approximately one-half of total U.S. R&D expenditures is provided by the Federal Government, and slightly more than 70 percent of this Federal R&D total is for defense activities. Although the Department of Energy provides support for defense-related research and development, two-thirds of the Federal R&D total is expected to be incurred by the Department of Defense (DOD) in 1988.[1] Increases in DOD's expenditures account for fully 90 percent of the estimated growth in Federal R&D support between 1980 and 1988.

DOD is expected to continue shifting its R&D emphasis from research to development. In 1980, development accounted for 83 percent of DOD's R&D support; in 1988, for an estimated 92 percent. When the funds of other agencies are included, the proportion of total Federal R&D funds devoted to development is estimated at 72 percent for 1988. Basic research and applied research each will receive an estimated 14 percent share of the Federal R&D dollar in 1988. In 1980, the percentage shares of Federal R&D support were 16 percent for basic research, 23 percent for applied research, and 61 percent for development.

During most of the eighties, industry has maintained its relative support for development at about 72 percent of its total R&D outlay. Basic research is expected to receive about 5 percent of industry's total R&D support in 1988 and applied research is to receive 23 percent. These percentage shares are largely unchanged from 1980 levels. In terms of performance, however, the data indicate that industry is increasingly committed to development. The share of development in industry's total R&D performance declined from 79 percent in the early seventies to 75 percent in 1985. Since then, development's share has increased—to an expected 77 percent in 1988.

## R&D Expenditures by Source and Performer

Federal R&D support is estimated at $65 billion for 1988 (table 1), which is 7 percent more than in 1987 (3 percent in real terms). Non-Federal support is expected to reach $67 billion, which also is a 7-percent increase over 1987 (or 3 percent in real terms) (chart 1). Of the non-Federal total, industry support is estimated at $63 billion; university and college support at $2.9 billion; and nonprofit support at $1.5 billion (table 1). These represent real-term increases of 3 percent, 3 percent, and 2 percent, respectively, from 1987 R&D support levels. Between 1977 and 1984, total non-Federal R&D support grew at an average annual rate of 6.4 percent in real terms. Since then, real-dollar non-Federal support has increased at half that rate—3.0 percent annually.

Industry and the Federal Government are expected to provide 97 percent of total R&D funds spent by the Nation in 1988. Federal support accounts for 49 percent of the expected national R&D total, and industry support for 48 percent. As recently as 1986, industry support for research and development was greater than such support provided by the Federal Government. Major increases in defense-related R&D spending during the eighties contributed most to the Federal Government's displacement of industry as the Nation's largest provider of R&D funds.

In terms of performance, industry is expected to account for $96 billion of the Nation's total R&D expenditures in 1988. This represents an 8-percent increase over 1987, or slightly more than 3 percent in real terms. Industry's estimated 73-percent share of the 1988 national R&D performance total is unchanged from the percentage share accounted for throughout the 1982-87 period.

In 1988, funding for an estimated 70 percent of industry's expected R&D performance is provided by companies' own funds; the rest is estimated to come from the Federal Government (table 2).

[1]These percentage share estimates of defense-related R&D expenditures are based on 1988 Federal budget totals.

**Table 1. Funds for research and development**

[Dollars in millions]

| Year | Total | Federal Government | Industry[1] | Academic sector: Universities and colleges | Academic sector: Associated FFRDCs[2] | Other nonprofit institutions[1] |
|---|---|---|---|---|---|---|
| | | | *By performer* | | | |
| 1977 | 42,783 | 6,012 | 29,825 | 4,067 | 1,384 | 1,495 |
| 1978 | 48,129 | 6,811 | 33,304 | 4,625 | 1,717 | 1,672 |
| 1979 | 54,933 | 7,417 | 38,226 | 5,361 | 1,935 | 1,994 |
| 1980 | 62,593 | 7,632 | 44,505 | 6,060 | 2,246 | 2,150 |
| 1981 | 71,840 | 8,425 | 51,810 | 6,819 | 2,486 | 2,300 |
| 1982 | 79,316 | 9,141 | 57,995 | 7,276 | 2,479 | 2,425 |
| 1983 | 87,204 | 10,582 | 63,403 | 7,807 | 2,737 | 2,675 |
| 1984 | 97,638 | 11,572 | 71,470 | 8,503 | 3,118 | 2,975 |
| 1985 | 107,436 | 12,945 | 78,208 | 9,504 | 3,529 | 3,250 |
| 1986 | 114,697 | 13,535 | 83,562 | 10,600 | 3,600 | 3,400 |
| 1987 (est.) | 123,050 | 15,450 | 89,200 | 11,150 | 3,800 | 3,450 |
| 1988 (est.) | 131,600 | 16,400 | 95,950 | 11,725 | 4,000 | 3,525 |
| | | | *By source* | | | |
| 1977 | 42,783 | 21,594 | 19,629 | 888 | — | 672 |
| 1978 | 48,129 | 23,876 | 22,450 | 1,037 | — | 766 |
| 1979 | 54,933 | 26,815 | 26,082 | 1,198 | — | 838 |
| 1980 | 62,593 | 29,453 | 30,913 | 1,318 | — | 909 |
| 1981 | 71,840 | 33,405 | 35,944 | 1,520 | — | 971 |
| 1982 | 79,316 | 36,505 | 40,096 | 1,690 | — | 1,025 |
| 1983 | 87,204 | 40,671 | 43,515 | 1,881 | — | 1,137 |
| 1984 | 97,638 | 45,340 | 49,066 | 2,024 | — | 1,208 |
| 1985 | 107,436 | 51,276 | 52,597 | 2,259 | — | 1,304 |
| 1986 | 114,697 | 55,273 | 55,549 | 2,500 | — | 1,375 |
| 1987 (est.) | 123,050 | 60,350 | 58,570 | 2,700 | — | 1,430 |
| 1988 (est.) | 131,600 | 64,550 | 62,625 | 2,900 | — | 1,525 |

[1]Includes expenditures for federally funded research and development centers (FFRDCs) administered by this sector. They account for less than 5 percent and 25 percent, respectively, of the industry and nonprofit performance totals.

[2]FFRDCs administered by individual universities and colleges and by university consortia.

SOURCE: National Science Foundation, SRS

**Table 2. Estimated funding for research and development by source of funds: 1988**

[Dollars in millions]

| Source of funds | Total | Performers: Federal Government | Performers: Industry[1] | Performers: Universities and colleges[2] | Performers: Other nonprofit institutions[1] |
|---|---|---|---|---|---|
| Total | $131,600 | $16,400 | $95,950 | $15,725 | $3,525 |
| Federal Government | 64,550 | 16,400 | 34,500 | 11,250 | 2,400 |
| Industry | 62,625 | — | 61,450 | 750 | 425 |
| Universities and colleges | 2,900 | — | — | 2,900 | — |
| Other nonprofit institutions | 1,525 | — | — | 825 | 700 |

[1]Includes expenditures for federally funded research and development centers (FFRDCs) administered by this sector.

[2]Includes expenditures for FFRDCs administered by individual universities and colleges and by university consortia.

SOURCE: National Science Foundation, SRS

The Federal Government historically is the Nation's second largest R&D performer, and is expected to account for 12 percent—$16 billion—of the national R&D effort in 1988. This is a 6 percent increase (2 percent in real terms) in Federal intramural R&D performance. Most of the remaining research and development is performed by the Nation's universities and colleges—including work done in federally funded research and development centers administered by universities and colleges. In 1988, the estimated R&D performance by the academic sector is $16 billion, or slightly less than 12 percent of the Nation's total. This represents a 5-percent increase over 1987, or 1 percent in real terms.

## Basic Research, Applied Research, and Development

The United States is expected to spend $15 billion on basic research in 1988, $27 billion on applied research, and $90 billion on development (chart 3). After adjusting for estimated inflation, basic research spending is expected to be down slightly from 1987 expenditures, applied research spending to be level, and development spending to be up 4 percent.

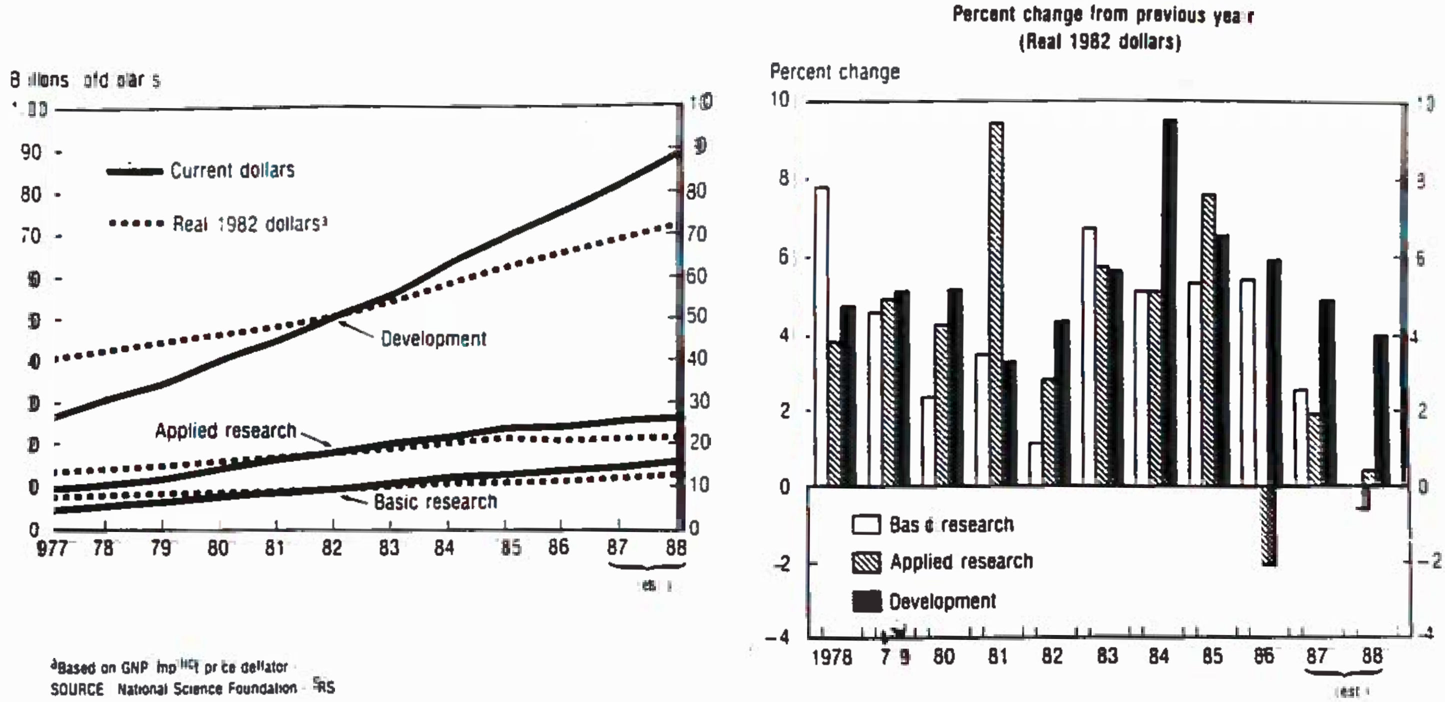
The 1988 estimates by type of R&D work represent a continuation in recent national funding patterns. For the past several years, growth in support for the research components has been slower than for development. Between 1982 and 1987, basic research funding is estimated to have increased at an inflation-adjusted 5-percent average annual rate; applied research funding, at 4 percent annually; and development funding, at more than 6 percent annually. Differences in these rates of growth have increased development's share of total R&D expenditures from 64 percent in 1982 to an expected 68 percent in 1988. This shift toward development is primarily a result of the increases in Federal support for defense research and development, which is about 90 percent development.

The Federal Government continues to support two-thirds of the Nation's basic research with more than half of such support going to universities and colleges. Industry provides an additional 20 percent of the Nation's basic research support. In terms of performance, basic research spending by Federal intramural labs is expected to decline 6 percent in 1988 after adjusting for expected inflation. Basic research performance by industrial and academic labs is expected to remain unchanged from 1987 real performance levels.

Support for applied research comes primarily from industry (52 percent of the national total in 1988) and the Federal Government (42 percent). While industry's applied research support is expected to increase by 3 percent in 1988 after adjusting for inflation, Federal real-term support is expected to decline by 3 percent. In terms of applied research performance, industry spending is expected to be up 2 percent in real terms, and will account for more than two-thirds of such performance nationwide. Applied research performance by the Federal Government is expected to be down 4 percent in real terms in 1988.

Support for development by both industry and the Federal Government is expected to increase in 1988; up 3 percent and 5 percent, respectively, in real terms. Most of the growth in Federal development support reflects a continuation in the shift toward increased emphasis on defense-related R&D

Chart 3. National basic research, applied research, and development expenditures




[a]Based on GNP implicit price deflator

SOURCE National Science Foundation SRS

programs that has taken place in the eighties. Such programs generally have a much higher development component than do federally supported nondefense programs. In terms of performance, industry accounts for more than 80 percent of the Nation's development work. Industry's development performance is expected to increase by 4 percent in real terms in 1988.

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## DIVISION OF SCIENCE RESOURCES STUDIES SURVEYS

* 1. Federal Funds for Research and Development

* 2. Federal Support to Universities, Colleges, and Nonprofit Institutions

3. Survey of Academic Research Facilities, 1987-88

* 4. Survey of Scientific and Engineering R&D Expenditures at Universities and Colleges

5. Survey of Academic Research Instrumentation and Instrumentation Needs, 1985-86

* 6. Survey of Industrial Research and Development

7. Industrial R&D Funding Estimates by Individual Industry

8. Occupational Employment Survey of Scientists, Engineers and Technicians in Industry

9. Survey of Demand for Scientists, Engineers, and Technicians in Industry

* 10. Survey of Natural and Social Scientists and Engineers

* 11. Survey of Recent Science and Engineering Graduates

* 12. Survey of Doctorate Recipients

13. Immigrant Scientists and Engineers

* 14. Graduate Science/Engineering Students and Postdoctorates

* 15. Survey of Earned Doctorates (Doctorate Record File)

* 16. Federal Scientists and Engineers

(*) Surveys with geographic data

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TABLE C-133. FEDERAL OBLIGATIONS FOR RESEARCH, DEVELOPMENT, AND R&D PLANT, BY GEOGRAPHIC DIVISION AND STATE: FISCAL YEAR 1986

(THOUSANDS OF DOLLARS)

| GEOGRAPHIC DIVISION AND STATE | RESEARCH, DEVELOPMENT AND R&D PLANT | RESEARCH AND DEVELOPMENT | R&D PLANT |
|---|---|---|---|
| TOTAL | 51,792,736 | 50,310,213 | 1,482,523 |
| NEW ENGLAND | 4,446,915 | 4,422,120 | 24,795 |
| CONNECTICUT | 578,503 | 577,288 | 1,215 |
| MAINE | 35,643 | 35,610 | 33 |
| MASSACHUSETTS | 3,257,372 | 3,239,665 | 17,707 |
| NEW HAMPSHIRE | 136,183 | 135,883 | 300 |
| RHODE ISLAND | 398,133 | 392,593 | 5,540 |
| VERMONT | 41,081 | 41,081 | - |
| MIDDLE ATLANTIC | 6,407,162 | 6,245,687 | 161,475 |
| NEW JERSEY | 1,818,813 | 1,781,208 | 37,605 |
| NEW YORK | 3,268,267 | 3,163,260 | 105,007 |
| PENNSYLVANIA | 1,320,082 | 1,301,219 | 18,863 |
| EAST NORTH CENTRAL | 3,393,643 | 3,273,493 | 120,150 |
| ILLINOIS | 841,202 | 744,619 | 96,583 |
| INDIANA | 295,522 | 294,988 | 534 |
| MICHIGAN | 461,423 | 460,344 | 1,079 |
| OHIO | 1,611,405 | 1,592,140 | 19,265 |
| WISCONSIN | 184,091 | 181,402 | 2,689 |
| WEST NORTH CENTRAL | 1,678,884 | 1,612,662 | 66,222 |
| IOWA | 227,311 | 224,049 | 3,262 |
| KANSAS | 153,686 | 112,643 | 41,043 |
| MINNESOTA | 516,420 | 515,342 | 1,078 |
| MISSOURI | 682,440 | 677,780 | 4,660 |
| NEBRASKA | 48,443 | 41,120 | 7,323 |
| NORTH DAKOTA | 35,977 | 27,170 | 8,807 |
| SOUTH DAKOTA | 14,607 | 14,558 | 49 |
| SOUTH ATLANTIC | 12,324,499 | 12,084,895 | 239,604 |
| DELAWARE | 30,598 | 30,216 | 382 |
| DISTRICT OF COLUMBIA | 2,352,184 | 2,324,183 | 28,001 |
| FLORIDA | 1,501,968 | 1,448,712 | 53,256 |
| GEORGIA | 266,081 | 250,495 | 15,586 |
| MARYLAND | 4,590,942 | 4,512,294 | 78,648 |
| NORTH CAROLINA | 499,881 | 497,641 | 2,240 |
| SOUTH CAROLINA | 128,154 | 122,492 | 5,662 |
| VIRGINIA | 2,855,779 | 2,810,172 | 45,607 |
| WEST VIRGINIA | 98,912 | 88,690 | 10,222 |
| EAST SOUTH CENTRAL | 2,068,313 | 1,982,479 | 85,834 |
| ALABAMA | 1,229,711 | 1,188,466 | 41,245 |
| KENTUCKY | 59,700 | 59,367 | 333 |
| MISSISSIPPI | 156,937 | 143,446 | 13,491 |
| TENNESSEE | 621,965 | 591,200 | 30,765 |
| WEST SOUTH CENTRAL | 2,203,268 | 2,118,306 | 84,962 |
| ARKANSAS | 41,353 | 40,493 | 860 |
| LOUISIANA | 94,552 | 92,370 | 2,182 |
| OKLAHOMA | 76,013 | 73,706 | 2,307 |
| TEXAS | 1,991,350 | 1,911,737 | 79,613 |
| MOUNTAIN | 5,897,111 | 5,578,530 | 318,581 |
| ARIZONA | 399,722 | 397,997 | 1,725 |
| COLORADO | 1,652,677 | 1,636,344 | 16,333 |
| IDAHO | 291,343 | 266,596 | 24,747 |
| MONTANA | 26,584 | 26,360 | 224 |
| NEVADA | 532,507 | 462,623 | 69,884 |
| NEW MEXICO | 2,691,624 | 2,499,657 | 191,967 |
| UTAH | 288,114 | 274,483 | 13,631 |
| WYOMING | 14,540 | 14,470 | 70 |
| PACIFIC | 13,258,608 | 12,896,039 | 362,569 |
| ALASKA | 49,225 | 49,225 | - |
| CALIFORNIA | 11,833,916 | 11,510,344 | 323,572 |
| HAWAII | 55,752 | 55,190 | 562 |
| OREGON | 139,529 | 127,543 | 11,986 |
| WASHINGTON | 1,180,186 | 1,153,737 | 26,449 |
| OUTLYING AREAS | 50,657 | 36,792 | 13,865 |
| OFFICES ABROAD | 63,676 | 59,210 | 4,466 |

NOTE: THE OBLIGATIONS OF THE 10 MAJOR R&D SUPPORTING AGENCIES INCLUDED IN THIS TABLE REPRESENT MORE THAN 98 PERCENT OF TOTAL FEDERAL R&D AND R&D PLANT OBLIGATIONS IN FISCAL YEAR 1986.

SOURCE: NATIONAL SCIENCE FOUNDATION, SRS

(THOUSANDS OF DOLLARS)

| STATE (IN ORDER OF TOTAL FEDERAL R&D OBLIGATIONS) | TOTAL | FEDERAL INTRAMURAL 1/ | EXTRAMURAL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | INDUSTRIAL FIRMS | FFRDCS ADMIN BY INDUSTRIAL FIRMS | UNIVERSITIES AND COLLEGES | FFRDCS ADMIN BY UNIVS AND COLLEGES | OTHER NONPROFIT INSTITUTIONS | FFRDCS ADMIN BY NONPROFIT INSTITUTIONS | STATE AND LOCAL GOVTS |
| TOTAL | 50,310,213 | 13,144,647 | 24,448,100 | 1,640,236 | 6,444,758 | 2,414,347 | 1,551,052 | 543,250 | 123,823 |
| CALIFORNIA | 11,510,344 | 1,480,495 | 7,295,930 | 22,615 | 1,223,785 | 1,082,244 | 213,631 | 176,457 | 15,187 |
| MARYLAND | 4,512,294 | 3,095,850 | 1,039,737 | 31,270 | 279,061 | 83 | 61,953 | 2,607 | 1,733 |
| MASSACHUSETTS | 3,239,665 | 205,383 | 1,813,111 | - | 464,384 | 121,144 | 467,448 | 163,654 | 4,541 |
| NEW YORK | 3,163,260 | 51,545 | 1,866,899 | 203,184 | 706,461 | 153,256 | 136,969 | - | 44,946 |
| VIRGINIA | 2,810,172 | 909,289 | 1,642,008 | - | 105,971 | - | 66,165 | 81,917 | 4,822 |
| NEW MEXICO | 2,499,657 | 962,129 | 343,627 | 565,525 | 73,708 | 542,423 | 11,796 | - | 449 |
| DISTRICT OF COLUMBIA | 2,324,183 | 1,519,474 | 659,541 | - | 53,600 | - | 91,024 | - | 544 |
| TEXAS | 1,911,737 | 261,456 | 1,312,738 | - | 311,821 | - | 23,359 | - | 2,363 |
| NEW JERSEY | 1,781,208 | 942,624 | 662,129 | - | 78,407 | 86,593 | 6,597 | 2,877 | 1,981 |
| COLORADO | 1,636,344 | 100,232 | 1,300,001 | - | 117,011 | 37,203 | 22,400 | 58,340 | 1,157 |
| OHIO | 1,592,140 | 563,145 | 819,825 | - | 167,098 | - | 40,688 | - | 1,384 |
| FLORIDA | 1,448,712 | 413,102 | 900,370 | - | 127,158 | - | 5,364 | - | 2,718 |
| PENNSYLVANIA | 1,301,219 | 290,207 | 327,915 | 252,260 | 350,901 | 10,749 | 67,796 | - | 1,391 |
| ALABAMA | 1,188,466 | 477,481 | 615,357 | - | 78,308 | - | 16,364 | - | 956 |
| WASHINGTON | 1,153,737 | 131,493 | 690,891 | 81,718 | 157,348 | - | 31,774 | 57,291 | 3,222 |
| ILLINOIS | 744,619 | 61,910 | 104,852 | - | 250,442 | 248,832 | 76,043 | - | 2,540 |
| MISSOURI | 677,780 | 51,316 | 502,190 | - | 109,957 | - | 13,483 | - | 834 |
| TENNESSEE | 591,200 | 99,330 | 144,159 | 237,051 | 85,191 | 11,328 | 12,981 | - | 1,160 |
| CONNECTICUT | 577,288 | 75,394 | 346,714 | - | 146,905 | - | 6,665 | - | 1,610 |
| MINNESOTA | 515,342 | 29,073 | 350,104 | - | 98,458 | - | 35,775 | - | 1,932 |
| NORTH CAROLINA | 497,641 | 131,280 | 156,929 | - | 191,392 | - | 16,315 | - | 1,725 |
| NEVADA | 462,623 | 93,374 | 354,247 | - | 14,101 | - | 129 | - | 772 |
| MICHIGAN | 460,344 | 82,032 | 177,286 | - | 177,951 | - | 22,033 | - | 1,042 |
| ARIZONA | 397,997 | 93,371 | 206,881 | - | 70,910 | 22,962 | 3,535 | 107 | 231 |
| RHODE ISLAND | 392,593 | 258,919 | 73,671 | - | 45,709 | - | 12,002 | - | 2,292 |
| INDIANA | 294,988 | 53,236 | 139,449 | - | 96,663 | - | 4,599 | - | 1,041 |
| UTAH | 274,483 | 70,578 | 102,198 | - | 78,472 | - | 22,151 | - | 1,084 |
| IDAHO | 266,596 | 16,073 | 7,324 | 176,506 | 5,500 | 60,788 | 75 | - | 330 |
| GEORGIA | 250,495 | 87,076 | 59,981 | - | 97,732 | - | 4,228 | - | 1,478 |
| IOWA | 224,049 | 19,326 | 122,593 | - | 66,417 | 14,583 | 172 | - | 958 |
| WISCONSIN | 181,402 | 24,927 | 12,762 | - | 140,701 | - | 2,245 | - | 767 |
| MISSISSIPPI | 143,446 | 97,088 | 14,226 | - | 29,852 | - | 1,564 | - | 716 |
| NEW HAMPSHIRE | 135,883 | 27,933 | 74,297 | - | 31,804 | - | 1,481 | - | 368 |
| OREGON | 127,543 | 32,144 | 11,151 | - | 67,433 | - | 13,851 | - | 2,964 |
| SOUTH CAROLINA | 122,492 | 13,016 | 2,278 | 70,107 | 34,678 | - | 1,800 | - | 613 |
| KANSAS | 112,643 | 8,371 | 64,429 | - | 38,626 | - | 751 | - | 466 |
| LOUISIANA | 92,370 | 34,606 | 10,307 | - | 44,764 | - | 1,357 | - | 1,336 |
| WEST VIRGINIA | 88,690 | 48,354 | 13,163 | - | 9,662 | 16,439 | 446 | - | 626 |
| OKLAHOMA | 73,706 | 28,598 | 9,899 | - | 27,427 | - | 7,119 | - | 663 |
| KENTUCKY | 59,367 | 27,182 | 2,031 | - | 28,914 | - | 95 | - | 1,145 |
| HAWAII | 55,190 | 18,499 | 1,532 | - | 29,820 | - | 4,912 | - | 427 |
| ALASKA | 49,225 | 31,393 | 3,041 | - | 13,132 | - | 67 | - | 1,592 |
| NEBRASKA | 41,120 | 18,614 | 3,195 | - | 17,626 | - | 1,249 | - | 436 |
| VERMONT | 41,081 | 7,089 | 6,970 | - | 22,467 | - | 4,186 | - | 369 |
| ARKANSAS | 40,493 | 24,264 | 875 | - | 12,120 | - | 2,248 | - | 986 |
| MAINE | 35,610 | 2,349 | 14,375 | - | 6,994 | - | 10,735 | - | 1,157 |
| DELAWARE | 30,216 | 2,464 | 12,327 | - | 13,152 | - | 2,074 | - | 199 |
| NORTH DAKOTA | 27,170 | 16,979 | 225 | - | 9,021 | - | 249 | - | 696 |
| MONTANA | 26,360 | 16,235 | 706 | - | 8,737 | - | 304 | - | 378 |
| SOUTH DAKOTA | 14,558 | 7,172 | 2,199 | - | 4,810 | - | 160 | - | 217 |
| WYOMING | 14,470 | 8,291 | - | - | 5,983 | - | - | - | 196 |
| OUTLYING AREAS | 36,792 | 10,400 | 4,129 | - | 15,460 | 5,720 | - | - | 1,083 |
| OFFICES ABROAD | 59,210 | 12,486 | 45,326 | - | 753 | - | 645 | - | - |

1/ FEDERAL INTRAMURAL ACTIVITIES COVER COSTS ASSOCIATED WITH THE ADMINISTRATION OF INTRAMURAL AND EXTRAMURAL PROGRAMS BY FEDERAL PERSONNEL AS WELL AS ACTUAL INTRAMURAL PERFORMANCE. SEE TECHNICAL NOTES FOR FURTHER DESCRIPTION.

NOTE: THE OBLIGATIONS OF THE 10 MAJOR R&D SUPPORTING AGENCIES INCLUDED IN THIS TABLE REPRESENT MORE THAN 98 PERCENT OF TOTAL FEDERAL R&D OBLIGATIONS IN FISCAL YEAR 1986.

SOURCE: NATIONAL SCIENCE FOUNDATION, SRS

TABLE C-135. FEDERAL OBLIGATIONS FOR RESEARCH AND DEVELOPMENT, BY STATE AND AGENCY: FISCAL YEAR 1986

(THOUSANDS OF DOLLARS)

| STATE (IN ORDER OF TOTAL FEDERAL R&D OBLIGATIONS) | TOTAL | DEPT OF AGRICULTURE | DEPT OF COMMERCE | DEPT OF DEFENSE | DEPT OF ENERGY | DEPT OF HEALTH & HUMAN SERVICES | DEPT OF THE INTERIOR | DEPT OF TRANSPORTATION | ENVIRONMENTAL PROTECTION AGENCY | NATIONAL AERONAUTICS & SPACE ADMIN | NATIONAL SCIENCE FOUNDATION |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL | 50,310,213 | 920,328 | 398,207 | 32,841,027 | 4,682,923 | 5,632,178 | 384,326 | 385,431 | 317,319 | 3,396,650 | 1,351,824 |
| CALIFORNIA | 11,510,344 | 54,523 | 24,725 | 8,540,337 | 1,014,552 | 656,505 | 30,224 | 74,586 | 25,692 | 896,667 | 192,533 |
| MARYLAND | 4,512,294 | 81,285 | 125,095 | 2,508,380 | 41,032 | 1,262,286 | 15,146 | 67,571 | 6,305 | 374,437 | 30,757 |
| MASSACHUSETTS | 3,239,665 | 14,683 | 13,006 | 2,451,879 | 61,877 | 471,083 | 3,100 | 40,642 | 22,495 | 53,941 | 106,959 |
| NEW YORK | 3,163,260 | 21,680 | 2,495 | 2,004,384 | 373,553 | 579,421 | 6,186 | 9,026 | 9,016 | 29,130 | 128,369 |
| VIRGINIA | 2,810,172 | 7,323 | 5,185 | 2,317,836 | 36,093 | 75,751 | 35,039 | 35,463 | 25,299 | 253,399 | 18,784 |
| NEW MEXICO | 2,499,657 | 5,111 | 50 | 1,433,751 | 1,011,497 | 16,899 | 6,586 | 865 | 629 | 14,477 | 9,792 |
| DISTRICT OF COLUMBIA | 2,324,183 | 104,291 | 8,502 | 1,629,079 | 82,046 | 108,664 | 25,017 | 40,932 | 20,584 | 138,637 | 166,431 |
| TEXAS | 1,911,737 | 39,828 | 1,696 | 1,308,259 | 19,344 | 209,634 | 3,708 | 4,507 | 15,738 | 271,944 | 37,079 |
| NEW JERSEY | 1,781,208 | 3,477 | 18,824 | 1,396,016 | 99,521 | 45,835 | 3,224 | 46,997 | 1,692 | 106,700 | 58,922 |
| COLORADO | 1,636,344 | 19,729 | 58,004 | 1,249,244 | 71,672 | 65,675 | 31,890 | 9,167 | 4,472 | 68,837 | 57,654 |
| OHIO | 1,592,140 | 12,878 | 610 | 1,129,932 | 42,904 | 125,380 | 2,957 | 5,621 | 41,419 | 208,411 | 22,028 |
| FLORIDA | 1,448,712 | 26,461 | 21,883 | 943,011 | 15,955 | 61,265 | 2,762 | 4,160 | 5,038 | 346,701 | 21,476 |
| PENNSYLVANIA | 1,301,219 | 33,938 | 866 | 582,217 | 279,262 | 259,249 | 29,741 | 3,981 | 3,482 | 52,684 | 55,799 |
| ALABAMA | 1,188,466 | 10,549 | 2,716 | 831,155 | 8,695 | 60,217 | 5,757 | 493 | 1,117 | 264,692 | 3,075 |
| WASHINGTON | 1,153,737 | 21,082 | 39,487 | 716,886 | 176,136 | 129,850 | 14,734 | 564 | 2,027 | 25,563 | 27,408 |
| ILLINOIS | 744,619 | 29,380 | 1,273 | 197,983 | 268,978 | 153,669 | 3,320 | 3,458 | 3,295 | 16,232 | 67,031 |
| MISSOURI | 677,780 | 13,033 | 479 | 537,725 | 3,091 | 97,687 | 9,010 | 644 | 287 | 7,354 | 8,470 |
| TENNESSEE | 591,200 | 7,744 | 825 | 220,581 | 254,356 | 73,483 | 2,501 | 823 | 12,622 | 10,380 | 7,885 |
| CONNECTICUT | 577,288 | 3,728 | 4,015 | 343,399 | 14,363 | 121,547 | 1,344 | 9,347 | 3,795 | 62,921 | 12,829 |
| MINNESOTA | 515,342 | 16,878 | 2,369 | 346,463 | 4,717 | 105,772 | 11,297 | 508 | 7,601 | 7,031 | 12,706 |
| NORTH CAROLINA | 497,641 | 23,294 | 4,228 | 180,854 | 5,009 | 200,150 | 2,916 | 1,267 | 56,117 | 5,387 | 18,419 |
| NEVADA | 462,623 | 1,939 | 1,071 | 110,140 | 329,033 | 2,683 | 8,677 | 68 | 6,052 | 1,209 | 1,751 |
| MICHIGAN | 460,344 | 13,143 | 4,498 | 245,844 | 21,981 | 111,183 | 4,863 | 3,007 | 1,974 | 15,132 | 38,719 |
| ARIZONA | 397,997 | 14,064 | 438 | 283,987 | 1,047 | 34,552 | 4,856 | 964 | 1,223 | 18,308 | 38,558 |
| RHODE ISLAND | 392,593 | 1,477 | 2,808 | 340,651 | 2,704 | 22,825 | 829 | 216 | 4,629 | 1,777 | 14,677 |
| INDIANA | 294,988 | 8,688 | 222 | 184,546 | 16,207 | 44,429 | 2,064 | 1,394 | 905 | 5,861 | 30,672 |
| UTAH | 274,483 | 8,957 | 501 | 169,606 | 7,517 | 40,546 | 10,662 | 463 | 1,374 | 22,945 | 11,912 |
| IDAHO | 266,596 | 10,676 | 70 | 1,721 | 243,711 | 915 | 8,091 | 344 | 356 | 213 | 499 |
| GEORGIA | 250,495 | 35,322 | 1,089 | 61,874 | 4,477 | 85,538 | 3,065 | 1,514 | 6,414 | 38,280 | 12,922 |
| IOWA | 224,049 | 24,560 | 202 | 126,343 | 15,520 | 43,509 | 1,037 | 574 | 1,117 | 4,445 | 6,742 |
| WISCONSIN | 181,402 | 27,305 | 2,672 | 5,490 | 11,382 | 83,967 | 5,817 | 394 | 1,675 | 19,904 | 22,796 |
| MISSISSIPPI | 143,446 | 31,204 | 8,960 | 63,953 | 3,808 | 8,587 | 4,026 | 505 | 445 | 20,611 | 1,345 |
| NEW HAMPSHIRE | 135,883 | 3,253 | 886 | 98,135 | 853 | 16,714 | 1,425 | 344 | 267 | 5,519 | 8,487 |
| OREGON | 127,543 | 21,281 | 7,859 | 11,135 | 7,028 | 42,845 | 12,278 | 197 | 6,678 | 3,515 | 14,727 |
| SOUTH CAROLINA | 122,492 | 11,237 | 2,419 | 9,957 | 71,885 | 17,768 | 2,270 | 277 | 583 | 404 | 5,692 |
| KANSAS | 112,643 | 8,144 | - | 75,976 | 1,639 | 16,195 | 1,377 | 2,363 | 516 | 2,199 | 4,234 |
| LOUISIANA | 92,370 | 26,497 | 3,425 | 14,943 | 1,518 | 34,228 | 4,284 | 647 | 1,016 | 1,788 | 4,024 |
| WEST VIRGINIA | 88,690 | 10,836 | 323 | 4,797 | 40,195 | 9,743 | 4,449 | 325 | 554 | 238 | 17,230 |
| OKLAHOMA | 73,706 | 12,147 | 3,041 | 16,957 | 4,297 | 13,626 | 2,474 | 4,982 | 7,729 | 5,089 | 3,364 |
| KENTUCKY | 59,367 | 8,635 | 90 | 14,299 | 808 | 27,509 | 1,949 | 688 | 1,130 | 1,320 | 2,939 |
| HAWAII | 55,190 | 8,619 | 6,820 | 11,496 | 1,490 | 9,410 | 3,409 | 176 | 63 | 5,409 | 8,302 |
| ALASKA | 49,225 | 5,036 | 7,152 | 10,107 | 1,379 | 442 | 16,306 | 179 | 30 | 2,247 | 6,347 |
| NEBRASKA | 41,120 | 14,570 | 180 | 3,538 | 567 | 9,905 | 7,958 | 170 | 122 | 409 | 3,701 |
| VERMONT | 41,081 | 3,293 | 40 | 10,322 | 5,200 | 17,939 | 1,126 | 122 | 255 | 1,429 | 1,355 |
| ARKANSAS | 40,493 | 6,589 | - | 1,014 | 695 | 27,193 | 1,554 | 214 | 412 | 249 | 2,573 |
| MAINE | 35,610 | 3,121 | 1,500 | 14,203 | 125 | 9,755 | 1,187 | 275 | 905 | 486 | 4,053 |
| DELAWARE | 30,216 | 2,743 | 1,564 | 12,175 | 982 | 2,693 | 607 | 98 | 481 | 943 | 7,930 |
| NORTH DAKOTA | 27,170 | 17,286 | 596 | 172 | 446 | 874 | 3,693 | 3,676 | 38 | - | 389 |
| MONTANA | 26,360 | 9,076 | 156 | 677 | 1,215 | 7,838 | 3,658 | 235 | 1,470 | 128 | 1,907 |
| SOUTH DAKOTA | 14,558 | 4,338 | - | 584 | 99 | 803 | 7,280 | 129 | 77 | 483 | 765 |
| WYOMING | 14,470 | 5,204 | - | 332 | 255 | 826 | 5,480 | 129 | 52 | 453 | 1,739 |
| OUTLYING AREAS | 36,792 | 9,553 | 3,232 | 8,338 | 207 | 7,116 | 950 | 140 | 55 | 134 | 7,067 |
| OFFICES ABROAD | 59,210 | 640 | 60 | 58,344 | - | - | 166 | - | - | - | - |

NOTE: THE OBLIGATIONS OF THE 10 MAJOR R&D SUPPORTING AGENCIES INCLUDED IN THIS TABLE REPRESENT MORE THAN 98 PERCENT OF TOTAL FEDERAL R&D OBLIGATIONS IN FISCAL YEAR 1986.

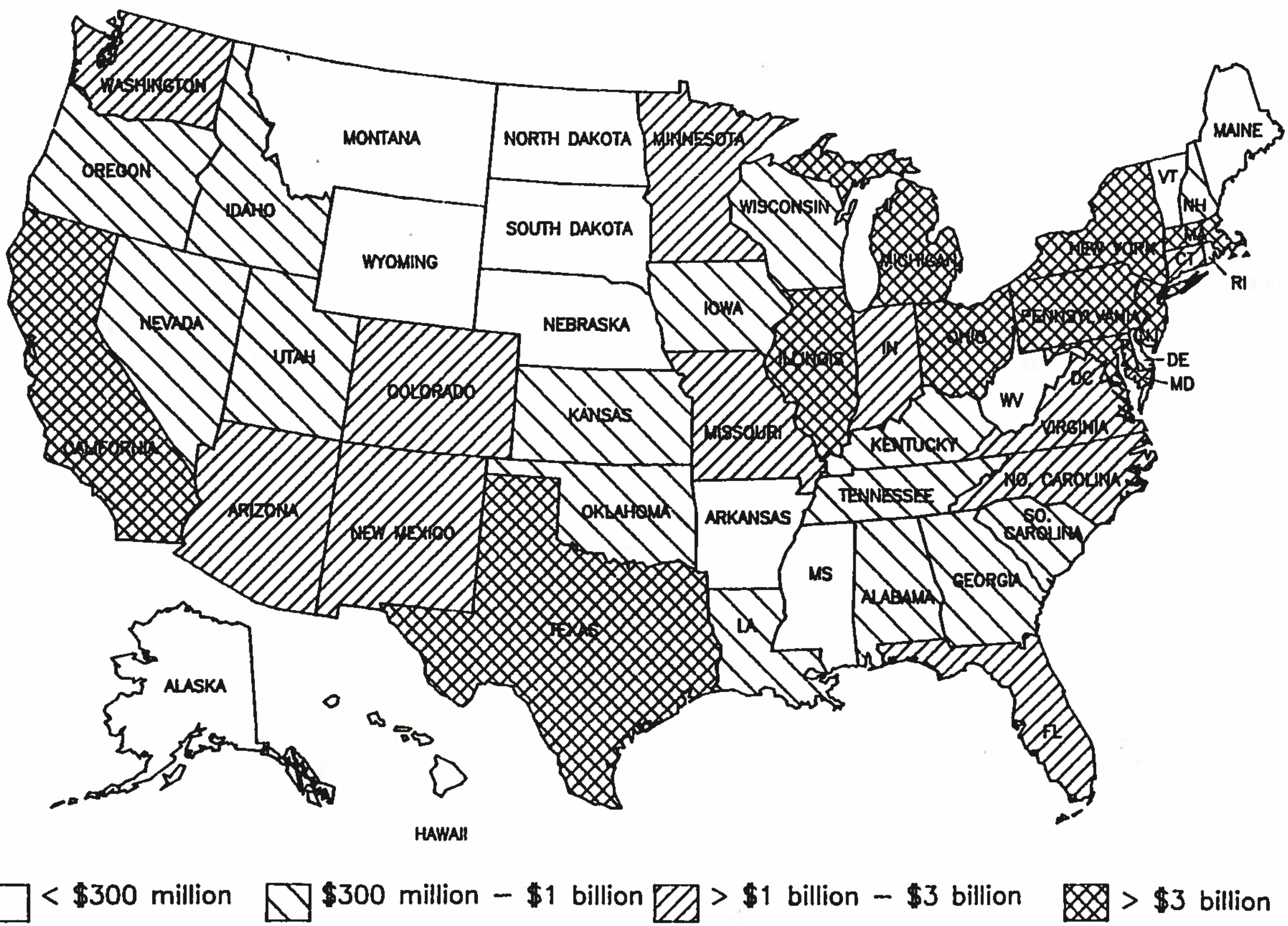
SOURCE: NATIONAL SCIENCE FOUNDATION, SRS

(THOUSANDS OF DOLLARS)

| GEOGRAPHIC DIVISION, STATE, AND AGENCY | TOTAL | FEDERAL INTRAMURAL 1/ | EXTRAMURAL | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | INDUSTRIAL FIRMS | FFRDCS ADMIN BY INDUSTRIAL FIRMS | UNIVERSITIES AND COLLEGES | FFRDCS ADMIN BY UNIVS AND COLLEGES | OTHER NONPROFIT INSTITUTIONS | FFRDCS ADMIN BY NON-PROFIT INSTITUTIONS | STATE AND LOCAL GOVTS |
| **TOTAL** | | | | | | | | | |
| TOTAL | 50,310,213 | 13,144,647 | 24,448,100 | 1,640,236 | 6,444,758 | 2,414,347 | 1,551,052 | 543,250 | 123,823 |
| DEPARTMENT OF AGRICULTURE | 920,328 | 629,637 | 10,089 | - | 273,533 | 165 | 5,678 | - | 1,226 |
| DEPARTMENT OF COMMERCE | 398,207 | 284,902 | 34,839 | - | 60,638 | 1,768 | 4,485 | - | 11,575 |
| DEPARTMENT OF DEFENSE | 32,841,027 | 8,880,526 | 21,502,381 | 145,536 | 1,097,778 | 285,017 | 494,049 | 435,700 | 40 |
| DEPARTMENT OF ENERGY | 4,682,923 | 205,850 | 738,219 | 1,455,133 | 344,611 | 1,797,344 | 39,130 | 101,953 | 683 |
| DEPARTMENT OF HEALTH & HUMAN SRVCS | 5,632,178 | 1,235,503 | 186,551 | 33,416 | 3,283,428 | 26,280 | 790,844 | 5,008 | 71,148 |
| DEPARTMENT OF THE INTERIOR | 384,326 | 332,038 | 9,739 | 3,850 | 36,440 | - | 332 | - | 1,927 |
| DEPARTMENT OF TRANSPORTATION | 385,431 | 131,321 | 188,412 | 196 | 12,520 | 7,695 | 20,926 | - | 24,361 |
| ENVIRONMENTAL PROTECTION AGENCY | 317,319 | 97,605 | 124,569 | - | 69,616 | 102 | 18,173 | - | 7,254 |
| NATIONAL AERONAUTICS AND SPACE ADMIN | 3,396,650 | 1,217,343 | 1,584,160 | - | 274,500 | 214,548 | 101,127 | 589 | 4,383 |
| NATIONAL SCIENCE FOUNDATION | 1,351,824 | 129,922 | 69,141 | 2,105 | 991,694 | 81,428 | 76,308 | - | 1,226 |
| **NEW ENGLAND** | | | | | | | | | |
| TOTAL | 4,422,120 | 577,067 | 2,329,138 | - | 718,263 | 121,144 | 502,517 | 163,654 | 10,337 |
| DEPARTMENT OF AGRICULTURE | 29,555 | 16,722 | 49 | - | 11,848 | - | 148 | - | 788 |
| DEPARTMENT OF COMMERCE | 22,255 | 10,938 | 1,593 | - | 7,259 | - | 1,183 | - | 1,282 |
| DEPARTMENT OF DEFENSE | 3,258,589 | 494,320 | 2,167,668 | - | 87,552 | 117,398 | 227,997 | 163,654 | - |
| DEPARTMENT OF ENERGY | 85,122 | - | 13,607 | - | 66,808 | - | 4,707 | - | - |
| DEPARTMENT OF HEALTH & HUMAN SRVCS | 659,863 | 1,964 | 38,054 | - | 380,385 | - | 234,750 | - | 4,710 |
| DEPARTMENT OF THE INTERIOR | 9,011 | 6,440 | 293 | - | 2,037 | - | 219 | - | 22 |
| DEPARTMENT OF TRANSPORTATION | 50,946 | 38,104 | 6,910 | - | 738 | 3,555 | 259 | - | 1,380 |
| ENVIRONMENTAL PROTECTION AGENCY | 32,346 | 2,313 | 15,693 | - | 7,450 | - | 4,800 | - | 2,090 |
| NATIONAL AERONAUTICS AND SPACE ADMIN | 126,073 | 6,024 | 77,449 | - | 23,885 | 191 | 18,524 | - | - |
| NATIONAL SCIENCE FOUNDATION | 148,360 | 242 | 7,822 | - | 130,301 | - | 9,930 | - | 65 |
| **CONNECTICUT** | | | | | | | | | |
| TOTAL | 577,288 | 75,394 | 346,714 | - | 146,905 | - | 6,665 | - | 1,610 |
| DEPARTMENT OF AGRICULTURE | 3,728 | 1,652 | - | - | 1,317 | - | - | - | 759 |
| DEPARTMENT OF COMMERCE | 4,015 | 2,262 | - | - | 1,753 | - | - | - | - |
| DEPARTMENT OF DEFENSE | 343,399 | 63,415 | 272,219 | - | 7,291 | - | 474 | - | - |
| DEPARTMENT OF ENERGY | 14,363 | - | 6,552 | - | 7,806 | - | 5 | - | - |
| DEPARTMENT OF HEALTH & HUMAN SRVCS | 121,547 | 66 | 1,374 | - | 115,218 | - | 4,516 | - | 373 |
| DEPARTMENT OF THE INTERIOR | 1,344 | 1,220 | - | - | 124 | - | - | - | - |
| DEPARTMENT OF TRANSPORTATION | 9,347 | 6,779 | 2,186 | - | - | - | - | - | 382 |
| ENVIRONMENTAL PROTECTION AGENCY | 3,795 | - | 2,590 | - | 317 | - | 792 | - | 96 |
| NATIONAL AERONAUTICS AND SPACE ADMIN | 62,921 | - | 61,162 | - | 1,031 | - | 728 | - | - |
| NATIONAL SCIENCE FOUNDATION | 12,829 | - | 631 | - | 12,048 | - | 150 | - | - |
| **MAINE** | | | | | | | | | |
| TOTAL | 35,610 | 2,349 | 14,375 | - | 6,994 | - | 10,735 | - | 1,157 |
| DEPARTMENT OF AGRICULTURE | 3,121 | 973 | - | - | 2,056 | - | 67 | - | 25 |
| DEPARTMENT OF COMMERCE | 1,500 | 468 | 10 | - | 635 | - | - | - | 387 |
| DEPARTMENT OF DEFENSE | 14,203 | 44 | 14,046 | - | 113 | - | - | - | - |
| DEPARTMENT OF ENERGY | 125 | - | - | - | - | - | 125 | - | - |
| DEPARTMENT OF HEALTH & HUMAN SRVCS | 9,755 | - | - | - | 564 | - | 8,681 | - | 510 |
| DEPARTMENT OF THE INTERIOR | 1,187 | 864 | - | - | 308 | - | - | - | 15 |
| DEPARTMENT OF TRANSPORTATION | 275 | - | 120 | - | - | - | - | - | 155 |
| ENVIRONMENTAL PROTECTION AGENCY | 905 | - | - | - | 731 | - | 174 | - | - |
| NATIONAL AERONAUTICS AND SPACE ADMIN | 486 | - | 137 | - | 89 | - | 260 | - | - |
| NATIONAL SCIENCE FOUNDATION | 4,053 | - | 62 | - | 2,498 | - | 1,428 | - | 65 |
| **MASSACHUSETTS** | | | | | | | | | |
| TOTAL | 3,239,665 | 205,383 | 1,813,111 | - | 464,384 | 121,144 | 467,448 | 163,654 | 4,541 |
| DEPARTMENT OF AGRICULTURE | 14,683 | 11,276 | 49 | - | 3,290 | - | 68 | - | - |
| DEPARTMENT OF COMMERCE | 13,006 | 7,385 | 1,583 | - | 2,522 | - | 1,183 | - | 333 |
| DEPARTMENT OF DEFENSE | 2,451,879 | 146,353 | 1,731,914 | - | 65,162 | 117,398 | 227,398 | 163,654 | - |
| DEPARTMENT OF ENERGY | 61,877 | - | 7,055 | - | 54,263 | - | 559 | - | - |
| DEPARTMENT OF HEALTH & HUMAN SRVCS | 471,083 | 1,898 | 34,609 | - | 221,080 | - | 210,292 | - | 3,204 |
| DEPARTMENT OF THE INTERIOR | 3,100 | 1,448 | 291 | - | 1,142 | - | 219 | - | - |
| DEPARTMENT OF TRANSPORTATION | 40,642 | 31,133 | 4,563 | - | 738 | 3,555 | 256 | - | 397 |
| ENVIRONMENTAL PROTECTION AGENCY | 22,495 | - | 13,103 | - | 5,018 | - | 3,767 | - | 607 |
| NATIONAL AERONAUTICS AND SPACE ADMIN | 53,941 | 5,765 | 13,343 | - | 17,185 | 191 | 17,457 | - | - |
| NATIONAL SCIENCE FOUNDATION | 106,959 | 125 | 6,601 | - | 93,984 | - | 6,249 | - | - |

NOTE: Data on individual universities and colleges is available from the Survey of Federal Support to Universities Colleges and non-profit Institutions.

## National Research & Development Performance*




SOURCE: National Science Foundation, SRS

(*) 1985 DATA

## Table B-1. State agency expenditures for research and development by State, character of work, and R&D plant: FY 1977

(Thousands of dollars)

| State | Total R & D and R & D plant | Research and development: Total | Basic | Applied | Development | R & D plant |
|---|---|---|---|---|---|---|
| TOTAL | 370 192 | 358 473 | 81 941 | 202 391 | 74 142 | 11 717 |
| ALABAMA | 1 359 | 1 227 | - | 963 | 263 | 132 |
| ALASKA | 7 855 | 7 655 | - | 7 358 | 297 | 200 |
| ARIZONA | 1 741 | 1 684 | 180 | 1 231 | 272 | 57 |
| ARKANSAS | 544 | 503 | 41 | 409 | 54 | 41 |
| CALIFORNIA | 37 832 | 37 496 | 5 690 | 19 653 | 12 153 | 336 |
| COLORADO | 9 648 | 9 620 | 25 | 8 367 | 1 229 | 28 |
| CONNECTICUT | 5 195 | 4 874 | 1 923 | 2 215 | 735 | 321 |
| DELAWARE | 696 | 611 | - | 290 | 321 | 84 |
| FLORIDA | 14 730 | 13 474 | 869 | 7 891 | 4 714 | 1 256 |
| GEORGIA | 3 201 | 3 199 | 86 | 1 123 | 1 991 | 2 |
| HAWAII | 3 370 | 2 873 | 3 | 1 599 | 1 271 | 497 |
| IDAHO | 1 690 | 1 690 | 801 | 849 | 41 | - |
| ILLINOIS | 18 380 | 17 908 | 4 739 | 10 058 | 3 112 | 472 |
| INDIANA | 4 101 | 4 089 | 1 798 | 1 876 | 414 | 12 |
| IOWA | 2 160 | 2 097 | 478 | 1 215 | 404 | 63 |
| KANSAS | 4 137 | 4 107 | 145 | 2 351 | 1 610 | 30 |
| KENTUCKY | 8 182 | 6 670 | 458 | 4 046 | 2 166 | 1 511 |
| LOUISIANA | 7 287 | 6 525 | 887 | 2 177 | 3 461 | 761 |
| MAINE | 1 349 | 1 344 | 198 | 1 146 | - | 5 |
| MARYLAND | 9 093 | 8 996 | 1 074 | 7 710 | 212 | 97 |
| MASSACHUSETTS | 3 550 | 3 286 | 856 | 1 698 | 733 | 264 |
| MICHIGAN | 8 574 | 8 353 | 452 | 7 307 | 594 | 221 |
| MINNESOTA | 4 247 | 4 199 | 1 220 | 2 721 | 258 | 48 |
| MISSISSIPPI | 1 627 | 1 627 | 785 | 812 | 31 | - |
| MISSOURI | 2 169 | 2 053 | 35 | 1 912 | 106 | 115 |
| MONTANA | 2 867 | 2 861 | 36 | 2 569 | 256 | 6 |
| NEBRASKA | 675 | 641 | 4 | 594 | 43 | 34 |
| NEVADA | 1 116 | 1 084 | - | 197 | 887 | 32 |
| NEW HAMPSHIRE | 1 292 | 1 210 | - | 445 | 765 | 82 |
| NEW JERSEY | 8 740 | 8 497 | 1 191 | 2 395 | 4 911 | 243 |
| NEW MEXICO | 4 501 | 4 012 | 2 523 | 944 | 545 | 489 |
| NEW YORK | 102 258 | 100 695 | 47 316 | 46 113 | 7 266 | 1 563 |
| NORTH CAROLINA | 11 703 | 11 583 | 1 338 | 3 619 | 6 627 | 120 |
| NORTH DAKOTA | 1 931 | 1 832 | 763 | 615 | 455 | 99 |
| OHIO | 7 239 | 7 228 | 342 | 4 150 | 2 736 | 11 |
| OKLAHOMA | 1 550 | 1 453 | 91 | 911 | 451 | 97 |
| OREGON | 6 160 | 6 070 | 161 | 4 293 | 1 616 | 90 |
| PENNSYLVANIA | 9 268 | 9 264 | 2 106 | 5 165 | 1 993 | 4 |
| RHODE ISLAND | 853 | 752 | 322 | 168 | 262 | 101 |
| SOUTH CAROLINA | 5 681 | 4 974 | 822 | 3 314 | 839 | 707 |
| SOUTH DAKOTA | 1 262 | 1 262 | 180 | 1 078 | 3 | - |
| TENNESSEE | 1 175 | 1 168 | 208 | 785 | 176 | 6 |
| TEXAS | 12 113 | 11 836 | 960 | 8 590 | 2 286 | 277 |
| UTAH | 2 332 | 1 918 | 113 | 1 742 | 62 | 415 |
| VERMONT | 188 | 188 | 6 | 183 | - | - |
| VIRGINIA | 5 501 | 5 155 | 166 | 2 785 | 2 203 | 346 |
| WASHINGTON | 12 184 | 12 062 | 100 | 10 343 | 1 620 | 121 |
| WEST VIRGINIA | 1 110 | 859 | - | 409 | 449 | 251 |
| WISCONSIN | 5 030 | 4 993 | 389 | 3 400 | 1 203 | 38 |
| WYOMING | 748 | 716 | 61 | 607 | 47 | 32 |

NOTE: Because of rounding, detail may not add to totals.

- Represents zero.

SOURCE: National Science Foundation

## Table B-2. State agency expenditures for research and development by State and functional area: FY 1977

(Thousands of dollars)

| State | Total | Health | Natural resources | Education | Transportation | Income security and social services | Environment | Crime prevention and control | Economic growth and productivity | Area and community development, housing, and public services | Science and technology base | Energy | Food, fiber and agri[illegible] |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL | 358 473 | 100 865 | 61 150 | 28 169 | 29 030 | 24 067 | 28 027 | 13 092 | 6 099 | 12 789 | 50 | 31 450 | 23 [illegible] |
| ALABAMA | 1 227 | 190 | 338 | 269 | 91 | - | 14 | 177 | - | - | - | - | |
| ALASKA | 7 655 | - | 1 135 | 957 | 138 | - | - | - | 50 | 682 | - | - | [illegible] |
| ARIZONA | 1 684 | - | 377 | 180 | 489 | 241 | 129 | - | 158 | 110 | - | - | |
| ARKANSAS | 503 | 27 | 105 | - | 215 | 99 | - | 9 | 47 | - | - | - | |
| CALIFORNIA | 37 496 | 3 797 | 3 578 | 4 404 | 4 947 | 1 869 | 4 535 | 1 582 | 450 | 1 196 | - | 7 880 | 3 [illegible] |
| COLORADO | 9 620 | 12 | 2 684 | 199 | 143 | 5 693 | - | 37 | 50 | 803 | - | - | |
| CONNECTICUT | 4 874 | 928 | 861 | 52 | 243 | 281 | 70 | 883 | - | 75 | - | 526 | |
| DELAWARE | 611 | 40 | 461 | - | - | - | - | 14 | - | 96 | - | - | |
| FLORIDA | 13 474 | 2 036 | 1 655 | 2 167 | 1 247 | 1 710 | 261 | 200 | 598 | 57 | - | 49 | 3 [illegible] |
| GEORGIA | 3 199 | 350 | 549 | 1 572 | 666 | - | - | 62 | - | - | - | - | |
| HAWAII | 2 873 | 10 | 713 | - | 2 | - | 32 | - | - | 1 001 | 50 | 401 | |
| IDAHO | 1 690 | - | 975 | 1 | 34 | - | 5 | 128 | - | - | - | 19 | |
| ILLINOIS | 17 908 | 1 685 | 3 623 | 2 549 | 1 001 | 390 | 5 768 | 577 | 841 | 72 | - | 750 | |
| INDIANA | 4 089 | 1 700 | 1 033 | 387 | 664 | - | - | 14 | 12 | 100 | - | 178 | |
| IOWA | 2 097 | - | 1 161 | 224 | 400 | 73 | 35 | 70 | - | - | - | 65 | |
| KANSAS | 4 107 | 7 | 1 941 | 1 562 | 391 | 50 | - | - | 12 | 42 | - | - | |
| KENTUCKY | 6 670 | - | 1 257 | 234 | 1 032 | 90 | 9 | - | 184 | 72 | - | 3 757 | |
| LOUISIANA | 6 525 | - | 5 337 | - | 835 | - | - | 44 | - | 284 | - | 25 | |
| MAINE | 1 344 | 34 | 671 | - | 75 | - | 217 | 23 | 54 | 139 | - | - | [illegible] |
| MARYLAND | 8 996 | 1 016 | 1 456 | - | 236 | 132 | 5 144 | 484 | 477 | - | - | - | |
| MASSACHUSETTS | 3 286 | 862 | 183 | 499 | 1 013 | 188 | 115 | 104 | 10 | - | - | 105 | |
| MICHIGAN | 8 353 | 3 247 | 1 530 | 97 | 1 624 | 416 | - | 208 | 739 | - | - | 352 | |
| MINNESOTA | 4 199 | 60 | 1 588 | 26 | 705 | 303 | 150 | 808 | 10 | 214 | - | 185 | |
| MISSISSIPPI | 1 627 | 965 | 46 | 21 | 490 | 48 | 31 | - | - | - | - | 26 | |
| MISSOURI | 2 053 | - | 1 525 | - | 250 | 151 | - | 40 | - | 87 | - | - | |
| MONTANA | 2 861 | - | 650 | 44 | 98 | 303 | 588 | - | 177 | 23 | - | 978 | |
| NEBRASKA | 641 | 45 | 422 | - | 30 | - | - | - | 54 | 10 | - | - | |
| NEVADA | 1 084 | - | 655 | - | 54 | 375 | - | - | - | - | - | - | |
| NEW HAMPSHIRE | 1 210 | - | 410 | - | - | 752 | - | - | - | - | - | - | |
| NEW JERSEY | 8 497 | 281 | 558 | 423 | 677 | 922 | 343 | 598 | - | 4 253 | - | - | [illegible] |
| NEW MEXICO | 4 012 | - | 325 | - | 74 | - | - | - | 9 | - | - | 3 604 | |
| NEW YORK | 100 695 | 75 919 | 795 | 1 180 | 1 530 | 2 275 | 8 053 | 2 422 | 515 | 1 164 | - | 6 569 | |
| NORTH CAROLINA | 11 583 | 1 441 | 3 177 | 3 587 | 154 | - | 289 | 188 | 2 | 631 | - | 153 | [illegible] |
| NORTH DAKOTA | 1 832 | - | 663 | 318 | 62 | - | 348 | - | 292 | 76 | - | - | |
| OHIO | 7 228 | 332 | 1 341 | 299 | 870 | 58 | 566 | 126 | 53 | 11 | - | 3 529 | |
| OKLAHOMA | 1 453 | 372 | 462 | 136 | 256 | - | 180 | - | 29 | - | - | - | |
| OREGON | 6 070 | 30 | 2 320 | 1 942 | 49 | 60 | 501 | - | 99 | 59 | - | 422 | |
| PENNSYLVANIA | 9 264 | 2 660 | 993 | 1 654 | 1 917 | - | 401 | 640 | 183 | 401 | - | 304 | |
| RHODE ISLAND | 752 | - | - | 137 | 33 | 22 | - | 10 | - | 250 | - | 300 | |
| SOUTH CAROLINA | 4 974 | 590 | 3 197 | - | 85 | 411 | 19 | 84 | - | 128 | - | - | [illegible] |
| SOUTH DAKOTA | 1 262 | - | 1 089 | - | 19 | - | - | - | 153 | - | - | - | |
| TENNESSEE | 1 168 | 58 | 543 | 105 | 145 | 242 | - | 75 | - | - | - | - | |
| TEXAS | 11 836 | 1 328 | 3 968 | 205 | 2 203 | 426 | - | 298 | 146 | 37 | - | 458 | [illegible] |
| UTAH | 1 918 | 8 | 63 | 1 461 | 137 | 31 | 132 | 1 | - | - | - | 85 | |
| VERMONT | 188 | - | - | - | - | 131 | 46 | - | 11 | - | - | - | |
| VIRGINIA | 5 155 | 146 | 229 | 1 120 | 2 143 | 116 | 17 | 585 | 100 | 71 | - | - | |
| WASHINGTON | 12 062 | 140 | 2 892 | 89 | 1 334 | 5 356 | - | 901 | 188 | 24 | - | 292 | |
| WEST VIRGINIA | 859 | 124 | 137 | - | 119 | 56 | - | - | 180 | 202 | - | 40 | |
| WISCONSIN | 4 993 | 423 | 891 | 67 | 87 | 797 | - | 1 699 | 216 | 371 | - | 398 | |
| WYOMING | 716 | - | 586 | - | 23 | - | 29 | - | - | 48 | - | - | |

NOTE: Because of rounding, detail may not add to totals.

- Represents zero.

SOURCE: National Science Foundation

## Table B-3. State agency expenditures for research and development by State, source of funds, and R&D plant: FY 1977

(Thousands of dollars)

| State | Total research and development and R&D plant: Total | Total R&D and R&D plant: Federal Government sources | Total R&D and R&D plant: Own State sources[a] | Total R&D and R&D plant: Other sources[b] | Research and development: Total | Research and development: Federal Government sources | Research and development: Own State sources[a] | Research and development: Other sources[b] | R&D plant: Total | R&D plant: Federal Government sources | R&D plant: Own State sources[a] | R&D plant: Other sources |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL | 370 192 | 145 158 | 205 710 | 19 323 | 358 473 | 142 036 | 197 561 | 18 877 | 11 717 | 3 122 | 8 199 | 487 |
| ALABAMA | 1 359 | 926 | 418 | 15 | 1 227 | 827 | 385 | 15 | 132 | 99 | 33 | - |
| ALASKA | 7 855 | 3 867 | 3 787 | 201 | 7 655 | 3 842 | 3 612 | 201 | 200 | 25 | 175 | - |
| ARIZONA | 1 741 | 1 283 | 456 | 2 | 1 684 | 1 253 | 429 | 2 | 57 | 30 | 27 | - |
| ARKANSAS | 544 | 292 | 252 | - | 503 | 292 | 211 | - | 41 | - | 41 | - |
| CALIFORNIA | 37 832 | 13 317 | 23 740 | 775 | 37 496 | 13 245 | 23 659 | 592 | 336 | 72 | 81 | 183 |
| COLORADO | 9 648 | 7 997 | 1 614 | 37 | 9 620 | 7 974 | 1 609 | 37 | 28 | 23 | 5 | - |
| CONNECTICUT | 5 195 | 2 259 | 2 621 | 315 | 4 874 | 2 259 | 2 300 | 315 | 321 | - | 321 | - |
| DELAWARE | 696 | 471 | 225 | - | 611 | 409 | 202 | - | 84 | 62 | 22 | - |
| FLORIDA | 14 730 | 5 518 | 8 629 | 584 | 13 474 | 5 515 | 7 374 | 584 | 1 256 | 2 | 1 254 | - |
| GEORGIA | 3 201 | 1 950 | 1 251 | - | 3 199 | 1 948 | 1 251 | - | 2 | 2 | - | - |
| HAWAII | 3 370 | 532 | 2 795 | 43 | 2 873 | 532 | 2 298 | 43 | 497 | - | 497 | - |
| IDAHO | 1 690 | 1 083 | 595 | 13 | 1 690 | 1 083 | 595 | 13 | - | - | - | - |
| ILLINOIS | 18 380 | 6 932 | 10 995 | 453 | 17 908 | 6 892 | 10 563 | 453 | 472 | 40 | 432 | - |
| INDIANA | 4 101 | 1 430 | 2 670 | - | 4 089 | 1 430 | 2 658 | - | 12 | - | 12 | - |
| IOWA | 2 160 | 918 | 1 242 | - | 2 097 | 918 | 1 179 | - | 63 | - | 63 | - |
| KANSAS | 4 137 | 2 849 | 987 | 300 | 4 107 | 2 819 | 987 | 300 | 30 | 30 | - | - |
| KENTUCKY | 8 182 | 1 156 | 6 929 | 97 | 6 670 | 1 156 | 5 418 | 97 | 1 511 | - | 1 511 | - |
| LOUISIANA | 7 287 | 2 359 | 4 928 | - | 6 525 | 2 076 | 4 450 | - | 761 | 284 | 478 | - |
| MAINE | 1 349 | 672 | 670 | 7 | 1 344 | 671 | 666 | 7 | 5 | 1 | 4 | - |
| MARYLAND | 9 093 | 1 255 | 7 703 | 135 | 8 996 | 1 255 | 7 606 | 135 | 97 | - | 97 | - |
| MASSACHUSETTS | 3 550 | 1 402 | 2 075 | 73 | 3 286 | 1 374 | 1 839 | 73 | 264 | 28 | 236 | - |
| MICHIGAN | 8 574 | 3 390 | 4 911 | 273 | 8 353 | 3 312 | 4 797 | 244 | 221 | 78 | 114 | 29 |
| MINNESOTA | 4 247 | 1 160 | 3 035 | 52 | 4 199 | 1 160 | 2 987 | 52 | 48 | - | 48 | - |
| MISSISSIPPI | 1 627 | 719 | 909 | - | 1 627 | 719 | 909 | - | - | - | - | - |
| MISSOURI | 2 169 | 1 421 | 741 | 7 | 2 053 | 1 413 | 634 | 7 | 115 | 8 | 107 | - |
| MONTANA | 2 867 | 1 074 | 1 787 | 5 | 2 861 | 1 072 | 1 783 | 5 | 6 | 2 | 4 | - |
| NEBRASKA | 675 | 409 | 266 | - | 641 | 389 | 252 | - | 34 | 20 | 14 | - |
| NEVADA | 1 116 | 916 | 200 | 1 | 1 084 | 884 | 199 | 1 | 32 | 31 | 1 | - |
| NEW HAMPSHIRE | 1 292 | 1 001 | 291 | - | 1 210 | 940 | 270 | - | 82 | 61 | 21 | - |
| NEW JERSEY | 8 740 | 3 418 | 2 120 | 3 202 | 8 497 | 3 248 | 2 060 | 3 191 | 243 | 171 | 60 | 12 |
| NEW MEXICO | 4 501 | 1 540 | 2 635 | 326 | 4 012 | 1 306 | 2 380 | 326 | 489 | 234 | 255 | - |
| NEW YORK | 102 258 | 27 571 | 64 738 | 9 950 | 100 695 | 26 667 | 64 298 | 9 732 | 1 563 | 904 | 441 | 218 |
| NORTH CAROLINA | 11 703 | 5 749 | 5 141 | 814 | 11 583 | 5 693 | 5 076 | 814 | 120 | 55 | 65 | - |
| NORTH DAKOTA | 1 931 | 743 | 1 176 | 12 | 1 832 | 743 | 1 077 | 12 | 99 | - | 99 | - |
| OHIO | 7 239 | 1 882 | 5 313 | 44 | 7 228 | 1 882 | 5 302 | 44 | 11 | - | 11 | - |
| OKLAHOMA | 1 550 | 894 | 655 | - | 1 453 | 809 | 643 | - | 97 | 85 | 12 | - |
| OREGON | 6 160 | 4 212 | 1 840 | 108 | 6 070 | 4 212 | 1 750 | 108 | 90 | - | 90 | - |
| PENNSYLVANIA | 9 268 | 3 496 | 5 716 | 56 | 9 264 | 3 496 | 5 712 | 56 | 4 | - | 4 | - |
| RHODE ISLAND | 853 | 217 | 591 | 45 | 752 | 217 | 491 | 45 | 101 | 1 | 100 | - |
| SOUTH CAROLINA | 5 681 | 2 813 | 2 869 | - | 4 974 | 2 786 | 2 189 | - | 707 | 27 | 680 | - |
| SOUTH DAKOTA | 1 262 | 389 | 872 | - | 1 262 | 389 | 872 | - | - | - | - | - |
| TENNESSEE | 1 175 | 648 | 519 | 7 | 1 168 | 643 | 518 | 7 | 6 | 5 | 1 | - |
| TEXAS | 12 113 | 6 482 | 4 984 | 648 | 11 836 | 6 275 | 4 914 | 648 | 277 | 207 | 70 | - |
| UTAH | 2 332 | 1 254 | 1 058 | 20 | 1 918 | 1 099 | 803 | 15 | 415 | 155 | 255 | 5 |
| VERMONT | 188 | 88 | 100 | - | 188 | 88 | 100 | - | - | - | - | - |
| VIRGINIA | 5 501 | 2 119 | 3 305 | 76 | 5 155 | 2 119 | 2 959 | 76 | 346 | - | 346 | - |
| WASHINGTON | 12 184 | 9 214 | 2 660 | 310 | 12 062 | 9 116 | 2 637 | 310 | 121 | 98 | 23 | - |
| WEST VIRGINIA | 1 110 | 882 | 228 | - | 859 | 631 | 227 | - | 251 | 251 | - | - |
| WISCONSIN | 5 030 | 2 450 | 2 282 | 298 | 4 993 | 2 443 | 2 251 | 298 | 38 | 7 | 31 | - |
| WYOMING | 748 | 541 | 188 | 19 | 716 | 517 | 180 | 19 | 32 | 29 | 8 | - |

NOTE: Because of rounding, detail may not add to totals.

- Represents zero or less than $500.

[a] Includes own agency funds and funds provided by other agencies of the same State.

[b] Includes grants, reimbursements, or cost-sharing amounts provided by foundations, business firms, universities and colleges, or other outside sources, such as agencies of other State governments.

SOURCE: National Science Foundation

## Table B-7. State agency expenditures for research and development by State and field of science: FY 1977

(Thousands of dollars)

| State | Total | Biological sciences | Medical sciences | Psychology | Physical sciences | Environmental sciences | Mathematics and computer sciences | Engineering | Economics | Social sciences other than economics | Other sciences |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL | 358 473 | 114 840 | 41 883 | 10 315 | 10 072 | 38 300 | 6 938 | 42 727 | 15 100 | 63 389 | 14 909 |
| ALABAMA | 1 227 | 565 | - | 115 | - | 14 | 107 | 87 | - | 269 | 70 |
| ALASKA | 7 655 | 5 827 | - | - | - | - | - | 351 | 732 | 84 | 660 |
| ARIZONA | 1 684 | 402 | - | 110 | - | - | - | 593 | 271 | 180 | 128 |
| ARKANSAS | 503 | 105 | 13 | - | - | - | - | 215 | 89 | 27 | 54 |
| CALIFORNIA | 37 496 | 9 513 | 992 | 619 | 1 133 | 4 490 | 65 | 9 141 | 1 559 | 7 242 | 2 742 |
| COLORADO | 9 620 | 2 487 | - | - | - | 203 | - | 120 | 50 | 6 630 | 131 |
| CONNECTICUT | 4 874 | 2 211 | 46 | 177 | 28 | - | 50 | 729 | 98 | 1 083 | 453 |
| DELAWARE | 611 | 166 | 11 | 64 | - | 258 | 31 | - | 5 | 36 | 39 |
| FLORIDA | 13 474 | 5 324 | 50 | 1 018 | 27 | 144 | 131 | 2 020 | 1 781 | 2 978 | - |
| GEORGIA | 3 199 | 609 | 40 | 250 | - | - | - | 666 | 17 | 1 617 | - |
| HAWAII | 2 873 | 1 185 | - | 7 | - | 47 | - | 157 | - | 1 011 | 466 |
| IDAHO | 1 690 | 1 341 | - | - | 4 | 16 | - | 97 | 95 | 10 | 128 |
| ILLINOIS | 17 908 | 2 945 | 237 | 1 072 | 2 634 | 4 709 | - | 1 105 | 978 | 3 320 | 910 |
| INDIANA | 4 089 | 319 | 1 578 | 39 | 992 | - | 10 | 664 | 100 | 348 | 39 |
| IOWA | 2 097 | 582 | - | - | 68 | 616 | 6 | 459 | - | 367 | - |
| KANSAS | 4 107 | 1 494 | 1 | 12 | 280 | - | - | 662 | 62 | 1 554 | 42 |
| KENTUCKY | 6 670 | 1 556 | 3 | - | 516 | 458 | 72 | 3 556 | 186 | 248 | 76 |
| LOUISIANA | 6 525 | 5 143 | - | - | - | 94 | 130 | 805 | 25 | 284 | 44 |
| MAINE | 1 344 | 690 | - | 34 | - | 328 | 23 | 52 | 70 | 7 | 139 |
| MARYLAND | 8 996 | 683 | 661 | 248 | - | 5 965 | 42 | 224 | 503 | 654 | 13 |
| MASSACHUSETTS | 3 286 | 517 | 300 | 88 | - | 88 | 117 | 940 | 184 | 988 | 64 |
| MICHIGAN | 8 353 | 1 817 | 2 364 | 806 | - | 97 | 68 | 1 059 | 1 151 | 886 | 106 |
| MINNESOTA | 4 199 | 1 284 | 19 | 15 | 285 | 268 | 52 | 759 | 269 | 1 126 | 121 |
| MISSISSIPPI | 1 627 | 696 | 300 | - | - | 72 | - | 490 | - | 20 | 50 |
| MISSOURI | 2 053 | 1 343 | - | - | - | 142 | 40 | 250 | 104 | 121 | 14 |
| MONTANA | 2 861 | 534 | 450 | 55 | - | 345 | 46 | 966 | 336 | 79 | 51 |
| NEBRASKA | 641 | 436 | - | 25 | - | 66 | - | 30 | 58 | 26 | - |
| NEVADA | 1 084 | 635 | - | - | - | 30 | 375 | 24 | - | 20 | - |
| NEW HAMPSHIRE | 1 210 | 453 | - | - | - | 5 | 722 | - | - | 30 | - |
| NEW JERSEY | 8 497 | 952 | - | 434 | - | 536 | - | 484 | 110 | 2 817 | 3 164 |
| NEW MEXICO | 4 012 | 300 | - | - | 1 084 | 717 | - | 678 | 185 | - | 1 048 |
| NEW YORK | 100 635 | 37 522 | 32 257 | 2 213 | 1 493 | 10 261 | 3 735 | 4 167 | 1 543 | 7 113 | 392 |
| NORTH CAROLINA | 11 585 | 6 528 | 205 | 47 | 168 | 110 | 54 | - | 366 | 4 105 | - |
| NORTH DAKOTA | 1 832 | 379 | - | - | 12 | 596 | - | 62 | 346 | 409 | 29 |
| OHIO | 7 228 | 549 | 100 | 236 | 6 | 2 000 | 42 | 3 219 | 589 | 426 | 62 |
| OKLAHOMA | 1 453 | 480 | 355 | 18 | 40 | 281 | - | 93 | 86 | 100 | - |
| OREGON | 6 070 | 2 600 | 30 | 60 | - | 881 | - | 49 | 431 | 1 942 | 77 |
| PENNSYLVANIA | 9 264 | 649 | 533 | 720 | - | 1 753 | 120 | 1 859 | 365 | 1 887 | 1 378 |
| RHODE ISLAND | 752 | 72 | - | - | - | - | - | 311 | - | 169 | 250 |
| SOUTH CAROLINA | 4 974 | 3 503 | 548 | 230 | - | 71 | 128 | 67 | 69 | 267 | 92 |
| SOUTH DAKOTA | 1 262 | 429 | - | - | - | 640 | - | 19 | 21 | 153 | - |
| TENNESSEE | 1 168 | 398 | - | - | - | 255 | - | 55 | - | 460 | - |
| TEXAS | 11 836 | 4 275 | 381 | 431 | 1 303 | 548 | 17 | 2 513 | 640 | 1 394 | 335 |
| UTAH | 1 918 | - | 8 | 1 | - | 165 | - | 252 | - | 1 492 | - |
| VERMONT | 188 | - | - | 131 | - | 23 | - | 23 | 11 | - | - |
| VIRGINIA | 5 155 | 643 | - | 75 | - | 415 | 456 | 1 656 | 130 | 404 | 1 375 |
| WASHINGTON | 12 062 | 3 333 | 72 | 242 | - | 544 | 110 | 839 | 386 | 6 537 | - |
| WEST VIRGINIA | 859 | 137 | 35 | - | - | - | 54 | 65 | 105 | 373 | 89 |
| WISCONSIN | 4 993 | 991 | 247 | 725 | - | 3 | 136 | 84 | 633 | 2 093 | 80 |
| WYOMING | 716 | 249 | 49 | - | - | 43 | - | 13 | 362 | - | - |

NOTE: Because of rounding, detail may not add to totals.

- Represents zero or less than $500.

SOURCE: National Science Foundation

NATIONAL SCIENCE FOUNDATION
WASHINGTON D C 20550

# DRAFT STATE R&D SURVEY--1987 - FOR COMMENT

## SECTION I -- FUNDING OF RESEARCH AND DEVELOPMENT

1. Total R&D Expenditures (Distributed by type below)

   A. Current R&D Expenditures, Total $________

      Basic Research $________
      Applied Research $________
      Development $________

   B. R&D Plant $________

2. Total R&D Expenditures by Source
   Current R&D Expenditures--total should equal item 1A. $________

   A. Federal Government Sources $________
   B. Own Sources $________
   C. Industrial Sources $________
   D. Other --specify in "NOTES" $________

3. Total R&D Plant Expenditures by Source
   Current R&D Expenditures--total should equal item 1B. $________

   A. Federal Government Sources (See #5) $________
   B. Own Sources $________
   C. Industrial Sources $________
   D. Other--specify in "NOTES" $________

4. Total R&D Expenditures by Performer
   Current R&D Expenditures--total should equal item 1A. $________

   A. R&D work performed directly by State $________

   Grants, contracts, and reimbursements to:
   B. State universities and colleges $________
   C. Private universities and colleges $________
   D. Nonprofit organizations $________
   E. Private individuals or firms $________
   F. Other--specify in "NOTES" $________

5. Supporting Federal Agencies

Federal Total--total should equal item 3A. $__________

AGENCIES:

A. ____________________ $__________
B. ____________________ $__________
C. ____________________ $__________
D. ____________________ $__________
E. Other--specify in "NOTES" $__________

6. Total R&D Expenditures by Field of Science/Engineering (Estimates are acceptable.)

Current R&D Expenditures--total should equal item 1A. $__________

A. Medical Sciences $__________
B. Biological Sciences $__________
C. Psychology $__________
D. Physical Sciences $__________
E. Environmental Sciences $__________
F. Mathematics $__________
G. Computer Sciences $__________
H. Engineering $__________
I. Social Sciences $__________
J. Other sciences not elsewhere classified $__________

7. Total R&D Expenditures by Functional Area

A. Health $__________
B. Natural Resources $__________
C. Education $__________
D. Transportation $__________
E. Income Security and Social Services $__________
F. Environment $__________
G. Crime Prevention and control $__________
H. Economic Growth and Productivity $__________
I. Area/community development & Public Service $__________
J. Science and Technology base $__________
K. Energy $__________
L. Food, fiber, & other agricultural products $__________

# Enhancing the Economic Output of the Federal Laboratories: New Initiatives

## "Overview of Technology Transfer Legislation and Programs"

presented by

Mr. Norm Peterson
Strategic Planning Group
Argonne National Laboratory

## FEDERAL LEGISLATION ON TECHNOLOGY TRANSFER

- 0 STEVENSON-WYDLER ACT: PL 96-480 (1980)
  - ESTABLISHED OFFICES OF RESEARCH & TECHNOLOGY APPLICATIONS, (ORTA) AND CENTER FOR UTILIZATION OF FEDERAL TECHNOLOGY (CUFT)
- 0 BAYH-DOLE BILL: PL 98-620 (1984)
  - ESTABLISHED NEW PATENT RIGHTS TO INVENTIONS BY SMALL BUSINESS FIRMS AND NONPROFIT ORGANIZATIONS
- 0 FEDERAL TECHNOLOGY TRANSFER ACT: PL 99-502 (1986)
  - COOPERATIVE R&D AGREEMENTS
  - EXTENDS PATENT POLICY TO CIVIL SERVICE LABS
  - INSTITUTIONALIZES THE FEDERAL LAB CONSORTIUM

MCS 106981

# FEDERAL TECHNOLOGY TRANSFER ACT OF 1986

## (P.L. 99-502)

Signed by President in October, 1986

## I. MAJOR FEATURES

- GIVES LABORATORY DIRECTORS LATITUDE TO ENTER INTO COOPERATIVE RESEARCH AGREEMENTS WITH OTHER AGENCIES, INDUSTRY AND UNIVERSITIES

- AUTHORIZES DISTRIBUTION OF ROYALTY INCOME FROM LICENSING AND ASSIGNMENT OF PATENTS DIRECTLY TO THE INVENTORS AND THE LABORATORIES PRODUCING THEM

- MAKES TECHNOLOGY TRANSFER A JOB REQUIREMENT OF EVERY LABORATORY SCIENTIST AND ENGINEER

- INCREASES OFFICE OF RESEARCH TECHNOLOGY ASSESSMENT (ORTA) INVOLVEMENT IN OVERALL LAB MANAGEMENT DEVELOPMENT PROGRAM

- PROVIDES HOME FOR THE FEDERAL LABORATORY CONSORTIUM (FLC) WITHIN THE NATIONAL BUREAU OF STANDARDS

- [illegible]

# FEDERAL TECHNOLOGY TRANSFER ACT OF 1986

## DEFINITION: COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT

*"(1) THE TERM 'COOPERATIVE RESEARCH AND DEVELOPMENT AGREEMENT' MEANS ANY AGREEMENT BETWEEN ONE OR MORE FEDERAL LABORATORIES AND ONE OR MORE NON-FEDERAL PARTIES UNDER WHICH THE GOVERNMENT, THROUGH ITS LABORATORIES, PROVIDES PERSONNEL, SERVICES, FACILITIES, EQUIPMENT, OR OTHER RESOURCES WITH OR WITHOUT REIMBURSEMENT (BUT NOT FUNDS TO NON-FEDERAL PARTIES) AND THE NON-FEDERAL PARTIES PROVIDE FUNDS, PERSONNEL, SERVICES, FACILITIES, EQUIPMENT, OR OTHER RESOURCES TOWARD THE CONDUCT OF SPECIFIED RESEARCH OR DEVELOPMENT EFFORTS WHICH ARE CONSISTENT WITH THE MISSIONS OF THE LABORATORY; EXCEPT THAT SUCH TERM DOES NOT INCLUDE A PROCUREMENT CONTRACT OR COOPERATIVE AGREEMENT AS THOSE TERMS ARE USED IN SECTIONS 6303, 6304, AND 6305 OF TITLE 31, UNITED STATES CODE."*

## P.L. 98-620
## IMPLEMENTATION AT ARGONNE

- UNIVERSITY OF CHICAGO AND DOE SIGN NEW CONTRACT TO OPERATE ARGONNE, WITH NEW PATENT LANGUAGE, JUNE 1987

- ABOUT 40 PATENTS WAIVED TO UNIVERSITY OF CHICAGO

- ARCH DEVELOPMENT CORPORATION FORMED IN 1985. PRESIDENT APPOINTED OCTOBER, 1986.

- ARCH COMPLETES FIRST LICENSING DEAL WITH ARGONNE TECHNOLOGY, JULY 1987.

- ARGONNE PUBLISHES LIST OF PATENTS AVAILABLE FOR LICENSING: UPDATED ANNUALLY.

## MECHANISMS OF TECHNOLOGY TRANSFER FROM DOE LABORATORIES

COOPERATIVE R&D AGREEMENTS

CONSORTIA

AFFILIATES PROGRAMS

WORK-FOR-OTHERS (CONTRACT RESEARCH BY LABS)

SUBCONTRACTS (INDUSTRY WORKS FOR LABS)

INDUSTRY RESIDENCIES

USE OF MAJOR FACILITIES

LICENSING OF PATENTS

# TECHNOLOGY TRANSFER AT ANL

- Cooperation with single companies
- Assistance to small technology-based businesses
- Patents and inventions: ARCH
- Industry-wide initiatives
- Encouragement of commercialization

# ARGONNE - UNIVERSITY OF CHICAGO DEVELOPMENT CORPORATION (ARCH)

A not-for-profit institution that takes title to inventions/patents from Argonne and University of Chicago

- Exploits inventions by:
  - licensing to existing businesses
  - starting new companies

- Revenues used for:
  - operating expenses of ARCH
  - awards to inventors
  - development of inventions to commercialization (possibly cost-shared with firms)

- Modified contract signed June 5, 1987

# TECHNOLOGY TRANSFER TO SMALL BUSINESSES

- State grant established ANL as a state technology commercialization center
- Worked with over 100 small businesses on:
  - technology assistance
  - access to Laboratory facilities
  - advice on state financial help
  - how to apply for SBIR awards
- Argonne Regional Consortium
- Licensing/Ventures

# INTERACTION WITH SINGLE COMPANIES

- Work for Others
  - Cabot Corporation: Packing of powders
  - Bethlehem Steel: Strip casting
  - McDonalds: Heat transfer in frying
  - Gould: Vehicle battery

- Staff Exchange
  - Exxon Corporation: Mathematics
  - Allied Signal: Ceramics
  - Schlumberger-Doll: Use of IPNS
  - Dow: Residency program

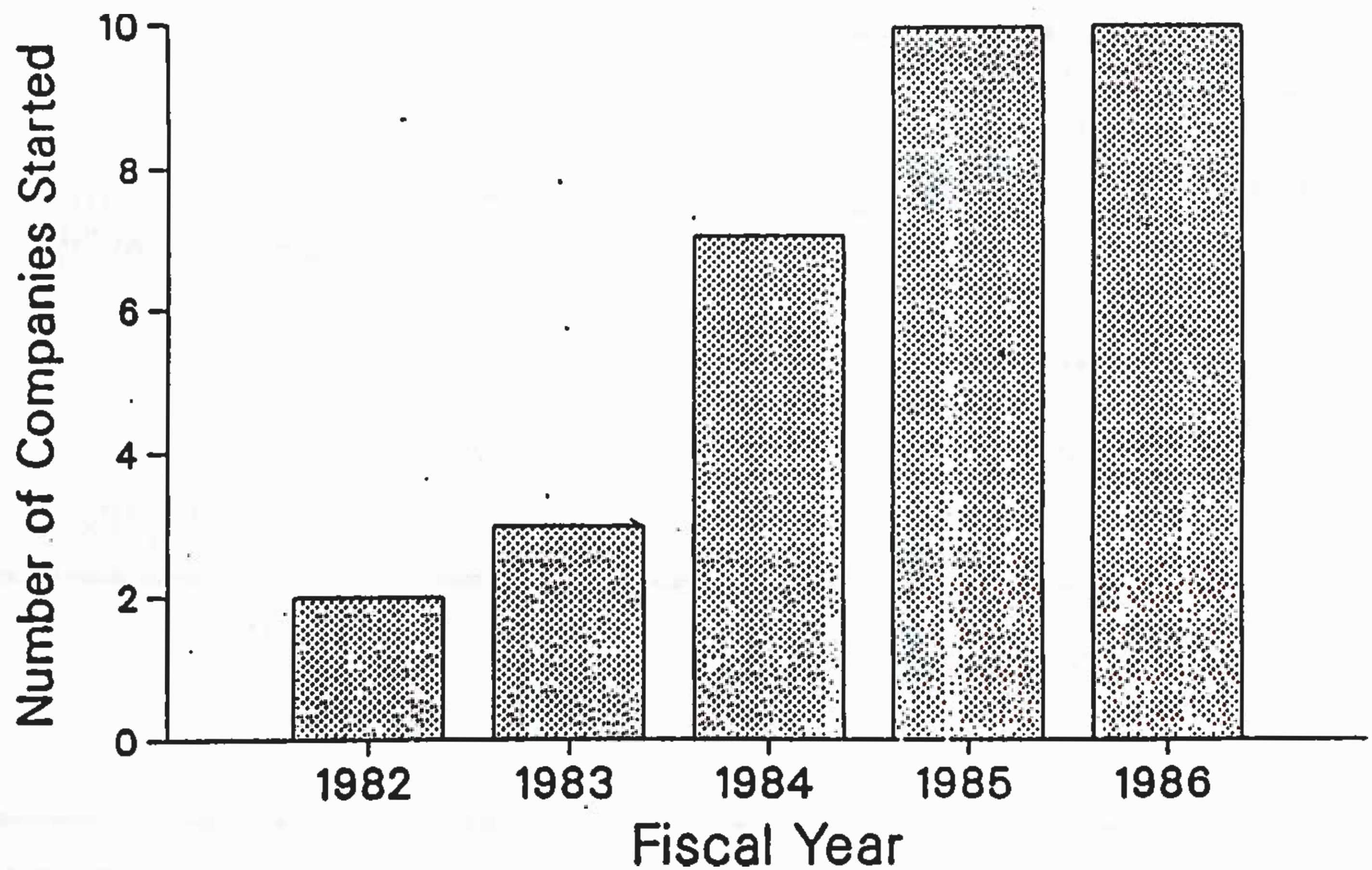
# ARGONNE's NEW INITIATIVES WITH INDUSTRY

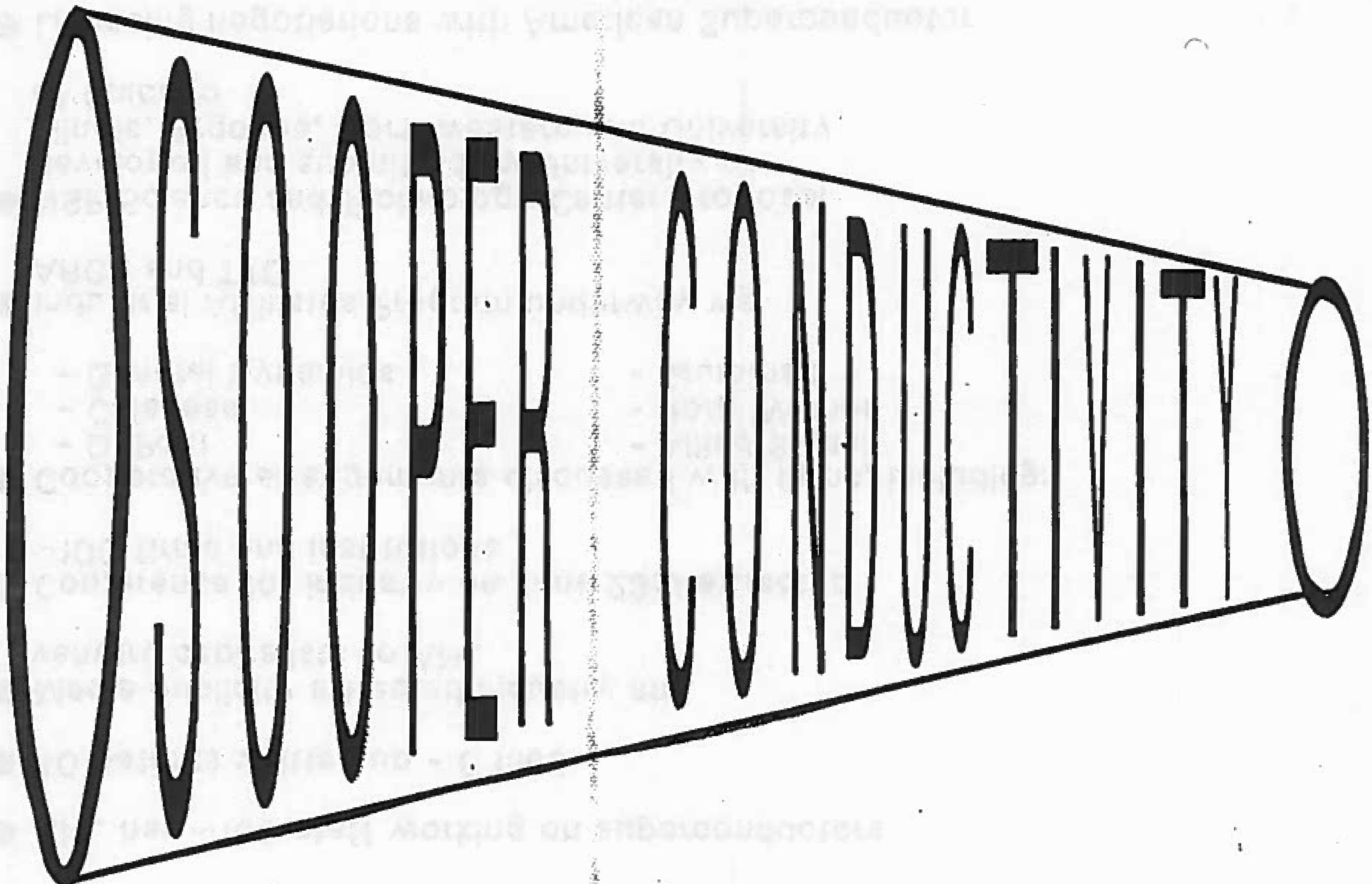
- Generic technology to assure the long-term competitiveness of basic industries in the USA
- Strong Illinois and Midwest focus
- Midwest industry will be the major benefactor

# INDUSTRY-WIDE INITIATIVES

| Initiative | Purpose |
| --- | --- |
| Steel Initiative | To develop new processes giving economic "edge" to U.S. industry |
| Midwest Plant Biotechnology Consortium | To develop/transfer results of basic research to industry such that new products/processes result |
| COMMIX | Computer modeling for metals casting (Ford, Cummins, Dohler-Jarvis, Kohler, CWC Textron, etc.) |

# SPIN-OFF BUSINESSES STARTED BY LAB EMPLOYEES




SOOPER CONDUCTIVITY

# HIGH $T_c$ SUPERCONDUCTORS

- ANL has ~100 staff working on superconductors
- 40 patents written up - 8 filed
- Media publicity attracted industry and venture capitalists to ANL
- Conference for industry on June 23rd attracted ~100 firms and institutions
- Cooperative arrangements discussed with firms, including:
  - DuPont
  - Celanese
  - General Dynamics
  - Allied Signal
  - Borg Warner
  - Grumman
- Industrial Affiliates Program underway via ARCH and TTC
- NSF Science and Technology Center proposal developed and submitted by University of Illinois, Argonne, Northwestern and University of Chicago
- Licensing negotiations with American Superconductor

# Enhancing the Economic Output of the Federal Laboratories: New Initiatives

presented by

Mr. Ray Gilbert, Manager
Applications Engineering
National Aeronautics and Space Administration
Technology Utilization Division

National Aeronautics and
Space Administration

# BRIEFING TO

NATIONAL GOVERNOR'S ASSOCIATION MEETING

RAY L. GILBERT
APRIL 29, 1988

NASA

TECHNOLOGY UTILIZATION PROGRAM MANDATE
SPACE ACT (1958)

# *Space Act Provides For:*

| | |
|---|---|
| Section 305(B) | New Technology Reporting on any Invention, Discovery, Improvement, or Innovation |
| Section 203(A)(B) | Widest Practical and Appropriate Dissemination of Information on New Technology |
| Section 102(F) | Application of NASA's Capabilities and Competance to Development and Demonstration Programs |

NASA

# Executive Order 12591

APRIL 1987

- Technology Share Program - Establishment of consortia of universities and private companies centered around a federal laboratory for purpose of promoting long-term national competitiveness.
- Requires agency heads to identify and encourage those persons and organizations best capable of promoting technology transfer for commercial use.

NASA

# Technology Transfer Act of 1986 (P.L. 99-502)

- Technology transfer is a responsibility of each scientist and engineer as a part of their position description in addition to being a criteria for promotion.

- Provides other federal agencies the flexibility and opportunity that NASA had under the Space Act - to be able to enter into cooperative agreements with outside organizations.

- Requires agencies to reward inventors by participation in return flow of royalty income.

- Encourages recognition of those persons sucessfully contributing to technology transfer activities.

- Allows participation of federal agencies in activities involving local & state governments, universities, and private sector companies for purposes of economic development.

# PROGRAM OBJECTIVES

- Accelerate Application and Use of Aeronautics and Space Technology by the Private Sector
- Facilitate Multiple Secondary Uses and Application of NASA Technology by Public and Private Sector and Academia
- Continue to Improve NASA Technology Transfer Process
- Promote Application of NASA Expertise and Capabilities to Non-Aerospace Needs of the Nation

NASA

# TECHNOLOGY UTILIZATION DIVISION

## *WHAT WE DO*

- **Acquisition, Dissemination, & Network Operations**
  - New Technology Reporting, Evaluation, & Preparation
    - 2 Contractors Involved (900 New Technologies / Year)

  - 10 Industrial Applications Centers (IACs)
    - 10 Contractors Involved (Mostly University Based) with 10,000 Industries / Clients Served per Year

  - 1 Computer Software Managent & Information Center ( 1500 Software Programs )
    - 1 Contractor Involved

  - Automation & Systems Integration
    - Technology Utilization Network System (All Field Centers & IACs Involved)
    - 1 Contractor Involved (Development, Integration, & Testing

NASA

# TECHNOLOGY UTILIZATION DIVISION

## *WHAT WE DO*

- **Acquisition, Dissemination, & Network Operations (Cont.)**
  - Technology Utilization Officers / Counselors
    - 5 IAC Contractors Involved at Field Centers (Value-added Engineering)
    - Technology Utilization/Transfer Office at Each Field Center
  - Industrial Applications Center Affiliates (Nationwide)
    - 30 State Assistance Centers (On-board)
    - 12 State Assistance Centers (Being Negotiated)
    - All Industrial Applications Centers Involved
  - Small Business Technology Transfer Operations
    - Developing Agreement with Small Business Administration
    - 51 Small Business Development Centers Affiliates (parents) Involved
    - Over 500 Small Business Development Centers Affiliates Involved

NASA

# TECHNOLOGY UTILIZATION DIVISION

## *WHAT WE DO*

- **Technology - Engineering Applications**
  - Applications Engineering Projects (60 at Field Centers)
    - Automation & Robotics (10%)
    - Bioengineering / Biotechnology (30%)
    - Advanced Materials / Composites (15%)
    - Electronics / Semiconductors (25%)
    - Rehabilitation (20%)

  - Technology Applications Teams
    - 2 Contractors Involved to Assist Field Centers with Applications Projects
    - Broker & Go-between at Field Centers and Industrial Clients / Other Government Organizations

NASA

## TECHNOLOGY UTILIZATION DIVISION
### *WHAT WE DO*

- **Project Development**
  - Publications & Printing (Bi-monthly NASA Tech Briefs Journal and Annual Spinoff Magazine)
    - 2 Contractors Involved
  - Brouchures / Films / Exhibits
    - 2 Contractors Involved
  - Commercialization Database / Software Development
    - 3 Contractors Involved

- **Industrial Outreach**
  - All Industrial Applications Centers
    - Industry / Trade Exhibits, Shows, & Expos
  - Market Development (Terrestrial Applications)
  - Industrial Associations / Professional Societies
  - AdaNET Software Repository
  - Commercialization Support (All IACs, Boeing Aerospace, and AIAA)
  - Federal Laboratory Consortium Network (Over 600 R&D Federal Labs Involved)

NASA

## TECHNOLOGY UTILIZATION DIVISION

### *WHAT WE DO*

- **Program Development, Evaluation, & Coordination**
  - Scientific Technical Information Facility Support
    - Technical Support Packages (TSPs) for Tech Briefs
    - Dissemination of Publications (Tech Briefs, Spinoff Magazine, TSPs)
    - Database Enhancements
    - Spinoff Case Development, Documentation, & Review
    - Surveillance of Tech Briefs Users
    - 1 Contractor Involved - Handles Approximately 1 Million Inquiries per Year

  - Market Assessment / Research
    - Industry, State, and Local Organizations
    - Assess Technology Needs and Technology Gaps
    - 2 Contractors Involved

  - Contract / Institutional Support
    - Institutional Management Support
    - Federal Laboratory Consortium Institutional Support
    - Defense Contract Administration Support

NASA

# TECHNOLOGY UTILIZATION
## DISSEMINATION MECHANISMS (History)

- NASA Tech Briefs Established in 1963
- First Industrial Application Center Established in 1963
- COSMIC (Computer Software Management Center) Established in 1966
- NASA SPINOFF Magazine Established in 1976
- NASA Average Yearly Expenditure Approximately $5.0M Over Last 10 Years
- Benefit to Cost Ratio of 14:1

NASA

# NASA Milestones in Technology Transfer
## Dissemination History

- **Tech Briefs**
  - One-page summaries of technological breakthroughs for broad distribution to industry (1963-1976)
  - In 1976, changed format to quarterly magazine
  - Currently published bi-monthly by industrial publisher with distribution of over 200,000 readers
  - 12,892 Tech Briefs published from 1963 to 1987

- Industrial Application Centers
  - First established in 1963 under agreement with University of Indiana
  - Currently 10 IACs
  - Provide assistance in technological searching and access to industrial engineers and scientists for U.S. businesses

NASA

## NASA Milestones in Technology Transfer
## Dissemination History

- **COSMIC**
  - Dissemination of NASA computer software programs
  - Established in 1966 via bilateral agreement with University of Georgia as distributor of software from Marshall Space Flight Center
  - Range broadened in 1968 to include distribution of all NASA-developed software to both NASA field centers and private users
  - NASA centers use 25% of documented COSMIC programs

- **Spinoff Magazine**
  - Initiated in 1976 as an upgraded version of the annual TU report providing a more graphic and dramatic presentation of sucessful transfers
  - Over 500 transfer cases reported up to 1988
  - Space Benefits, a related publication, was initiated simultaneously and provides vignettes on a wide variety of transfer cases and the benefits derived from them
  - Annual publication of 45 to 60 SPINOFF cases

NASA

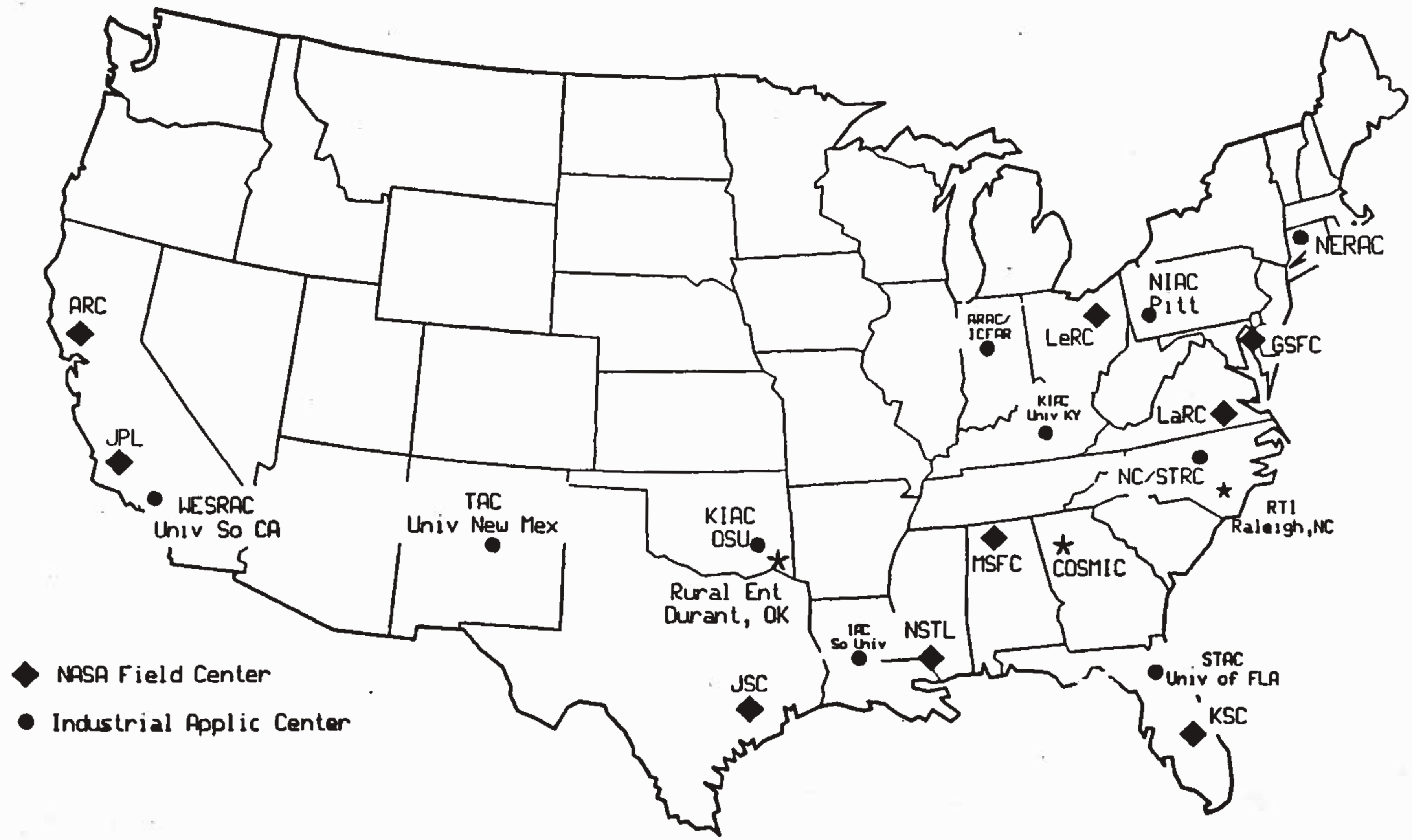
# TECHNOLOGY UTILIZATION DISSEMINATION CENTERS

## OBJECTIVES

- Provide Means for Acquisition, Dissemination, and Application of NASA Technology
- Provide Private Sector Access to NASA Technical and Management Information
- Utilize NASA Capabilities to Solve Private Sector Problems
- Contribute to Private Sector Development of New Businesses and Expanded Product Lines

NASA

# TECHNOLOGY UTILIZATION DISSEMINATION/APPLICATION NETWORK



NASA

# TOTAL TSPs BY YEAR
## 1964 - 1984

| Calendar Year | Number of TSPs |
|---|---|
| 1964 | 3507 |
| 1965 | 6105 |
| 1966 | 8268 |
| 1967 | 9878 |
| 1968 | 13451 |
| 1969 | 9452 |
| 1970 | 16996 |
| 1971 | 51731 |
| 1972 | 68144 |
| 1973 | 40485 |
| 1974 | 32108 |
| 1975 | 28105 |
| 1976 | 53602 |
| 1977 | 125586 |
| 1978 | 63312 |
| 1979 | 190325 |
| 1980 | 212045 |
| 1981 | 151866 |
| 1982 | 78180 |
| 1983 | 54415 |
| 1984 | 71522 |
| 1985 | 83113 |
| 1986 | 60152 |
| 1987 | 107994 |
| ***Total:*** | ***1,540,360*** |

***Average Total per Year:***

***64,182***

NASA

# TECHNOLOGY UTILIZATION
# INDUSTRIAL OUTREACH

## OBJECTIVE

To encourage private sector investment in products, services, and opportunities offered by NASA in Commercial Uses of Space (CUS), Technology Utilization, and Small Business Innovation Research (SBIR) programs.

## GOALS

CUS • Foster cooperative activities in space-related research for commercial purposes

TU • Encourage the effective application and use of NASA technology in industry

SBIR • Enhance submittal of effective innovative proposals to further the scientific and technical needs of the Agency through SBIR grants

NASA

# NEW TECHNOLOGY REPORTING

## 1964 - 1984

| Calendar Year | Contractor (Inc. JPL) | NASA (Inc. HQ not JPL) | Total |
|---|---|---|---|
| 1964 | 311 | 427 | 738 |
| 1965 | 864 | 218 | 1082 |
| 1966 | 2996 | 328 | 3324 |
| 1967 | 3631 | 477 | 4108 |
| 1968 | 4038 | 642 | 4680 |
| 1969 | 3263 | 664 | 3927 |
| 1970 | 3121 | 473 | 3594 |
| 1971 | 2475 | 430 | 2905 |
| 1972 | 2609 | 369 | 2978 |
| 1973 | 1560 | 338 | 1898 |
| 1974 | 1089 | 348 | 1437 |
| 1975 | 1201 | 359 | 1560 |
| 1976 | 1326 | 497 | 1823 |
| 1977 | 1354 | 562 | 1916 |
| 1978 | 1473 | 305 | 1778 |
| 1979 | 1475 | 314 | 1789 |
| 1980 | 1140 | 488 | 1628 |
| 1981 | 1085 | 543 | 1628 |
| 1982 | 919 | 491 | 1410 |
| 1983 | 840 | 381 | 1221 |
| 1984 | 712 | 362 | 1074 |
| 1985 | 712 | 447 | 1159 |
| 1986 | 899 | 500 | 1399 |
| 1987 | 417 | 310 | 727 |
| **Totals:** | **39,430** | **10,273** | **49,783** |

NASA

# TECH BRIEF CONTRIBUTION OF NASA TECHNOLOGY TO SPINOFF

- 48,783 New Technology Reports from 1964 to 1987
- 12,892 of These New Technology Reports Published in Tech Briefs
- In Response to Published Tech Briefs, 1,540,360 Requests for Technology Support Packages Received

NASA

# TECHNOLOGY UTILIZATION
## SPINOFFS 1976 - 1987

| *CATEGORY* | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | Tot |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Transportation | 4 | 6 | 4 | 6 | 5 | | 6 | | 7 | | 4 | 2 | 44 |
| Manuf Technology | 5 | 3 | | 8 | 6 | 8 | 7 | 6 | 11 | 11 | 8 | 7 | 80 |
| Health & Medicine | 12 | 11 | 8 | 7 | 5 | 5 | 6 | 6 | 5 | 8 | 8 | 5 | 86 |
| Public Safety | 7 | 7 | 8 | 7 | 5 | 7 | 7 | 4 | 3 | 5 | 3 | 3 | 66 |
| Construction | 5 | 4 | 10 | 5 | 6 | | | 5 | | 9 | | | 44 |
| Environ/Resrc Mgmt | 8 | 5 | | | 7 | | | 4 | | 5 | 5 | 6 | 40 |
| Energy | 3 | | | 6 | 7 | 9 | | 5 | | 6 | 6 | 8 | 50 |
| Food & Agriculture | | 5 | 4 | | 5 | | | | | | 5 | | 19 |
| Home/Consumer Rec | 12 | 1 | 11 | 5 | 5 | 4 | 5 | 6 | 4 | 5 | 5 | 7 | 70 |
| Community Services | | | 8 | 10 | 4 | 5 | | | | | | | 27 |
| Computer Processes | | | | | | | | | | | | | |
| Comm Remote Sensing | | | | | | | 5 | | | | | | 5 |
| Technology Demos | | | | | | | 7 | 4 | 7 | | | | 18 |
| ***Totals:*** | 56 | 42 | 53 | 54 | 55 | 38 | 43 | 40 | 37 | 49 | 44 | 38 | 549 |

# TRACKING SUCCESS
# TECHNOLOGY TRANSFER SPINOFF

- Clipping Services
  - Daily & Weekly U.S. Newspapers
  - Trade Press
- TU Officers
- IAC Directors
- COSMIC
- Technology Applications Teams
- Technology Support Package (TSP) Followup

NASA

# APPLICATIONS
# TECHNOLOGY TRANSFER PROCESS

- Requirements
  - Other Federal or Mission Agencies (VA,NIHR, NIA, etc)
  - NASA Applications Teams (RTI and REI)
  - Private Sector

- Feasibility
  - Understand the Problem
  - Determine Available Technology
  - Determine if Match of Technology to Problem is Likely

- Project
  - Selection of Manufacturer
  - Test, Demonstration, and Evaluation
  - Commercialization

NASA

# NASA Milestones in Technology Transfer
## Applications History

- **Technology Applications Teams**
  - Established in 1971 to provide assistance from specialized group of experts
  - Currently two TA teams operating:
    - Research Triangle Institute
    - Rural Enterprises, Inc.

- Technology Counselors
  - **Initiated in 1978 to provide a more direct link between IACs and NASA field centers**
  - Typically retired scientists or engineers who are familiar with center and know programs and personnel

NASA

## NASA Milestones In Technology Transfer
## Applications History

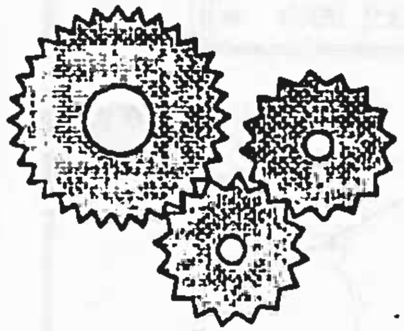
- **Application Engineering Projects**
  - Established in 1970 to provide direct NASA assistance & primary funding to promote secondary use of aerospace technology
  - Involves cooperative efforts to build and test prototype hardware if industrial partner agrees to provide partial funding and is prepared to complete marketing of transfer
  - Over 150 projects initiated with 75 sucessful transfers completed
    - Automation - 10%, Bioengineering - 40%
      Materials - 10%, Electronics - 20%,
      Rehabilitation - 20%

NASA

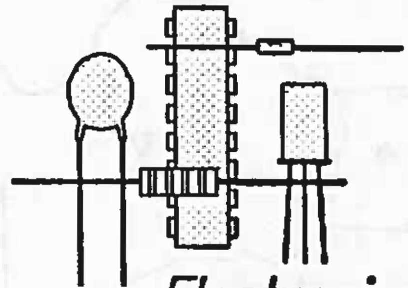
# TECHNOLOGY UTILIZATION
## APPLICATIONS MECHANISMS (History)

- Applications Engineering Projects Established in 1970
- Technology Application Teams Established in 1971
- Technology Counselors Established in 1978
- NASA Average Yearly Expenditure Approximately $4.0M Over Last 10 Years
- Benefit to Cost Ratio of 8:1

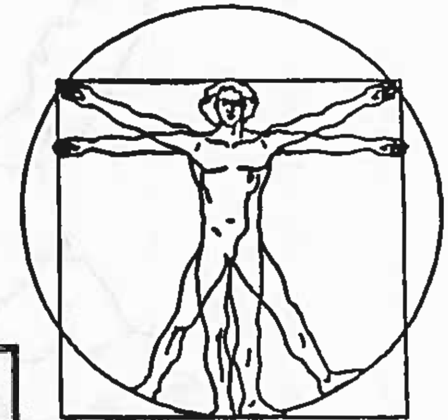
# NASA TECHNOLOGY APPLICATIONS



Automation



Electronics



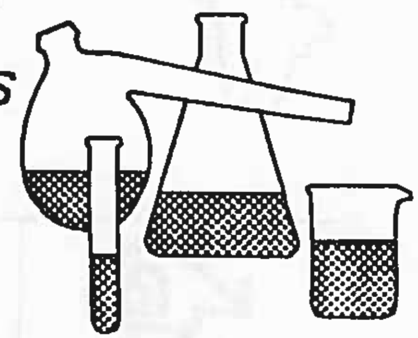
Bioengineering

## TECHNOLOGY APPLICATIONS OBJECTIVE

*To Promote the Application of Aeronautics and Space Technology Through Cooperative Programs*

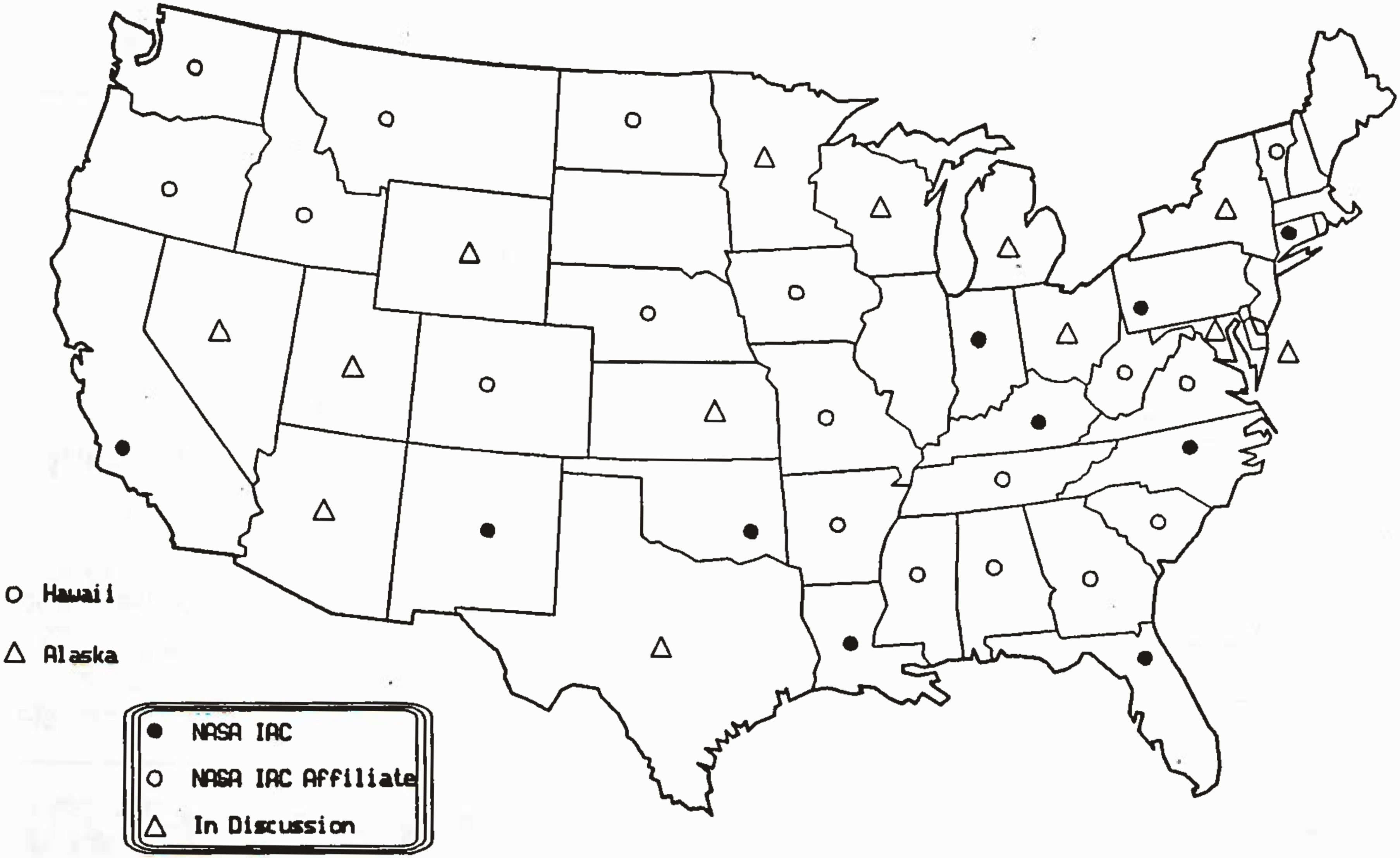
Rehabilitation

Materials



NASA

# NASA INDUSTRIAL APPLICATIONS AFFILIATE PROGRAM



NASA

# TECHNOLOGY UTILIZATION
# IAC TERRITORIAL ASSIGNMENTS

| | |
|---|---|
| ARAC - | Indiana, Illinois, Missouri, Iowa, Michigan, Wisconsin, Minnesota |
| KIAC - | Oklahoma, Texas, Kansas, Nebraska, South Dakota, North Dakota |
| NC/STRC - | North Carolina, South Carolina, Virginia, Tennesee, West Virginia |
| WESRAC - | California, Nevada, Idaho, Oregon, Hawaii, Washington, Alaska |
| STAC - | Florida, Georgia, Alabama, Mississippi, Arkansas |
| UKTAP - | Kentucky |
| NERAC - | Connecticut, New York, Massachusetts, Rhode Island, New Hampshire, Maine, Vermont, New Jersey |
| TAC - | New Mexico, Arizona, Utah, Wyoming, Colorado, Montana |
| NIAC - | Pennslyvania, Ohio, Maryland, Delaware |
| SU IAC - | Louisiana |

# TECHNOLOGY UTILIZATION
## INDUSTRIAL APPLICATION CENTERS

| *NAME* | *ACRONYM* | *AFFILIATION* | *LOCATION* |
|---|---|---|---|
| Aerospace Research Application Center | ARAC | ICFAR/INDIANA UNIVERSITY | INDIANAPOLIS,IN |
| Computer Software Management Center | COSMIC | UNIVERSITY OF GEORGIA | ATHENS,GA |
| Kerr Industrial Applications Center | KIAC | SOUTHEASTERN OKLAHOMA STATE UNIVERSITY | DURANT,OK |
| NASA Industrial Applications Center | NIAC | UNIVERSITY OF PITTSBURGH | PITTSBURGH,PA |
| New England Research Applications Center | NERAC | *NOT FOR PROFIT* | STORRS,CT |
| N. Carolina Science & Tech Research Center | NC/STRC | UNIVERSITY OF NORTH CAROLINA | RALEIGH-DURHAM,NC |
| Southern Technology Application Center | STAC | UNIVERSITY OF FLORIDA | GAINESVILLE,FL |
| Technology Applications Center | TAC | UNIVERSITY OF NEW MEXICO | ALBUQUERQUE,NM |
| NASA/UK Technology Applications Program | UKTAP | UNIVERSITY OF KENTUCKY | LEXINGTON,KY |
| NASA Industrial Applications Center | WESRAC | UNIVERSITY OF SOUTHERN CALIFORNIA | LOS ANGELES,CA |
| NASA Industrial Applications Center | SU-IAC | SOUTHERN UNIVERSITY | BATON ROUGE,LA |

# Foreign Trade Opportunities for State Technology Programs

presented by

Dr. Robert Yuan
Senior Advisor in Biotechnology
U.S. International Trade Administration

## THE INTERNATIONAL EXPERIENCE IN TECHNOLOGY TRANSFER

**Dr. Robert Yuan**

**Senior Adviser in Biotechnology to the U.S. International Trade Administration**

**REMARKS TO**
**THE NATIONAL CONFERENCE ON COLLABORATIVE INITIATIVES**
**IN BIOTECHNOLOGY**
**NOVEMBER 2, 1987**

## THE INTERNATIONAL EXPERIENCE IN TECHNOLOGY TRANSFER

Technology transfer is the process by which research findings are introduced into the industrial sector and converted into new products and processes. Recently, the International Trade Administration, U.S. Department of Commerce, has carried out a series of studies on biotechnology in Western Europe and the Far East.

In this paper, the mechanisms of technology transfer will be reviewed with special emphasis being placed on biotechnology centers. The implications of such developments for state initiatives in biotechnology will be explored.

### I. MECHANISMS OF TECHNOLOGY TRANSFER

The principal mechanism for technology transfer in the United States is the creation of new biotechnology companies. Most of these are spinoffs from work carried out in university laboratories and research institutes. Western Europe, in general, and the U.K. in particular, have experimented with more mechanisms of technology transfer than any other region of the world. The newly industrializing countries of the Pacific Rim are starting from a weak research base and concentrating their efforts on technology transfer. Table 1 summarizes the mechanisms for technology transfer observed in Western Europe and the Far East. It cannot be overemphasized that the success or failure of a specific form of technology transfer is a function of a given society and is not necessarily applicable to a different country and a different culture.

#### 1. Institutional Mechanisms

These mechanisms involve long-term commitments and large budgets. The justification for these is that certain types of R&D require an interdisciplinary approach and long-term funding. Government institutes include the network of TNO institutes (Netherlands), the transfer centers (France) and the GBF (West Germany). These institutes have focused on specific research problems (e.g. food processing, waste treatment) and tried to develop joint projects with industry. The Genetic Engineering Research Center (South Korea) and the Development Center for Biotechnology (Taiwan) receive a major portion of the government funds for biotechnology. Though their principal mission is the application of basic research, their first goal has been the introduction of the new technologies from abroad.

Swiss industry has invested heavily in private research institutes such as the Miescher Institute (Ciba-Geigy) and the Roche Institute of Molecular Biology. Though such institutes have done first class research, there have been serious questions as to the effectiveness of the technology transfer. South Korea has also established a large number of private research institutes, and an increasing number of those are in biotechnology. However, recruitment of qualified staff remains a major problem. The Battelle institutes in Frankfurt and Geneva are part of the U.S. not-for-profit organization that does contract R&D for government and industry. It is felt that in biotechnology, they have not been competitive with the small biotechnology companies. Cambridge and

**TABLE 1**

**MECHANISMS OF TECHNOLOGY TRANSFER**

1. Institutional
   a. Government institutes
   b. Private research institutes: corporate or independent
   c. University biocenters
   d. University science parks

2. Financial
   a. Grants for applied/generic research: industrial R&D
      university-industry R&D
   b. Grants for technological innovation
   c. Research clubs (government-industry)
   d. Joint ventures (academic research-industry)

3. Administrative
   a. University technology transfer office
   b. Graduate studentships in industry
   c. Consultantships in industry
   d. Temporary assignments from academia to industry and vice-versa
   e. Postdoctoral fellowships and visiting professorships for international collaboration
   f. Research round tables

4. Corporate
   a. Companies created by the government with special access to public research
   b. Public Corporation: licenses and invests in public research
   d. Establishment of new companies

5. Transnational R&D
   a. Contracts with new biotechnology companies (mainly U.S.)
   b. Funding of research in foreign countries (mainly in U.S.)

Leicester universities (U.K.) have established biocenters in collaboration with private companies. The biocenters carry out research on topics of interest to those firms.

## 2. Financial Mechanisms

Government support for applied R&D is an obvious extension of existing mechanisms for funding basic research. Most countries provide grants for applied R&D and technological innovation. There has been a growing emphasis on those projects involving university-industry interactions. The amount of funding is usually not large in comparison to industrial budgets, but is comparable to research grants. Such applied R&D grants provide seed money for new projects, and particularly in Asia, fund projects that would not otherwise be undertaken by private companies. Possibly their most important effect is to involve academic researchers in industrial projects.

Research clubs in the U.K. bring together university laboratories and companies that are interested in a specific research area. For example, the Protein Engineering Club brings together six universities (Bristol, Leeds, Oxford, Sheffield, Birbeck and Imperial) and five companies (Celltech, Glaxo, ICI, RTZ and E. Sturgis). The companies contribute 30,000 pounds ($38,800) each over four years and the Science and Engineering Research Council 2.5 million pounds ($3.24 million) over the same period. In addition, the Biological Sciences Committee will fund 900,000 pounds ($1.16 million) of basic research projects related to protein engineering.

Typical examples of joint ventures include the four companies formed by the Institute Pasteur (France):

- Pasteur Vaccines: production of vaccines and sera. It is owned 49% by the Institute and 51% by the Institut Merieux.
- Diagnostics Pasteur: diagnostics. It is 49% owned by the Institute and 51% by Sanofi.
- Biochem: development of biological pesticides. It is owned 15% by the Institute and 85% by Solvay.
- GIRPI: research on immunostimulants. Three equal partners: the Institute, CHOAY and Sanofi.

Following the patenting of any new discovery at the Pasteur Institute, the affiliate companies examine it for a period of six weeks and have three months in which to decide whether to commercialize it. There are a significant number of agreements with U.S. companies.

## 3. Administrative Mechanisms

Administrative arrangements have existed for a long time and provide a mechanism for individual involvement in technology transfer. New regulations allow students funded by government fellowships to do research in industry (CASE program in the U.K.). It has also been generally accepted that university faculty members can act as consultants to private firms. This practice is spreading to government research institutes. In addition, countries such as France and West Germany now allow academic researchers to be seconded to industrial laboratories and vice versa. It is not known whether this has increased the movement of personnel between the academic and industrial sectors and, if so, whether it has had much effect on technology transfer. In Singapore, some faculty members do work with companies, but this practice is not common in either South Korea or Taiwan except in the framework of specific government projects.

Universities have introduced technology transfer offices (e.g. University of Leiden in the Netherlands). These usually have dual functions: providing advice on patents and licenses, and acting as agents. It is felt that they provide a useful advisory function, but do not have the experience or resources to be successful marketing organizations.

Research round tables (U.K.) are periodic, open discussions between scientists and industrialists on specific research topics. Given the relatively weak science base in Asia, fellowships and visiting appointments play an important role in technology transfer. For example: Taiwan sends both young and established investigators to the United States for research and training and also brings researchers to Taiwan from abroad.

Administrative measures are simple, relatively inexpensive, and targeted towards individuals. They do serve to foster university-industry interactions.

## 4. Corporate Mechanisms

The establishment of new biotechnology companies is the most glamorous form of technology transfer, but is also expensive, complex, and very risky. The dilemma in Europe and Asia is whether to leave this to the private sector or to have direct government involvement. The U.K. government has had the principal role in establishing several new biotechnology companies (e.g. Amersham, Celltech and Agricultural Genetics Co.) in partnership with private investors. These new firms had, at the outset, access to the research from government-funded laboratories. As these firms became fully established, the government divested itself of its holdings. The Taiwan government has been a major partner in the establishment of Lifeguard Pharmaceutical and General Biologicals Corp., two new biotechnology companies spun off from the government supported Development Center for Biotechnology. In contrast, the Singapore government has not been directly involved in the four new biotechnology companies created there, but has provided a package of financial and tax incentives for new high technology companies.

The British Technology Group is a public corporation that initially had rights of first refusal to all government-funded research. It functions as an agent, provides funds for joint ventures, and is a source of venture capital. In general, European governments have preferred to provide indirect support through loans and grants. Direct government support allows new companies to survive. However, their commercial success depends on a combination of technical expertise and sound business management plus compatible and wealthy large partners for production and marketing. There is little evidence that direct government involvement is more effective than indirect support in increasing the chances of success for new start-ups.

A variation on this theme is the effort of certain European and Asian countries to attract new U.S. biotechnology companies. If indigenous scientists are unwilling to establish new companies, the next best thing is to recruit foreign companies. The Netherlands now has five U.S. biotechnology companies. The U.K. has pursued a similar policy and a number of U.S.-U.K. joint ventures now exist. Of the four new Singaporean biotechnology companies, three are joint ventures with U.S. companies.

Alternatively, two large Korean conglomerates, Samsung and Lucky, have established new biotechnology companies (Eugenetech and Lucky Biotech) in the United States. These offspring carry out contract R&D for the parent organizations and provide a window on developments in U.S. biotechnology.

5. Transnational R&D

For large multinationals, transnational R&D is the fastest and probably the most effective form of technology transfer. There are seven major types of biotechnology contracts between foreign and U.S. companies: 1) acquisition, 2) venture capital/equity, 3) contract R&D, 4) joint R&D, 5) license/production, 6) license/distribution/marketing, and 7) joint production/marketing/distribution or establishment of a new firm. Since the mechanisms for technology transfer in their own countries have been slow, and in many cases unproven, foreign corporations have used their extensive financial resources to enter into agreements with U.S. companies (particularly the small, new ones). The numbers of such contracts has increased steadily in the period from 1981-1986 (Table 2). Many of them included more than one type of agreement (e.g. a contract can cover agreements on both joint R&D and license/production). Japan is far ahead with a total of 141 contracts followed by the U.K. (35), West Germany (31), Switzerland (26), France (21) and Sweden (19). The total number of contracts for Western Europe is 173. The most common agreements with both Western Europe and Japan, are licenses for production and distribution/marketing. For the period under study, the significant difference between Europe and Japan is that the Japanese were not involved in acquisitions until 1986 while the Europeans started in 1981. The Japanese have made more use of contract R&D reaching a peak of 11 contracts in 1982, and then dropping to 3 in 1985. This probably reflects the stronger science base in Europe at the beginning of this period while the shift to joint R&D is probably an indicator of increased research capabilities. Our studies have shown very limited contract activity between companies in the Pacific Rim and U.S. companies. It is likely that there is a larger number of agreements with Japanese companies.

In addition, European multinationals have increased their funding of R&D in the United States. As the competition for biotechnology products increases, many of the foreign multinationals have expanded their production and business operations in the United States which is

## TABLE 2

**INTERNATIONAL BIOTECHNOLOGY AGREEMENTS**
**1981-1st Quarter of 1986**

| | Acquisition | Venture Capital/ Equity Investment | Contract R&D | Joint R&D | License/Production | Distribution/Marketing | Joint Production/Marketing Distrib./Estab. of New Firm | Total Types of Agreements* | Total Number of Contracts |
|---|---|---|---|---|---|---|---|---|---|
| Belgium | 1 | 1 | 1 | 3 | | 1 | 2 | 9 | 9 |
| Denmark | | 1 | 2 | 2 | 1 | 1 | 1 | 8 | 7 |
| Finland | | | 1 | | 1 | 3 | | 5 | 3 |
| France | 4 | 1 | 6 | 3 | 4 | 6 | 5 | 29 | 21 |
| Germany | 1 | 1 | 7 | 6 | 14 | 18 | 3 | 50 | 31 |
| Italy | | 3 | 1 | 3 | 2 | 1 | 1 | 11 | 10 |
| Netherlands | 2 | 3 | | 2 | | 2 | 1 | 10 | 9 |
| Norway | | 1 | | | | | | 1 | 1 |
| Spain | | 1 | | 1 | | | 1 | 3 | 2 |
| Sweden | 3 | 3 | 5 | 4 | 5 | 6 | 3 | 29 | 19 |
| Switzerland | 1 | 2 | 11 | 4 | 5 | 6 | 5 | 34 | 26 |
| U.K. | 4 | 11 | 4 | 5 | 4 | 5 | 5 | 38 | 35 |
| Total Europe | 16 | 28 | 38 | 33 | 36 | 49 | 27 | 227 | 173 |
| Japan | 2 | 24 | 30 | 24 | 40 | 59 | 24 | 203 | 141 |

Note: This table is based on data compiled by Rachel Schiller, Office of Basic Industries, International Trade Administration, U.S. Department of Commerce.

*Some contracts may involve more than one type of agreement.

frequently their largest single market. Traditionally, while multinational corporations have had their manufacturing and business operations all over the world, they have tended to retain their R&D operations in their home Country. Now, in addition to their contracts with U.S. companies, there is every indication that R&D activities will also be located in the most advantageous environment. The United States provides one of the most appealing locations because of the size and quality of its research establishment as well as its pool of scientific manpower. Table 3 shows a number of instances of R&D funding in the United States by European companies. This can take a number of different forms: funding of university departments/institutes (e.g. Hoechst), establishment of private research institutes (e.g. Roche) and acquisition of a company with its own research institute (e.g.AKZO). Frequently the company gains access to basic research unavailable in its home country (e.g. Hoechst, AKZO) or increases the R&D capabilities in its major market (e.g. Alfa Laval).

Though almost all governments studied have placed a major emphasis on technology transfer, there is seldom a clear-cut definition of its objectives, nor milestones to measure its progress. Furthermore, in most cases, there is no mechanism for evaluating technology transfer.

## II. BIOTECHNOLOGY CENTERS

During the past few years, a number of states have established biotechnology programs and centers. Their stated purpose is to promote the development of biotechnology-related industries in those states. In addition, the National Science Foundation has a program for Centers of Excellence some of which are in the biological area. It would therefore be useful to examine in some detail the experience with such Centers in Western Europe and Asia.

Table 4 lists some of the major biotechnology centers that are involved in technology transfer. All of these centers are national and with the exception of the ATV in Denmark they are funded in large part by the national government. The scope of such activities ranges from large networks such as those in France and the Netherlands to single centers such as those in Spain, South Korea and Taiwan. Their principal function is R&D and any educational component is a relatively small part of their activities. More often than not, their priorities are set within the context of national science policy (many of them are part of a National Biotechnology Program). Their budgets include government funds, contracts from other government agencies and private industry. The size of most of these centers is quite large with budgets ranging from $3.5 million to almost $16 million and staffs of 200-400. Even though technology transfer is of paramount importance to industry, the fact remains that none of these centers could survive on the basis of funding from the private sector. Therefore, technology transfer is perceived as an extension of government responsibilities for basic research and education.

The Genetic Engineering Research Center (South Korea) and the Development Center for Biotechnology (Taiwan) were created for the

TABLE B

FUNDING OF R&D IN THE U.S. BY EUROPEAN COMPANIES

| European Company | U.S. Institution | Funding Mechanism | Cost | R&D Area |
|---|---|---|---|---|
| Hoechst (FRG) 1981 | Massachusetts General Hospital | Research grant to Dept. of Genetics | $50M/10 yrs | Plant molecular biology |
| Alfa-Laval (Sweden) 1985 | Massachusetts Institute of Technology (MIT) | Equipment of Dept. of Biochemical Engineering | $1M | Fermentation & downstream processing |
| FIDIA (Italy) 1985 | Georgetown University | Funding of new research institute | $3M/yr for twenty years | Neurophysiology |
| Roche (Switzerland) 1969 | Institute of Molecular Biology | Funding of industrial research institute | $15M/yr | Molecular & cell biology |
| Glaxo (U.K.) 1986 | Glaxo Research Institute | Funding of industrial research institute | $9M | Pharmaceutical |
| AKZO (Netherlands) 1985 | Litton Institute of Advanced Biotechnology | Acquisition of industrial research institute | $59M | Cancer diagnosis & therapy |

TABLE 4
NATIONAL TECHNOLOGY TRANSFER ORGANIZATIONS

| COUNTRY | INSTITUTIONS | STRUCTURE | ANNUAL BUDGET | STAFF |
|---|---|---|---|---|
| France | . Univ. of Compiegne<br>. Pasteur Institute<br>. National Inst. of Agronomy<br>. Univ. of Aix<br>. Univ. & Inst. of Applied Sciences of Toulouse | Government laboratories attached to existing universities or institutes | NA | NA |
| Netherlands | TNO (35 institutes; 7 in biotechnology) | Network of government institutes doing applied R&D | $60m | 5000 |
| Denmark | ATV (19 institutes; 3 in biotechnology) | Network of applied R&D institutes funded by private industry | $42.5m | 1250 |
| Germany | GBF | National biotechnology research center | $15.6m | 390 |
| Spain | Centro Nacional de Biotechnologia | National biotechnology research center | $5.3m projected | 300 |
| Sweden | Huddinge Center for Biotechnology | Center funded by county & national governments | planned | |
| Korea | Genetic Engineering Research Center (KAIST) | Autonomous research center mostly funded by government | $3.5m | 170 |
| Taiwan | Development Center for Biotechnology | Autonomous research center funded by government and government owned companies | $7m | 103 |

explicit purpose of technology transfer. They receive contracts from private industry and are also involved in joint projects with companies. However, technology transfer in the absence of a strong indigenous research base is a daunting task. Therefore, both institutions have the added responsibility of introducing new research procedures and technologies into their respective countries and disseminating them to other laboratories.

The situation in the U.K. is probably more relevant to an American audience since it is decentralized and much less linked to national policy and industrial planning. These biotechnology centers are usually associated with universities and are on a much smaller scale than those mentioned above. For example, the Biotechnology Center at Imperial College (London) has an operating budget of approximately $500,000 and a staff of 50; the Leicester Biocenter (in partnership with five companies) has a budget of $500,000 and a staff of 30; and the Cambridge Biocenter has a budget of about $1.3 million and a staff of 31. Most of these were started with local initiative and funds from the university plus support from the University Grants Committee and other government agencies. They focused their activities on those research areas in which they were traditionally strong.

Table 5 summarizes the major policy issues which all of these biotechnology centers have to deal with.

1. Institutional autonomy: scientific and administrative flexibility are important in technology transfer. Therefore, it would be preferable that biotechnology centers are not part of a large bureacracy whether that is a government ministry or a large university system.
2. Relationship to universities: being part of a university provides a better interphase with basic research, gives access to skilled manpower and provides the opportunity to upgrade university curriculums. On the other hand, there are those who feel that university activities provide a distraction from the more industry-related activities of a technology transfer center, and might siphon off badly needed resources.
3. Nature of industrial involvement: the objectives of the centers do not always coincide with those of industry since they would emphasize long-term mechanisms such as joint projects and partnerships while industry prefers the cost advantages and flexibility of shorter term grants and contracts.
4. Scientific focus: one of the most controversial issues is whether the priorities of the scientific program should be set by the government, the center or industry. If the industrial clients play the most important role, then there is always the risk that the center becomes an organization for contract R&D.
5. Relationship to economic development programs: the technology transfer activities should be related to economic development goals since new products and processes have to find industrial users and markets. However, new technologies and established industries do not always make for an easy mix, and the outcome is dependent on the goals of development programs (save jobs now vs create companies tomorrow).
6. Networks and information transfer: one of the most important functions that can be served by a biotechnology center is to be an information center and to promote the rapid dissemination of new research findings and applications.

## TABLE 5

KEY FACTORS IN TECHNOLOGY TRANSFER ORGANIZATIONS

1. INSTITUTIONAL AUTONOMY.
2. RELATIONSHIP TO UNIVERSITIES.
3. NATURE OF INDUSTRIAL INVOLVEMENT.
   A) GRANTS AND CONTRACTS
   B) JOINT PROJECTS
   C) SPONSORSHIP
4. SCIENTIFIC FOCUS
5. RELATIONSHIP TO ECONOMIC DEVELOPMENT PROGRAMS
6. NETWORKS AND INFORMATION TRANSFER
7. INTERNATIONAL AGREEMENTS

TABLE 6

CHALLENGES FOR U.S. BIOTECHNOLOGY CENTERS

1. NEW ORGANIZATIONAL STRUCTURES.
2. COLLABORATION BETWEEN CENTERS.
3. EFFECTIVE RELATIONSHIP WITH STATE ECONOMIC DEVELOPMENT PROGRAMS AND LOCAL INDUSTRY.
4. COLLABORATION WITH FOREIGN RESEARCH CENTERS AND UNIVERSITIES.
5. TECHNOLOGY TRANSFER ON A GLOBAL SCALE.
6. DEVELOPMENT OF INNOVATIVE TRAINING PROGRAMS.

programs.

For too long the United States has relied on one principal mechanism of technology transfer, the creation of new companies. It is evident that this is no longer sufficient to meet all of our needs, and that new mechanisms need to be developed. This is an exciting challenge and one which will profit from careful study of that which is happening all over the United States and all over the world.

DR. ROBERT YUAN
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Dr. Robert Yuan is a molecular biologist and is currently professor of Microbiology at the University of Maryland at College Park. He has done research and taught at Harvard University, the University of Edinburgh (Scotland) and at the Biozentrum of the University of Basel (Switzerland). In addition, he has been a section head at the NCI-Frederick Cancer Research Facility. Dr. Yuan was on temporary assignment to the U.S. International Trade Administration for a period of two years. He was stationed during 1985-86 at the U.S. Embassy in London in order to carry out a technical and industrial assessment of biotechnology in Western Europe. He has recently published "Biotechnology in Western Europe." Dr. Yuan is currently Senior Advisor in Biotechnology to the U.S. Department of Commerce and has just completed a second study on biotechnology in Singapore, South Korea and Taiwan. He is presently writing a book on this topic.

# BIOTECHNOLOGY IN WESTERN EUROPE AND THE PACIFIC RIM

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Summary: Technical and industrial assessments of biotechnology have been carried out in eleven countries in Western Europe (Denmark, Finland, France, West Germany, Italy, Netherlands, Norway, Spain, Sweden, Switzerland, United Kingdom) and three countries in Asia (Singapore, South Korea and Taiwan). In addition, some of the political factors that affect biotechnology in Western Europe have been examined. A new trade initiative for biotechnology in the Pacific Rim is discussed .

The Biotechnology Program of the U.S. International Trade Administration is carrying out a series of studies on biotechnology worldwide. These include studies on Western Europe, Japan and the Pacific Rim. The principal objectives were to:

1. determine the government policies in support of biotechnology,
2. identify the principal research laboratories and their activities,
3. identify the principal companies involved in biotechnology and their activities, and
4. study the various mechanisms for technology transfer from the research laboratories to the industrial sector.

In addition, a recent study has analyzed the political factors that are likely to affect the development of biotechnology in Western Europe.

The results of our European study have been published and been widely disseminated, so I will not dwell on them at this time. I would rather discuss a recent analysis of biotechnology in Singapore, South Korea and Taiwan, and a new initiative for collaboration between the Trade Development Program and a number of state economic development agencies.

Biotechnology in the Pacific Rim

The growth of biotechnology in the newly industrializing countries of Singapore, South Korea and Taiwan coincides with government policies directed towards restructuring the economy away from labor-intensive manufacturing and towards high technology sectors. All of these countries have dynamic economies with annual growth rates of 8-9%. They have a common Confucian tradition, and a strong regard for education, hard work and frugality. The United States has negative trade balances with all three ranging from $838 million for Singapore to $13.6 billion for Taiwan (in 1986). The per capita GNP varies considerably with Singapore's $6519 being the second highest in Asia after Japan while South Korea's $2296 makes it the least affluent of the three. One of the remarkable achievements of these rapidly expanding economies has been a fairly broad distribution of wealth.

I. Government Policy

Government policy is the single most important element in the development of biotechnology. In all three countries, the government is involved in biotechnology at all levels starting with basic research and extending to financial support for industrial development. In this respect, the role of the government closely follows the patterns of Japan and numerous European countries. Though the government represents a major source of research funding, the amounts involved are small when compared to the United States, and some of the major European countries. The budgets of $10 million reported for South Korea and Taiwan are small when compared to the $4.3 billion reported for the United States or the $180 million for Japan. Though basic research is carried out at university laboratories, government policy has focused on the establishment and operation of national research institutes. A significant proportion of the government funds has been invested on technology transfer institutes in South Korea and Taiwan.

Biotechnology has been chosen as one of the priority areas for industrial development. Both South Korea and Taiwan have National Programs of Biotechnology. In all cases, biotechnology's special status has led to additional R&D funding and financing of new products and processes. Health care in general, and the hepatitis problem in particular have been chosen for early application of biotechnology. Singapore government policy is strongly market oriented, but the development of a hepatitis vaccine and a number of diagnostic tests for AIDS and hepatitis has been actively encouraged. South Korea has established a New Drug Association (a partnership between the government and drug companies) while the Taiwan government has a National Hepatitis Program. The emphasis on hepatitis is not only an attempt to find a solution to a serious public health problem, but also serves an important function in establishing a political consensus in support of biotechnology and in educating the national leadership on its industrial and commercial applications.

The governments provide powerful incentives for R&D and the introduction of new technologies including biotechnology. Both Singapore and Taiwan have more comprehensive programs for high technology than South Korea. While the Singapore government does not take a major role in the financing of new companies (unlike Taiwan), it does have the unusual INIT program for upgrading the skills of its workers. In South Korea, the government has a close partnership with the chaebols (industrial conglomerates) that encourages the targeting of new industries.

The lack of strong intellectual property laws and of comprehensive rules for approval and registration of new drugs as well as new rDNA products have been major obstacles to the development of biotechnology. The long history of patent infringements, product copying, protection of domestic manufacturers, has been a major inhibitor of transfer of new technologies to these countries. Singapore has a Western-style patent system that follows British law while both South Korea and Taiwan have introduced new patent regulations, but their impact remains to be seen.

## II. Science Base

The basic research establishment in Singapore, South Korea and Taiwan is weak. Of the three, Taiwan has the strongest science base in the biological sciences. The governments' efforts to build up basic research is primarily directed towards the creation of new research centers. New government funding has led to the creation of the Institute of Molecular and Cell Biology in Singapore, the Central Laboratory of Molecular Biology, the Institute of Biomedical Sciences and the Development Center for Biotechnology in Taiwan, and the Genetic Engineering Center and the Institute of Molecular Biology and Genetics in South Korea.

The major limiting factor in the development of both R&D and industry in the biotechnology sector is a shortage of professional manpower. Of the three countries visited, Singapore has the most visible shortage of biological scientists while Taiwan is in the strongest position. The most rapid solution to this problem is the active recruitment of expatriate scientists (primarily resident in the United States). Taiwan has a large pool of scientists in the United States while Singapoe has used a policy of high salaries and excellent working conditions to try to create an international scientific establishment. If the problem is already serious at the scientific level, it becomes severely limiting at the level of management/administration due to a lack of senior scientists with broad experience.

## III. Industrial Base

The biotechnology industry is in its infancy in these countries. Both Singapore and Taiwan are committed to the creation of new biotechnology companies while South Korea is likely to see new industrial activities associated with its large conglomerates. While the governments encourage the activities of the multinational companies as a source of employment and tax revenue, they accept the fact that such large corporations will not introduce new technologies and products. Therefore, one of the primary roles of the government is to promote new companies. There are three different models: 1) closely associated with government institutions (Taiwan); 2) part of large industrial conglomerates (South Korea), and 3) new private companies frequently as joint ventures with U.S. companies (Singapore).

The pharmaceutical market is commercially important, but the domestic pharmaceutical industry is highly fragmented in South Korea and Taiwan, and small in Singapore. The markets are lucrative and the few new industrial activities in biotechnology are heavily oriented towards human health care. The other two important industrial sectors are agriculture/food processing and specialty chemicals, but with the exception of Plantek and Everbloom in Singapore, efforts in these directions have been limited.

All of these countries have an active entrepreneurial environment particularly Singapore and Taiwan. Investment capital is plentiful, but there is little experience with R&D companies and there is a generally conservative attitude towards funding new companies without clearly defined products. Financial organizations associated with the government therefore play a major role in the funding of new high technology companies. Profits from export sales and funds from overseas Chinese represent large pools of domestic capital.

The single most important problem in industrial development of biotechnology is the recruitment of an integrated team of scientists, managers, and marketing specialists.

## IV. Technology Transfer

The principal mechanism for technology transfer is licensing from foreign companies. However, the move into high technology industries and the highly competitive nature of such markets has led to a search for new ways of introducing new technologies. Singapore has used its free market environment to encourage the creation of new companies in collaboration with foreign companies. It has made effective use of its grant system for retraining its workers. At the government level, South Korea has established the Genetic Engineering Center as a technology transfer institution and organized the Korea Genetic Engineering Research Association (a partnership between the government and private companies). At the private level, Samsung and Lucky have established genetic engineering companies in the United States in order to carry out research and act as a window on developments in U.S. biotechnology. The Taiwan government has established the Development Center for Biotechnology as a center for technology transfer and for the spinning off of new companies. To date, none of these countries have scored any major successes.

## The Political Environment in Western Europe

The regulation of new biotechnology products and processes in Western Europe is a patchwork of national laws and requirements ranging from the permissive to the restrictive. None of the countries except Denmark have specific legislation for biotechnology products, but make use of existing statutes. Three of the twelve require mandatory registration of rDNA experiments while Denmark requires registration of all biotechnology work. In general, the regulatory framework for biotechnology in Western Europe is both reasonable and workable. There is however an element of political volatility both in national legislatures and public opinion that could lead to changes in the existing regulations.

There is serious concern in industry that the lack of common regulations will unduly delay the development of biotechnology in Western Europe. It had been hoped that the creation of an EEC regulatory system would preempt national biotechnology regulations and avoid the slow, painful process of harmonization. The passage of new regulations by Denmark and the possible introduction of similar legislation in the FRG makes it now unlikely that the EEC regulatory system can be put in place before national systems.

The majority of the European governments (seven of twelve with a possible eighth) are under the control of conservative parties. There are five conservative-led coalitions in power, three of which are minority governments. The major European Socialist parties are Social Democrats in all but name, and have become among the strongest advocates for R&D, industrial development, privatization of state industries, and creation of new entrepreneurial high technology companies. They have also been the architects of many of the national biotechnology programs.

The Green parties have been among the most vociferous opponents to biotechnology, but their influence has been less through the electoral process than through the leveraging of weak minority governments and/or providing for alternative politics. The Greens are less likely to have a decisive influence if there is a consensus for the orderly development of biotechnology among academics, government officials, and industrial managers. This consensus is most effective when it is transparent to the public.

<u>The Pacific Rim: An Opportunity for U.S. Biotechnology</u>

Though the Biotechnology Program in collaboration with the U.S. Embassies overseas have been successful in obtaining valuable information about the biotechnology activities of our competitors, this information has not been translated into new opportunities for U.S. industry. Several major problems have been identified:
1. The lack of stable funding for the assessment projects and administrative delays in carrying out specific studies;
2. the lack of effective mechanisms to make the information available to U.S. companies, and
3. the absence of any follow-up activities by U.S. companies overseas.

It is in order to make the most effective use of the information that the International Trade Administration and the Trade Development Program have organized a conference on Biotechnology in the Pacific Rim which will bring together key leaders in government, research, and industry from the U.S., Singapore, South Korea and Taiwan. At the same time, we have begun to establish close ties to state economic development agencies in order to identify appropriate mechanisms to increase the activities of U.S. companies in that potentially rich market. In the long term, it is hoped that this partnership between ITA, TDP and the states will lead to:
1. Continuous technical and industrial assessment of biotechnology in both Western Europe and the Far East;
2. market analyses for new biotechnology products;
3. identification of appropriate foreign partners for joint ventures, and
4. the development of cooperative R&D between the U.S. and foreign institutions.

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REPORT PROVIDES AN ASSESSMENT OF BIOTECHNOLOGY IN WESTERN EUROPEAN COUNTRIES

The International Trade Administration has released a report that presents a technical and industrial assessment of biotechnology in the major nations of Western Europe. Biotechnology in Western Europe includes country reports which describe the national environment for biotechnology in eleven European nations.

The country reports focus on the general characteristics of each country, including government policy, scientific and industrial bases, and technology transfer. The report also discusses three international biotechnology programs directed towards increasing collaboration across national borders. The European Molecular Biology Organization (EMBO) program focuses on basic research, scientific exchange, and training as a means of creating a favorable enviroment for the development of biotechnology, the European Economic Community (EEC) program is concerned with building up the European Western scientific infrastructure, and the EUREKA program stresses the establishment of industrial projects between companies and organization in the various European countries.

The report also includes numerous tables and charts, a glossary of terms, and references for further reading.

The authoritative 276-page publication, Biotechnology in Western Europe, stock number 003-009-00509-4, is available for $ 13.00. Send prepayment to Dept. 36-XG, Superintendent of Documents, Washington, DC 20402-9325; or to order with Visa or MasterCard phone (202) 783-3238.

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## BIOTECHNOLOGY IN SINGAPORE, SOUTH KOREA AND TAIWAN

This is the first comprehensive study of biotechnology in the newly industrializing countries of Singapore, South Korea and Taiwan. Until recently these countries have been mainly known for their highly efficient manufacturing industries, but have now begun to make their first tentative moves into high technology. Biotechnology is considered by all of them to be an industrial technology of the highest priority.

The author of this 108-page report, Dr. Robert Yuan, was also responsible for a recent study on biotechnology in Western Europe. Drawing on his European experience, he has focused on four major topics:

1. government policy for the promotion of biotechnology;
2. the principal research organizations and their activities;
3. the principal companies with biotechnology activities; and
4. the mechanisms of technology transfer.

In addition, he has also looked into issues that have been major sources of friction between the United States and its Asian trading partners. These issues include protection of intellectual property, protection of domestic industries, regulation of foreign investment, and repatriation of profits. Much of the data is summarized in easy to read tables and figures. The information was obtained primarily during travel to these countries, and many of the documents were translated directly from Chinese or Korean.

Though all of these three countries share a common heritage, they differ sharply in their philosophies of economic development and their cultural environment. The author has endeavored to provide a sense of the environment for biotechnology in each of these countries and of the opportunities for collaboration in R&D and in the development of new markets and industrial joint ventures.

Biotechnology in Singapore, South Korea and Taiwan is available from the National Technical Information Service in Springfield, VA. To order a copy, contact the Sales Office at (703) 487-4650. The price per copy is $19.95 and the stock number is PB 88172440.

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1. Report on State-Supported Small Business Innovation Research Programs and Related State Technology Programs

2. Survey on the Structure and Function of State Science and Technology Offices

3. Publication of Shifting Responsibilities: Federalism in Economic Development

Ongoing Issues and Potential Projects

4. State Government Strategies for Self-Assessment of Science and Technology Programs for Economic Development

5. Clearinghouse on State and Federal Science and Technology Initiatives

6. Science and Mathematics Education proposal

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E. - 6

# TECHNOLOGICAL INNOVATION

The United States has long led the world in technological innovation, a major source of our economic strength. Now, however, our nation faces a serious challenge to continued leadership in this area. At home, our technologies have matured and the pace of new technological development has slowed; at the same time, much of our infrastructure and industrial plant equipment is aging. Abroad there is increased competition from emerging as well as established industrialized countries. The industrial nations face unprecedented energy and resource constraints combined with growing geopolitical pressures.

To help address these problems, state and national policy initiatives are needed to promote technological innovation and industrial competitiveness. Perhaps the most important goal of these policies should be to maximize our human potential for technological innovation. To achieve this, our educational system must give new emphasis to training technical personnel and ensure that graduates have received appropriate training for available jobs, while having the flexibility to adapt to new technologies. We must demand increased exposure and substantially higher levels of achievement in math, science, engineering, and computer learning in our schools and universities for all students. In focusing attention on these disciplines, we must not neglect the humanistic education necessary to protect our national values.

A well-trained and educated workforce can make a vital contribution to technological innovation and economic growth. We must develop policies to encourage workers' contributions to technological innovation, while minimizing potential hazards to health and threats to personal economic security. Training and retraining programs must be available for unemployed and displaced workers.

The participation of universities in developing the fundamental research that is the knowledge base for technological innovation is as important as their role in education and training. Public and private research is an important prerequisite for future growth and improvement in the quality of life. Universities should be assisted and encouraged to more closely link their research and development efforts with technological innovation that contributes to economic progress. The traditional intellectual purity of the university, however, must not be compromised.

Policies affecting financial capital like those affecting human capital must be targeted toward encouraging technological innovation. Capital is needed to finance research and development and to introduce new and advanced technologies in new establishments and mature enterprises. We must promote policies that will encourage markets to direct funds to investments that advance technological innovation. The ability of business executives and entrepreneurs to undertake long-term planning, take risks, and innovate is crucial to economic success. Therefore, we must create an environment in which business decisions and investment aimed at long-term productivity gains and real growth through technological innovation are the norm.

States have taken vanguard initiatives in the task of recharging our economy. However, this task can most effectively be accomplished by state government in partnership with federal and local government, business, labor, and academia. Wherever desirable and feasible, these groups should cooperate in developing and implementing the programs necessary to promote technological innovation.

As a national competitiveness policy is developed, the federal government should acknowledge the role of states in serving as effective intermediaries between universities, government, and industry. By investing significant resources in technology research and education, states have been successful in creating new jobs and promoting economic development to improve their competitiveness in the world economy. Too often states and the federal government pursue independent technology development initiatives lacking the coordination, cooperation, and cohesiveness necessary for the U.S. to compete effectively. There is a demand for cooperative mechanisms to bring the resources of state and federal governments, research universities, and industry together. Federal and state governments should develop an effective partnership between federal competitiveness programs and state applied research initiatives.

Federally funded research and development must be regarded as a long-term investment in the nation's economic well-being through the direct and indirect fostering of technological innovation for economic development. This investment is also important when considering the potential of advances in science and engineering for achieving greater efficiency and effectiveness in state and local government. Increasingly, it has been demonstrated that a wide range of problems can be solved and that program costs can be reduced without reduction in the quality of public services. To achieve a greater return for state governments and their citizens, a stronger link between state and local needs and the federal science and technology establishment must be forged and maintained.

Federal Actions Suggested

- The federal government should give increased priority to support for civilian sector basic and applied research in the overall federal research and development budget in ways designed to strengthen and stimulate the U.S. economy. States should play an important role in setting federal civilian research priorities. A productive mechanism for federal support of civilian research and development lies in joining with states to support university/industry research partnerships and consortia.

- Congress should continue to improve the federal tax climate for innovation through judicious use of incentives designed to promote corporate research and development, capital investment in production facilities, business expansion, and formation of new ventures.

- Congress should ensure the continuity of existing grant programs such as Urban Development Action Grant and Community Development Block Grant programs and amend them to allow greater flexibility for their use by states in developing state and local technological infrastructure, providing support for new and advanced technology-based businesses, and encouraging the formation of new and advanced technology ventures.

- Congress should repeal the 1993 "sunset" provision of the Small Business Innovation Research (SBIR) program making the program permanent. The SBIR program has proven to be a strong and effective means of fostering the role of small business in federal research and development, spurring economic development within the states. Federal agencies should facilitate states' assistance to SBIR applicants. To achieve the goals of the SBIR program, this would include funded and unfunded SBIR applicants.

- The federal government should work diligently to further enhance the role of the federal research and development agencies and laboratories in economic development. Where feasible, avenues for the utilization of federal research and development agency and laboratory technology for technological innovation by the private sector and by state and local government should be provided through regional programs. Participation of federal research and development agencies and laboratories with universities and industry in cooperative civilian research should be encouraged.

- The federal government should give priority to the support of university programs designed to train the scientific and engineering personnel essential to continued economic growth. Federal programs should augment and complement state and local government programs. The federal government should make substantially greater investments in our nation's research infrastructure. Federal policies must recognize that the costs of university research facilities and equipment are a necessary part of federally sponsored. university-based research costs. The portion of federal research grants and contracts that reimburse universities for use or depreciation of facilities and equipment should be based on realistic useful lifetimes. To allow universities to restore their infrastructure in a timely fashion, a facilities fund should be established within the National Science Foundation. There should be a greater concentration of investment incentives for industrial participation in the sponsorship of university science and engineering programs.

- The Job Training Partnership Act should be examined with state, labor, and private sector input to assess its long-term utility for providing the training required in the fields of employment that will be important to the nation as the impact of technological innovation is felt.

- The federal government should support state economic development efforts to encourage business export activity in commodities, products, and services based on new and advanced technologies. Federal action is required in concert with state initiatives to: provide assistance for state trade promotion programs, streamline export licensing application processes, provide centralized export technical and marketing assistance, and meet the alternative financing needs of small and medium-sized business.

- Congress should modify existing antitrust statutes to encourage increased joint corporate research and development ventures.

- The formulation of a national competitiveness policy should recognize the leadership of states in technology development and take all steps to coordinate with state programs and encourage interstate and regional cooperation.

- A federal/state matching grant program should be established to support existing state technology programs and encourage the development of new programs in states where they do not exist.

- Potential cooperation and coordination with state programs should be considered prior to funding research centers initiated by the National Science Foundation (NSF), the Department of Defense (DoD), the National Institutes of Health (NIH), and other federal agencies.

- A clearinghouse on state technology development programs should be established with federal support to collect and share information among and between states and with federal agencies, to provide training and technical assistance to better coordinate state and federal efforts, and to assist those states interested in developing such programs.

<u>State Actions Suggested</u>

- States should continue their leadership in promoting economic growth by the development of state programs designed to encourage technological innovation in new and existing businesses. States are in a more appropriate position than the federal government to provide the direct leadership and partnership involvement that are necessary for effective programs tailored to their individual needs.

- States should, with federal assistance, continue to play the dominant role in improving elementary and secondary education, and in providing essential training and retraining; catalyze university/industry research and technical partnerships; encourage the establishment of new and advanced technology ventures; provide comprehensive technical and managerial assistance to new and advanced technology entrepreneurs; assist new and advanced technology-based businesses as well as traditional businesses in reaching international markets; and aggressively promote the application of advanced technologies in assisting industrial, agricultural, and commercial enterprises to achieve economies and to increase productivity in order to make such enterprises more competitive in domestic and world markets.

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