In the National Interest

The Federal Government and Research-Intensive Universities

A Report to the Federal Coordinating Council for Science, Engineering, and Technology

from

The Ad Hoc Working Group on Research-Intensive Universities and the Federal Government

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Director, National Science Foundation

The Federal Coordinating Council for Science, Engineering and Technology

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

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

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

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

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December 1992

EXECUTIVE OFFICE OF THE PRESIDENT
OFFICE OF SCIENCE AND TECHNOLOGY POLICY
WASHINGTON D.C. 20506

December 10, 1992

Dear Mr. President:

As Chairman of the Federal Coordinating Council for Science, Engineering and Technology, I have the pleasure of transmitting to you the report In the National Interest: The Federal Government and Research-Intensive Universities. This is a worthy companion to the report from the President's Council of Advisors on Science and Technology titled Renewing the Promise: Research-Intensive Universities and the Nation, which I transmitted to you on November 23. Taken together, these reports provide an unprecedented and invaluable perspective on the government-university relationship, representing as they do both Federal and private sector viewpoints.

The importance of research-intensive universities to the nation derives from their joint mission, namely providing education at the most advanced levels and performing much of the fundamental research upon which our technological progress ultimately depends. The two reports should be central to national discussions about the current needs and future roles of those institutions.

For the first time, representatives of seventeen research-supporting Federal agencies worked together to develop a joint perspective on that relationship. Also for the first time, PCAST and FCCSET are co-publishing related reports developed along parallel lines. The FCCSET report provides the perspectives of the individual agencies, as well as a coordinated interagency view, on the government-university relationship; comments on a number of current issues affecting that relationship; and makes a series of recommendations that are generally in consonance with those of the PCAST report. I am confident that the two reports, taken together, will have a significant and far-reaching impact on many matters affecting the relationship.

The agency representatives who participated in the FCCSET Working Group are listed in the report. I would like to thank all of them, and particularly Dr. Walter Massey, who chaired the Group so effectively.

Sincerely Yours,

D. Allan Bromley
Director

The President
The White House

Enclosure

NATIONAL SCIENCE FOUNDATION
WASHINGTON, D.C. 20550

December 8, 1992

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OFFICE OF THE
DIRECTOR

Honorable D. Allan Bromley
Assistant to the President
for Science and Technology
Room 358
Old Executive Office Building
Washington, D.C. 20500

Dear Allan:

It is my pleasure to transmit to you, ***In the National Interest: The Federal Government and Research-Intensive Universities***, a report by the FCCSET Ad Hoc Working Group on Research-Intensive Universities (WGRIU) and the Federal Government. This report constitutes a landmark: seventeen agencies have developed a Federal government perspective on its relationship with research-intensive universities both now and for the future, an unprecedented achievement.

This report conveys three key themes. First, it describes the broad, complex, and interdependent relationship that has developed between research-intensive universities and the Federal government. Second, it identifies critical trends and issues that are affecting this relationship. And third, it reaffirms principles and makes recommendations whose purpose is to assure that the relationship between the Federal government and the research-intensive universities is maintained, nurtured, and enhanced.

The strength of this report is directly attributable to the personal attention demonstrated by each of the agencies in developing a common set of recommendations. The report is further enriched by the individual agency perspectives papers -- a reflection of the diversity of the Federal government's relationship with research-intensive universities. This document provides a basis for pursuing and nurturing this relationship with the research-intensive universities well into the next century.

I appreciate the opportunity to have chaired this effort in David Kearns' absence. The process has been valuable from an interagency perspective and I believe we have all learned a great deal from it.

Sincerely,

Walter E. Massey
Director

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*In Dr. Kearns' absence, Dr. Massey served as acting Chairman of this activity.

THE CHARGE

The importance of the Research-Intensive Universities (RIUs)[1] to the Nation is reflected in the broad, complex, and interdependent relationship that has developed between them and the Federal government over many decades. The extraordinary economic and social transformation occurring nationally and world-wide has put this relationship under stress.

The continued strength and excellence of the American academic research and education infrastructure is fundamental to the health of the American economy and quality of life, and to the discharge of the missions and responsibilities of the Federal government. It is in the best interest of the Nation that the relationship between the Federal government and the RIUs be maintained and that its effectiveness and productivity be nurtured and enhanced.

Therefore, the Ad Hoc Working Group on Research-Intensive Universities (WGRIU), established under the Federal Coordinating Council for Science, Engineering, and Technology (FCCSET) was charged to:

I. Characterize the present nature of the relationship between the Federal government and the RIUs;

II. Identify critical trends and issues that are affecting this relationship; and

III. Define a statement of principles and recommendations for the future of the relationship.

[1]The 170 universities which, as a set, comprise 90 percent or more of each of the following variables for 1981-90: Total expenditures for academic R&D, Federal obligations for academic science and engineering, Federal obligations for academic R&D, number of doctorates granted in science and engineering, and number of doctorates granted in natural science and engineering.

INTRODUCTION

America's research-intensive universities have played a critical role in the development of our knowledge driven technological society. With their unique combination of responsibility for both research and education, our institutions of higher learning are unmatched by those of any other country with respect to their excellence, creativity, and benefits to society. They provide a steady supply of highly trained scientists and engineers for industry, government, and academia. They also produce new knowledge essential to major national objectives, such as economic progress, industrial innovation, improved health care, environmental quality, and the assurance of national security. The fulfillment of these critical national objectives depends on the continued health, excellence, and productivity of the research-intensive universities. It also depends on the continued vitality and synergy of the relationship between the universities and the Federal government.

The unique and prominent role of RIUs in our Nation is in part the result of a conscious and long-term commitment on the part of the Federal government to the development and support of research universities. Since World War II, Federal agencies have provided the research-intensive universities with a major portion of their research funding. The Federal government has supported the education of students at the graduate and undergraduate levels, directly through fellowships and traineeships and indirectly by their involvement in Federally funded research.

The context within which this relationship has developed and prospered is currently undergoing major changes. The Cold War, which served as a major stimulus for Federal support of research for half a century, has come to an end, and science and technology are recognized as critical elements in the emergence of a global international economy.

The conduct of research itself has changed, with an explosion of new opportunities generated by the accelerating rate by which knowledge is created and communicated, and by new problems and challenges, in areas from cancer to cosmology, and from global change to genetic engineering. The new challenges and opportunities have increased the importance of multidisciplinary research. Shorter time horizons between concept and application and more iterative relationships between fundamental research and technology have increased the need for collaborative relationships among researchers.

Public awareness of the critical role of science and technology has been accompanied by heightened public scrutiny of Federally funded research, by increased demand for accountability, and by growing attention to the management of ethical, legal, and safety issues. Growing public and Federal concern to assure a demonstrable return on the taxpayer's investment has increased the attention of the Federal agencies to strategic research areas, to directed research even in areas of fundamental science, and to institutional strategies that encourage cross-sectoral communication and collaboration among academia, industry, and government.

Finally, there is a growing divergence between the expectations of university researchers and the Federal resources available to support their work. The result has been increased competition, anxiety, and a sense of insecurity among researchers.

This report responds to the request by FCCSET that the Working Group examine the effects of these changes on the relationship between the Federal government and the RIUs. The report reviews the basis of the Federal relationship with the research-intensive universities in the current context, affirms the principles that will ensure that it will continue to flourish in the future to the mutual benefit of both parties, and makes recommendations in areas where the Federal government has a specific interest or role. In so doing, the Working Group notes that some responsibilities for the health of the relationship are shared, and some are beyond the Federal purview.

The Working Group affirms the vital and continuing importance of the Federal-RIU relationship for the Nation. In addressing the challenges posed by new demands, limited resources, and changes in the geopolitical and research environments, the activities of the Federal agencies with respect to the research-intensive universities should be guided by the following principles:

1. ***Federal policies and requirements should contribute to the health of universities and their operations and to the strength of the research infrastructure.***
2. ***Federal policies should serve to maximize the benefits resulting from the Nation's investment in universities and provide increasing dividends in the form of improved quality of life and economic growth.***
3. ***Federal policies and investments in university research and education should encourage the full utilization of the rich and varied demographic base of the Nation, the maintenance of a highly educated pool of scientists and engineers, and the development of a scientifically literate citizenry.***
4. ***In implementing its policies and regulations with respect to public funding to universities, the Federal government should seek accountability and simplicity, maintain interagency uniformity and compatibility, and reduce duplication.***

RECOMMENDATION

- *The WGRIU recommends that FCCSET establish a standing subcommittee to serve as a forum for continued discussion of issues related to RIUs, to provide continuing oversight for the process of implementing the recommendations of this report, to provide oversight for implementation of other Federal/university initiatives and recommendations, and to serve as a resource for other FCCSET committees.*

ORIGINS AND NATURE OF THE RELATIONSHIP

Origins

The first long-term partnership of national scope between Federal and state governments in support of higher education and research was initiated by the Morrill Act of 1862. The Act granted parcels of Federal land to each state for the creation of a "land grant" college for instruction in agriculture and mechanic arts. Additional Acts, in 1887, 1900, and 1914 expanded the scientific subject matter taught at these institutions and established agricultural experiment stations and extension services for research and dissemination of results. The Nation benefited significantly from the availability of a constant source of new knowledge applied to agricultural productivity.

The current relationship between the Federal government and the RIUs, while consistent with this pattern, is specifically rooted in policies established at the conclusion of the Second World War.[2] As noted by President Franklin D. Roosevelt, these policies, mindful of the contributions of university research to the war effort, aimed to employ profitably "...the lessons to be found in this experiment...in times of peace."[3]

During the 1950s and 1960s, Federal spending for academic research grew rapidly at all agencies, as did broad support for general education and institution building activities by the National Science Foundation (NSF), the Department of Defense (DOD), the National Aeronautics and Space Administration (NASA), and the National Institutes of Health (NIH). New universities came into being, particularly in the public sector, resulting in a broader distribution of research capacity and funds among universities.

Rapid growth in funding for academic research, in constant dollars, came to an abrupt end in 1968, and the 1968 funding level was not exceeded until ten years later. Beginning in the late 1960s and continuing into the early 1970s, the focus of Federal support for universities shifted from defense and space to domestic and social concerns. For example, NIH initiated the wars on cancer and heart disease in 1971 and 1972, respectively; NSF was explicitly authorized to include applied research in its support; and DOD was directed by the Mansfield Amendment to limit its research support at universities to areas directly focused on its mission.

During the 1980s, Federal support for university research increased dramatically in constant dollars. Furthermore, dispersion of research spending to a larger number of universities continued. The number of institutions with at least one research program over a million dollars (in-

[2]Data describing RIU contributions to U.S. research and education and the Federal role in supporting such RIU activities are provided in Appendix A.

[3]Letter from President Franklin Roosevelt to Vannevar Bush, reproduced in Vannevar Bush, *The Endless Frontier* (National Science Foundation: Washington, DC, 1990), p. 3.

flation adjusted) grew by 20 percent over the decade. Nevertheless, the Federal share of academic research support, which peaked in 1966 at 74 percent, declined steadily to a 1991 share of under 60 percent, as other sources of support grew faster than the Federal contribution.

By 1990, many states experienced the beginnings of the economic downturn that continues to constrain the Federal, state, and private sector resources available for academic research and higher education. Sustaining or increasing Federal obligations for academic research now faces more intense competition from other legitimate claims. Meanwhile, other sources of support for the RIUs are also undergoing financial stress. Tuition has risen to such an extent that additional large increases appear to be unlikely. State and local funding of higher education has been cut, and declining interest rates reduce endowment income.

Approximately 50 percent of Federally funded basic research is conducted in universities. The Federal government spent $8.1 billion at the RIUs for all types of research in 1990. Total Federal research funding to all academic institutions in that year was about $9 billion. Federal support to research at RIUs comprised an average of about 12 percent of RIU total operating expenditures, and about 58 percent of their total research spending.

The superiority of the U.S higher education system is internationally acknowledged and the linking of research with education is one of its defining strengths. Though most Federal support of RIUs goes for research, that support also contributes to education through direct involvement of students in research, and by helping to maintain high quality research capabilities of the faculty and institution. Education, including higher education, is primarily the responsibility of state and local governments. However, recently the Federal government has been increasing its support for improving science, engineering, and mathematics education at all levels.

In addition to providing direct support to universities, the Federal government plays a major role in financial aid to students at all academic institutions, including RIUs. About half of the undergraduates in U.S. universities and colleges, including two year institutions, receive some form of financial aid and of these about 75 percent have some form of Federal aid. Among the students receiving aid, full-time students and minority students are more likely than others to receive Federal aid (about 80 percent and 85 percent of aid recipients in these groups, respectively). About 70 percent of full-time graduate students receive financial aid; 46 percent of these receive some form of aid from the Federal government. Federal financial aid in FY 1991 was $4.2 billion for Guaranteed Student Loans and $6.0 billion for Student Financial Assistance.

Nature of the Relationship

From its relationship with RIUs, the Federal government expects specific contributions to the execution of agency missions such as improved health, defense, environmental protection, agricultural productivity, and space exploration. The government also expects contributions to the quality of national life, including coherent and rigorous undergraduate education, the widespread appreciation of scientific knowledge, and the encouragement of full potential for all Americans.

The Federal government's research interests coincide with and complement RIUs' core commitments in many areas. The government looks to the RIUs for expansion of the knowledge base and investigation of specific research questions. The RIUs rely on Federal funding for financial assistance in support of such research, with associated benefits to advanced training programs and to their human and physical infrastructure.

Some agencies, such as the Department of Agriculture, Department of Veterans Affairs, Department of Defense, and NASA, emphasize academic research in areas where the resulting new knowledge is judged most likely to contribute to specific agency missions. Other agencies, such as the National Science Foundation, provide support across a broader spectrum of research areas to advance fundamental understanding and to strengthen and expand American academic infrastructure, while still other agencies, such as the National Institutes of Health, provide both. The full range of these activities constitute a substantial investment in academic research capacity and, therefore, in the Nation's future.

The connections between the Federal agencies and the RIUs are complex, varying in response to distinct missions, objectives, and processes among different agencies and even subunits within them. (Descriptions of individual agency relationships with the RIUs are provided in Appendix B.) They are also modulated by diverse needs, operations, and opportunities among RIUs. The pluralism in sources of funding and diversity of programmatic approaches contribute to the flexibility and creativity of the system and its responsiveness to new opportunities.

Agencies use a variety of mechanisms to support research at universities, including grants, contracts, and cooperative agreements. The specific mechanism used is determined by agency requirements and objectives, rather than whether the research is fundamental or applied. Grants and cooperative agreements impose fewer requirements on researchers and rely more heavily on investigator initiative than do contracts. A "procurement" relationship between the Federal government and universities is the consequence of the imposition of specific requirements on the conduct and outcomes of research. In contrast, government support for a range of activities to expand the knowledge base of science, engineering, and technology and to strengthen the research and education infrastructure constitutes an "investment."

An essential component of the Federal/RIU relationship in research is its foundation in excellence, regardless of the funding mechanism or objectives. The use of merit review for competitive proposals has a demonstrated record of ensuring support for the highest quality research.

ISSUES AND CHALLENGES

The Federal government exercises a substantial influence on RIUs through the impact of its funding and its policies and regulations. The Federal agencies recognize that they need to focus more sharply on the consequences of their policies and actions for universities. Federal actions will be more effective if the RIUs, in parallel, develop a clearer definition of their missions and strategies and adopt practices and processes that improve management, efficiency, and accountability.

Issue: The Conduct of Research

Some of the most far-reaching changes in the research environment are occurring in the conduct of research itself, including the intellectual organization of the task, the processes by which it is accomplished, and the institutional relationships that support it. The net result is an increase in cost and complexity of research along with an explosion of opportunities to expand knowledge.

RECOMMENDATION:

- *Federal agencies should increase bilateral and multiagency cooperative activities, thereby encouraging significant multidisciplinary initiatives that might otherwise not be funded.*

State-of-the-art facilities and instruments for advanced education at RIUs are vital elements of American education as well as research. The costs of these facilities have risen rapidly, as frontier research has become increasingly dependent on advanced technology. There is a shared Federal and university interest in maintaining capability for frontier research at universities. Such facilities are not only essential to graduate education and state-of-the-art research but also to the advancement of the national research agenda and execution of individual agency missions.

Support provided by Federal agencies through research grants includes salary for researchers, in some cases full salary support. Full salary support may be an appropriate aspect of full payment of costs of research procured by the Federal government from universities. However, full salary support is inappropriate in situations where the interests and responsibilities are shared between the university and the Federal government. Furthermore, Federal salary support in the latter instance should not displace universities' own responsibilities for faculty support.

RECOMMENDATIONS

- *Federal agencies should act on their shared interest in the health of university research infrastructure, including equipment and facilities, by clarifying and establishing their shared responsibilities and those of universities based on a careful and focused allocation of shared resources.*
- *The challenges to science and technology require a diversity of research mechanisms. Federal agencies should balance continued strong support for individual investigators with effective focus on centers and groups, and on multidisciplinary research.*
- *Federal agencies should pay even greater attention to efficiency in the allocation of resources for university-based research, to encourage shared facilities, and to ensure that resources are commensurate with the objectives for which they are allocated.*

The costs of research performed by universities and the appropriate sharing of these costs between the universities and the Federal government have long been a source of controversy. The Federal government makes payments to universities for the indirect costs of research. However, specific policies have varied and some controversy stems from differences in purposes of research funding by Federal agencies. In many cases, agencies are procuring specific research services or products from the universities. In others, the principal purpose is to underwrite university research and research infrastructure; in the latter case it is reasonable that the universities share the costs as well as the benefits of the investment.

Federal reliance on cost-sharing and leveraging arrangements with universities has increased. These arrangements frequently serve as a requirement for the applicant's inclusion in competition for funding. Requirements for sharing of costs of research by academia and other sectors help to conserve limited Federal funds at the same time that they assure real commitment to the project by the other participants. However, such cost sharing requirements can result in long-term financial obligations that may exert pressures on other university missions.

RECOMMENDATIONS

- *The Federal government and RIUs should work together to assess and clarify the respective responsibilities of universities and agencies in supporting human and physical academic infrastructure.*
- *The Federal government should systematically review and, if necessary, clarify and simplify cost sharing guidelines and principles in major research projects with universities.*
- *As a counterpart to greater clarity and predictability on the part of the Federal government, the universities should establish accounting systems that adhere to common standards and facilitate the identification of the costs of research.*

Reliance on excellence and competitive merit review by peers as the basis for decisions to support research assures the continued quality of U.S. scientific and technical research.

RECOMMENDATIONS

- *The Federal agencies should strengthen and expand their reliance on merit review in funding decisions for science and engineering research.*
- *In recognition of the growing burden of the review process on the academic community, Federal agencies should simplify their award procedures and make their requirements more uniform where appropriate.*

Issue: Education and Development of the Talent Pool

Federal interests in the broad goal of human resource development cut across all agencies and transcend specific research issues. In addition, individual agencies have a special interest in helping to develop the human resource pool in fields specific to their mission areas.

RECOMMENDATIONS

- *Federal agencies should work with RIUs and with state and local governments to promote systemic improvements in science, engineering, and mathematics education.*
- *Federal agencies should promote excellent teaching by providing incentives to universities to foster sound, rigorous education in elementary and secondary schools, and to nurture the proficiency and expertise of their own faculty and of the teachers that they train.*

A major benefit of Federal funding of research at universities has been the involvement of graduate students on an apprenticeship basis with cutting edge research, thereby making available to industry, academia, and government technical personnel of unmatched competence and creativity. Nevertheless, there is a rising concern that the greater rewards associated with research, accentuated by patterns of Federal support, may be having adverse effects on the quality of undergraduate education. Federal research support may also affect the choice of specialties by graduate students, with unintended consequences. The result can be an overemphasis and oversupply in some areas of expertise, or more seriously, neglect of others, thus weakening future national research and education capacity.

RECOMMENDATION

- *Federal agencies should examine the impact of Federal research support on university undergraduate and graduate education and identify strategies to ensure against unintentional degradation of the educational mission and excellence of the RIUs.*

Several trends affecting both the applicant pool and the technical competency of the future work force could have implications for Federal policies toward higher education. Low student interest at precollege and undergraduate levels affects preparedness for employment and for future studies. Also, women and underrepresented minorities are a growing share of the college age population. Yet their interest in pursuing courses and careers in the sciences and engineering has traditionally been low. Furthermore, at the graduate level, about a third of natural science and engineering Ph.D. recipients come from other countries, including about 60 percent of engineering and over half of computer science Ph.D.s. As more job opportunities are created in other

countries, the proportion of those who remain in the United States to work may shrink, affecting the adequacy of the talent pool in key disciplines. In addition to creating uncertainty in the availability of the human resource base for national purposes, the low rate of U.S. participation in science and engineering will reduce the benefits of U.S. higher education to industry. It is important that the university research system be open internationally, but the United States should not be dependent on foreign citizens to fill technical work force needs. Currently, not enough U.S. students select careers in science and engineering.

RECOMMENDATION

- *The Federal government should develop strategies for enhancing the participation and retention of students in the sciences, mathematics, and engineering with special focus on women and underrepresented minorities.*

Issue: Dissemination and Utilization of Knowledge

It is not enough to generate new knowledge; the new knowledge must be put to work to the benefit of the American people. To translate gains in knowledge into tangible gains in economic activity, environmental quality, public health, and the quality of life generally requires extensive, rapid dissemination of knowledge resulting from Federally supported research at universities. Growth in the utility of knowledge relies on the continued development of knowledge networks and collaborative relationships among academic institutions, industry, and government, and on legal assurances for intellectual property rights for researchers and inventors funded by the Federal government.

RECOMMENDATION

- *The Federal government should encourage use of existing and new institutional arrangements to increase the dissemination and utilization of knowledge and increase emphasis on university/industry cooperation.*

Issue: Accountability and Administrative Burdens

Public expectations have increased with respect to universities' fulfillment of their fundamental responsibilities for education and stewardship of public resources. Increasingly, the conduct of research also raises a variety of legal, social, and ethical issues, including scientific misconduct and conflict of interest. In response to these concerns, university activities have become subject to a wide variety of administrative requirements on expenditures of Federal funds and certification of compliance with Federal statutes. Since these Federal requirements can be ex-

pected to increase, their cumulative burden on RIUs, as well as their interaction with state and local government policies, need to be better understood.

The Federal government has a broad responsibility to achieve coherence and simplicity in its regulatory activities as they affect relationships with the RIUs. For example, simplification, coordination, and standardization of administrative practices and requirements across Federal agencies can offer improvements in clarity and process to both the RIUs and the Federal government.

RECOMMENDATIONS

- *The Federal government should review the requirements it places on research-intensive universities in grant and contract administration, requests for data, research cost accounting, and other areas, and simplify these to the greatest degree consistent with its fiduciary responsibilities. An interagency coordinating mechanism should be established to facilitate this process, especially through pilot projects to develop and test simplified procedures.*
- *Individual Federal agencies should review existing internal and intergovernmental requirements, as well as proposed regulations, to minimize administrative burdens.*
- *The Federal government should hold universities fully accountable for compliance with Federal regulations and with high standards of professional integrity in research.*

ISSUES FOR FURTHER ATTENTION

In this report, the WGRIU has addressed a number of complex issues whose purpose is to provide direction on salient aspects of the Federal government's relationship with the RIUs. In the course of its deliberations, the WGRIU additionally identified a number of issues, beyond those already mentioned in the recommendations, that should be the subject of further study. These include:

- Effects of Federal policies on international activities of RIUs;
- Relationships among academic researchers and RIUs and other Federally-funded research laboratories, including national laboratories and Federally funded research and development centers (FFRDCs);
- Effects on the overall health of the RIU research base resulting from increases in Federal emphasis on directed research;
- Balance and relationship between individual investigator research and other modes of university research support;
- Effects of Federal policies toward salary funding on researchers and RIUs; and

- Desirability of shifting current funding patterns, which were set in the post war period, to meeting emerging national objectives, including quality of life, industrial productivity and economic growth.

CONCLUSION

The American research university system has been a remarkable achievement of cooperation between the public and non-profit sectors. It has enabled continual and broadly based challenges at the frontiers of knowledge and has contributed enormously to the quality of life in this country through the success of its research and education programs. The strength and excellence of the American academic research and education infrastructure is fundamental to the national strength in science and technology and to the discharge of a wide range of missions and responsibilities of the Federal government. It is in the best interest of the Nation that the relationship between the Federal government and the RIUs be maintained and that its effectiveness and productivity be nurtured and enhanced. The recommendations contained in this report are provided with the purpose of advancing this goal.

The RIUS in the Academic System
Data Overview

APPENDIX A

A DATA OVERVIEW OF RESEARCH-INTENSIVE UNIVERSITIES

This appendix provides some selected data about the role and activities of the research-intensive universities (RIUs), the context in which they operate, and their Federally supported research activities. Data are presented in four sections:

- Research-intensive universities in the U.S. academic system
- Research-intensive universities' operating revenues
- Research-intensive universities' education outputs
- Federal support of R&D at research-intensive universities

The coverage is concise, and a list of data sources is provided for the benefit of readers who wish to pursue a topic in more depth.

The U.S. academic research enterprise is marked as much by its size and diversity as by its generally acknowledged excellence. Some 1,100 universities, colleges, and specialty institutions in 1990 reported *some* amount of research expenditures to the U.S. Department of Education. Major centers of research participate in this activity, along with schools whose research portfolios are more limited, and still others whose participation may be limited to the occasional activities of a handful of their professors.

At the core of the academic research enterprise is a smaller number of institutions that have both a high volume of sustained research activity over a large number of fields and training programs that contribute heavily to the education of Ph.D.s in the sciences and engineering. For the present study, a set of 170 *research-intensive universities* was identified which together accounted for at least 90 percent of each of the following national totals for 1981-1990:

- Academic R&D expenditures
- Federal obligations for academic science and engineering
- Federal obligations for academic R&D
- Number of Ph.D.s awarded in all science and engineering fields
- Number of Ph.D.s in *natural* sciences and engineering (NS&E), excluding medical and social sciences and psychology

There is of course no "natural" way of defining such a set, and judgment may differ over the "best" criteria to use. Nevertheless, whichever reasonable definition is used, the general trends and central tendencies discussed here will remain valid.

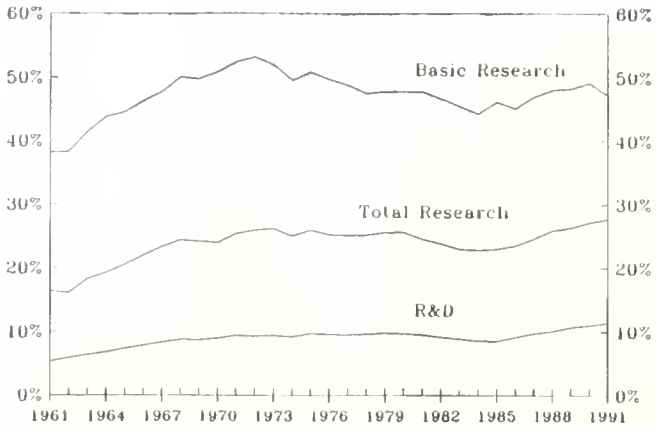
RESEARCH-INTENSIVE UNIVERSITIES IN THE ACADEMIC SYSTEM

Academic institutions spent an estimated $17.2 billion for R&D in 1991, about 11 percent of the national total. University-managed, Federally funded R&D centers (FFRDCs) accounted for an additional 3 percent of total R&D. The prominence of academic institutions as performers of R&D varies with the type of research activity being considered. Universities perform almost half of the nation's basic research, about 28 percent of its total research, and less

than 1 percent of its development activities (Figure 1). Academia has held these positions in the U.S. R&D context since the early 1970s, resulting from a strong build-up of academic research capacity during the 1950s and, especially, the 1960s.

Compared to the early '60s, the institutional base for academic R&D has grown considerably in terms of the number of people involved, amount expended, and number of institutions involved. Though few in number, the research-intensive universities stand out in the nation's higher education system in many ways. They expend 60 percent of the operating funds of the nearly 2,000 institutions awarding baccalaureate or advanced degrees, enroll 40 percent of the fulltime students, and grant 35 percent of all bachelors degrees. They are even more prominent in training in the sciences and engineering, where they award 45 percent of all bachelors degrees, more than half in the *natural* sciences and engineering, 90 percent of the Ph.D.s, and almost 95 percent of doctorates in NS&E (Figure 2). These numbers have changed little in the past two decades.

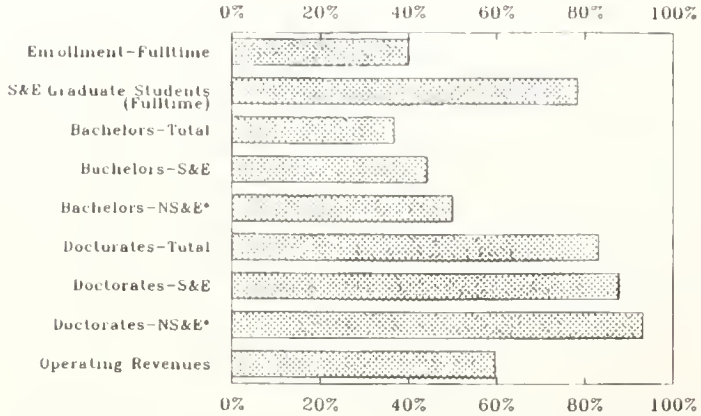
Figure 1: U.S. Academic Share of National R&D By Character of Work



Source National Science Foundation (see reference 1)

These universities also accounted for about 90 to 95 percent of R&D funds from various sources. They spent 90 percent of the national total for facilities used in science and engineering research or training, and 80 percent of the Federal funds for this purpose (Figure 3).

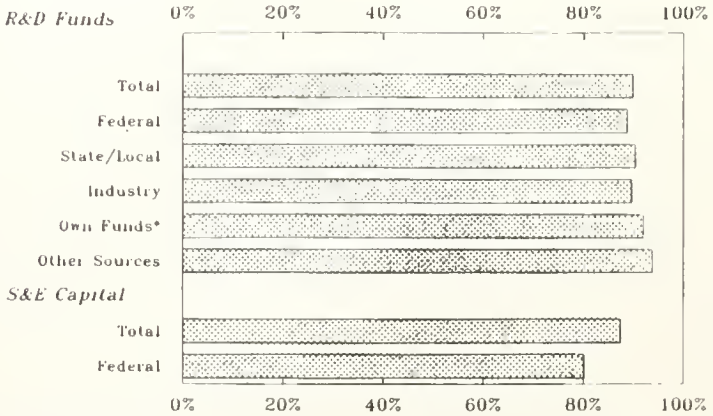
Figure 2: Research-Intensive Universities' Share of Selected Production Indicators for All Four-Year Institutions, 1990



* S&E less medical and social sciences and psychology

Source NSF, special tabulation from NSF and Department of Education data (see reference 2)

Figure 3: Research-Intensive Universities' Share of Academic R&D and S&E Capital Funds from Various Sources, 1990



* Includes unknown amount of state funds for public institutions. R&D funds exclude APL

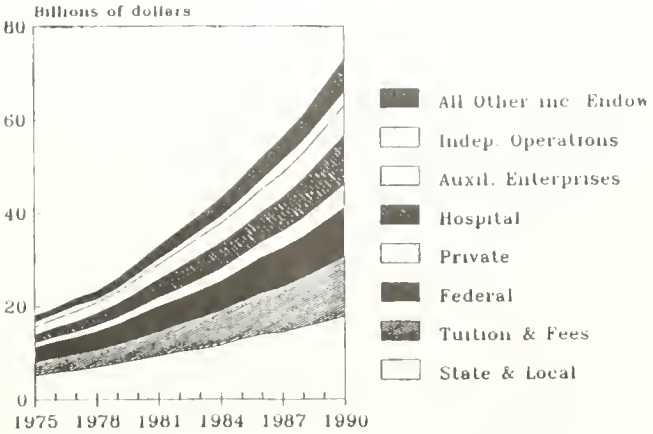
Source National Science Foundation, special tabulation (see reference 3)

RIUS' OPERATING REVENUES

Operating revenues of the research-intensive universities have grown at a strong pace, from $17.9 billion in 1975 to $72.8 billion in 1990 (Figure 4). This translates into average nominal annual growth of 9.8 percent (3.9 percent in 1987 constant dollars) over the 15-year period. In fact, after-inflation growth was more rapid during much of the 1980s, as the rate of inflation declined.

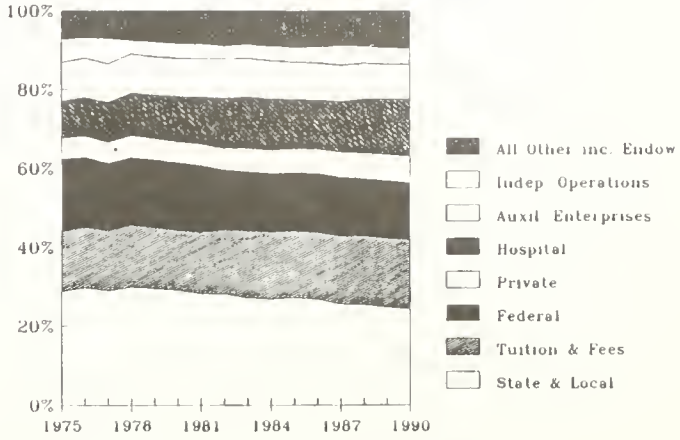
The slowest-growing sources of university revenues were Federal and state government funds, along with funds from university-managed FFRDCs, large special programs, and university bookstores and other such enterprises (Figure 5). Funds from hospitals, private sources, endowment, and tuition and fees grew more rapidly. As a result, the composition of revenues underwent a slow but marked shift, whose most pronounced aspect is the decline since the mid-1970s in the share of Federal funding from 19 to 15 percent and state government funding from 29 to 24 percent of total revenues. In recent years, state appropriations growth has continued to slow, and a number of major public research-intensive universities have received decreased state funding, before adjusting to inflation, compared to earlier years.

Figure 4: Operating Revenues of Research-Intensive Universities by Source of Funds



Source: National Science Foundation, special tabulation from Department of Education data (see reference 4)

Figure 5: Shares of Universities' Operating Revenues Contributed by Different Sources



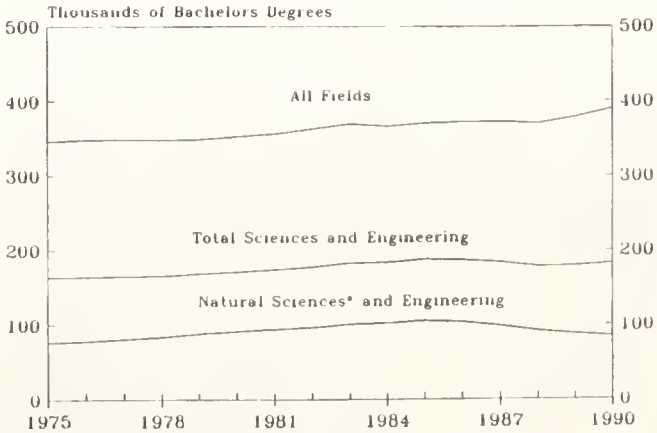
Source: National Science Foundation, special tabulation from Department of Education data (see reference 5)

RIUS: EDUCATION OUTPUTS

In line with rising enrollments, the number of bachelors degrees awarded by the research-intensive universities has grown as well, from 345,000 in 1975 to 390,000 in 1990 (Figure 6). But science and engineering baccalaureates have declined by 3 percent from their 1985 peak, and bachelors degrees in the *natural* sciences and engineering have fallen by 20 percent.

In contrast, doctoral degree production of the research-intensive universities has increased across the board since the late 1970s; by the late 1980s, the number of doctorates in all fields combined, in the sciences and engineering, and in the natural sciences

Figure 6: Bachelors Degrees Awarded by Research-Intensive Universities



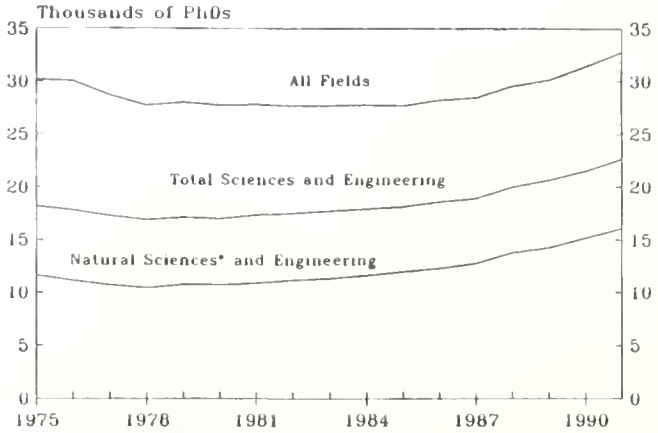
* S&E less medical and social sciences and psychology

Source: National Science Foundation, special tabulation from Department of Education data (see reference 6)

and engineering all had exceeded their previous historical highs (Figure 7). Over the decade, the RIUs' share of Ph.D.s in the sciences and engineering declined from 94 to 88 percent, but for the smaller set of NS&E fields it increased 95 to 96 percent of the total.

Women have increasingly participated in science and engineering fields. In the RIUs, as in academia generally, they have earned a growing share of all types of degrees (Figure 8). Between 1975 and 1990, their share of doctorates in science and engineering rose from 34 to 42 percent, with increases in the *natural* sciences and engineering from 18 to 28 percent. Over the same period, women also roughly doubled their share of science and engineering Ph.D.s. Of doctorates awarded to citizens and resident visa holders, women represented 35 percent in 1991, and 25 percent in the natural sciences and engineering.

Figure 7: Doctoral Degrees Awarded by Research-Intensive Universities

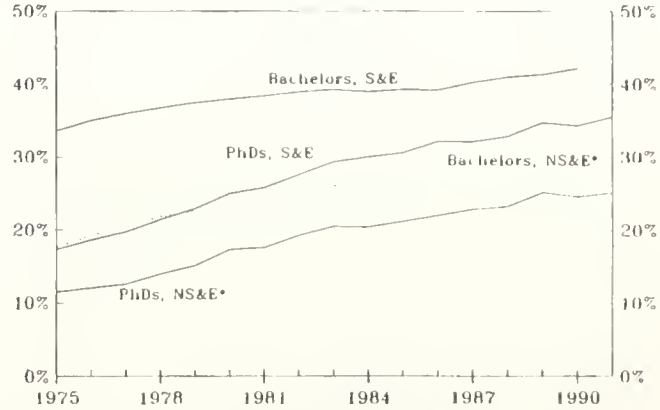


* S&E less medical and social sciences and psychology

Source: National Science Foundation, special tabulation (see reference 7)

Minority students have more than doubled their shares of both science and engineering and natural sciences and engineering baccalaureate degrees since 1977, when such data first became available (Figure 9). They accounted for 17 to 18 percent of these degrees in 1990. But their share of Ph.D. degrees awarded to citizens and residents in these fields has increased more slowly, reaching roughly 14 percent in 1991, compared with 8 to 9 percent in 1975.

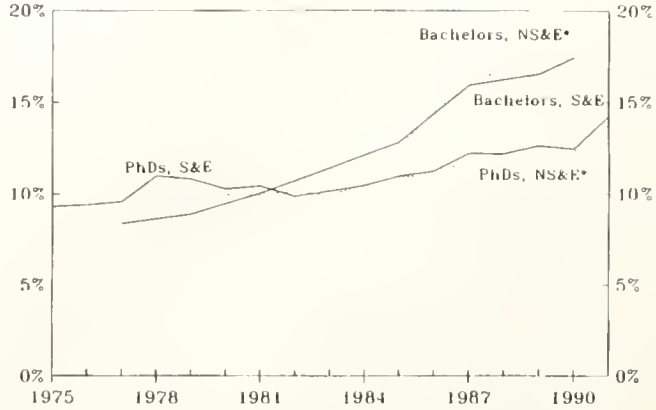
Figure 8: Fraction of S&E or NS&E Degrees Awarded to *Women* by Research-Intensive Universities, by Degree Level



* NS&E: S&E less medical and social sciences and psychology, bachelors degree data not available for all years

Source: National Science Foundation, special tabulation from NSF and Department of Education data, based on degrees to citizens and residents only (see reference 8)

Figure 9: Fraction of S&E or NS&E Degrees Awarded to *Minorities* by Research-Intensive Universities by Degree Level

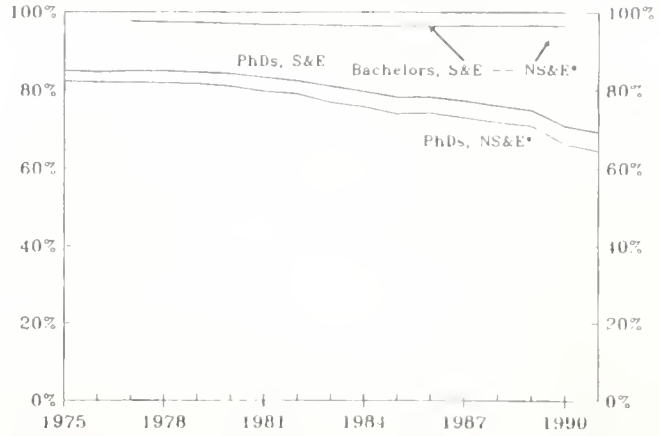


* NS&E: S&E less medical and social sciences and psychology, bachelors degree data not available for all years

Source: National Science Foundation, special tabulation from NSF and Department of Education data, based on degrees to citizens and permanent residents only (see reference

Foreign students continue to seek out education in RIUs. They are a major presence in graduate education in science and engineering at these institutions, less so at the undergraduate level (Figure 10). Baccalaureate degrees awarded to foreign students in 1990 amounted to 3 percent of the institutions' science and engineering total, and 4 percent for the natural sciences and engineering, barely changed from the mid-70s. On the other hand, the share of Ph.D.s awarded to foreign students has continued to increase, even as the total number of these degrees has grown. Foreigners earned 30 percent of the science and engineering Ph.D.s awarded by U.S. institutions in 1991, an increase of 15 percentage points since 1977; and they earned 36 percent of the Ph.D.s in the natural sciences and engineering, a rise of 17 points over the period.

Figure 10: Fraction of Total S&E or NS&E Degrees Awarded to Citizens by Research-Intensive Universities by Degree Level



* S&E less medical and social sciences and psychology, bachelors degree data unavailable

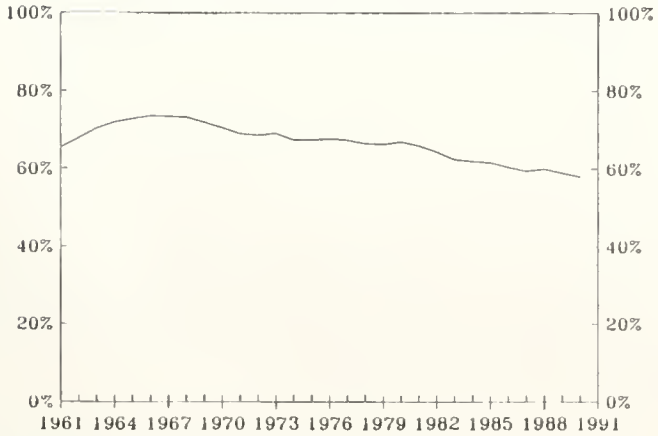
Source: National Science Foundation, special tabulation from NSF and Department of Education data (see reference 10)

FEDERAL SUPPORT OF R&D AT RESEARCH-INTENSIVE UNIVERSITIES

The Federal government has been, and remains, the largest single source of funding for R&D at RIUs (Figure 11). However, support from other sources has grown more rapidly than Federal funds. As a result, the share of total funds provided by the Federal government has steadily declined from a 1966 high of 74 percent to an estimated 58 percent in 1990.

The mix of R&D functions supported by the Federal government has been remarkably stable since the early 1970s (Figure 12). Basic research has fluctuated between 70 and 75 percent of Federal support, applied research between 20 and 25 percent, and development has constituted 3 to 5 percent of the total.

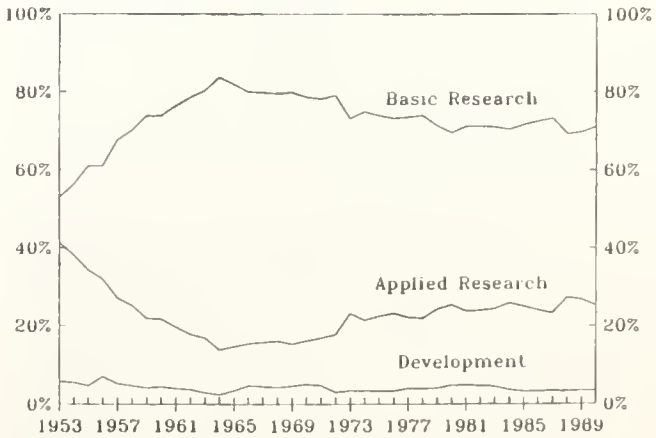
Figure 11: Federal Share of R&D Funding at Research-Intensive Universities



1961-71 estimated from Federal share of total academic R&D; 1991 data unavailable

Source National Science Foundation, special tabulation (see reference 11)

Figure 12: Fraction of Federal Academic R&D Support Allocated to Different Types of R&D

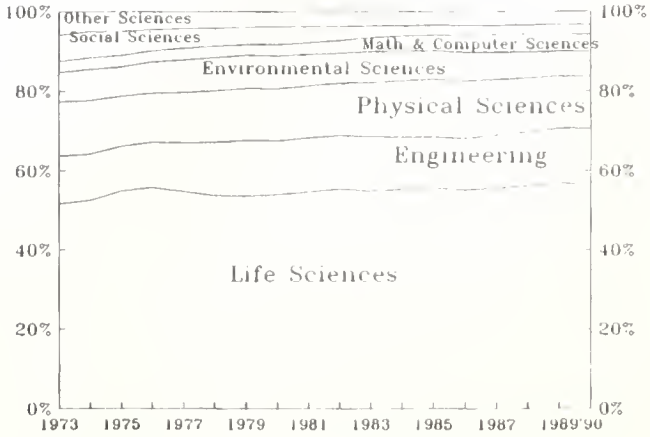


Source National Science Foundation (see reference 12)

The broad field mix of Federally supported academic R&D has fluctuated, but shifts among major science and engineering areas have generally been slow and evolutionary (Figure 13). The life sciences have long been dominant, and have increased their share of the Federal total from 52 percent in the early 1970s to 56 percent in 1990. Engineering and the physical sciences have fluctuated between 12 and 14 percent of the total, environmental sciences between 6 and 8 percent, and mathematics and computer sciences between 3 and 4 percent. An exception to this general picture is the social sciences, whose share fell from 7 percent to 2 percent between 1973 and 1990.

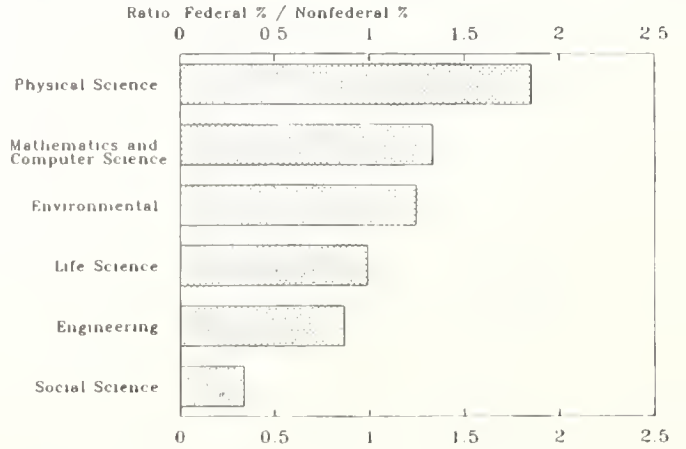
The Federal government puts relatively more emphasis than other funders on the physical sciences, mathematics, computer sciences, and environmental sciences (Figure 14). The life sciences occupy about the same relative position in Federal and aggregate non-Federal sources. Engineering and, especially, the social sciences receive relatively less funding emphasis from Federal as compared to other funding sources.

Figure 13: Distribution of Federal Academic R&D by Field of Science



Source: National Science Foundation (see reference 13)

Figure 14: Relative Emphasis of Federal Academic R&D, 1990: Ratio of Field Share of Federal to Field Share of Nonfederal Funds



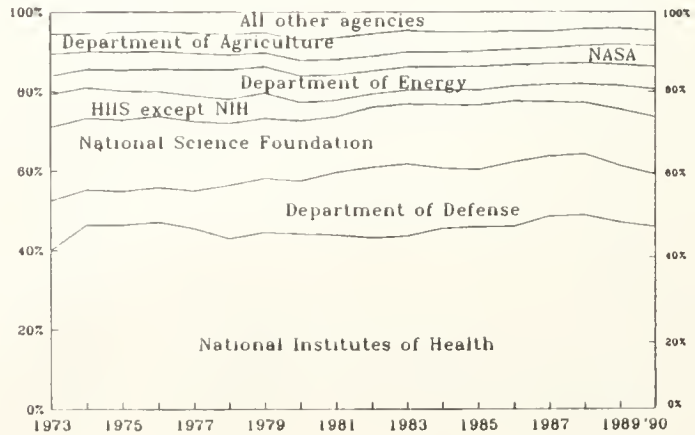
Ratio >1 indicates relatively greater share of Federal than of non-Federal funds to given field

Source. National Science Foundation (see reference 14)

Three agencies—The National Institutes of Health (NIH), the National Science Foundation (NSF), and the Department of Defense (DOD)—have provided roughly three-quarters of the Federal government's academic R&D funding (Figure 15). NIH by itself has provided 40 to 45 percent of the total, with DOD and NSF shares roughly equal during much of the 1980s. In recent years, the shares of DOD, NIH, and the Department of Agriculture (USDA) have declined somewhat, but overall, the picture is one of a fairly steady funding pattern.

Agencies deal with universities in their individual ways, depending on mission, tradition, types of research, and other factors, as detailed in the Agency Perspectives section of this report. One feature of this diversity in relationships is the relative prominence of universities as performers of the different agencies' *research*, i.e., excluding development. Some agencies, like NSF and NIH, have the bulk of their research conducted by

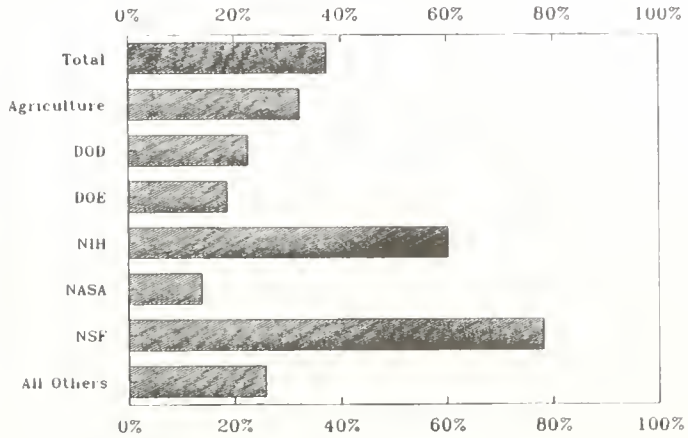
Figure 15: Agency Shares of Federal Academic R&D Support



Source National Science Foundation (see reference 15)

academic performers, with other major agencies' proportions ranging from 12 percent for the National Aeronautics and Space Administration (NASA) to 30 percent for USDA (Figure 16). However, both NASA and, especially, the Department of Energy (DOE) also rely on university-managed FFRDCs for a share of their research, which in DOE's case amounts to more than half of its total research spending.

Figure 16: Fraction of Federal Agencies' Research Funds to Academic Institutions, 1990



Source National Science Foundation (see reference 16)

Data Source References

Figure 1: National Science Board, *Science & Engineering Indicators-1991,* Wash., D.C., GPO, 1991, Appendix Tables 4-4, 4-5, 4-6.

Figure 2: Special tabulations. Enrollment: U.S. Department of Education IPEDS survey of Opening Fall Enrollment in Colleges and Universities, 1990. Bachelors degrees: U.S. Department of Education IPEDS survey of Earned Degrees Conferred, 1990. Doctorates: NAS/NRC Survey of Earned Doctorates, 1990. Operating revenues: U.S. Department of Education IPEDS survey of Financial Statistics of Institutions of Higher Education, 1990.

Figure 3: Special tabulations. NSF, surveys of Academic Science/Engineering: R&D Funds, Fiscal Year 1990.

Figure 4: Special tabulation. U.S. Department of Education IPEDS Surveys of Financial Statistics of Institutions of Higher Education.

Figure 5: Special tabulation. U.S. Department of Education IPEDS Surveys of Financial Statistics of Institutions of Higher Education.

Figure 6: Special tabulations. U.S. Department of Education IPEDS Surveys of Earned Degrees Conferred.

Figure 7: Special tabulations. National Science Foundation, NAS/NRC Surveys of Earned Doctorates.

Figure 8: Special tabulations. Bachelors degrees: U.S. Department of Education Surveys of Earned Degrees Conferred. Doctorates: National Science Foundation, NAS/NRC Surveys of Earned Doctorates.

Figure 9: Special tabulations. Bachelors degrees: U.S. Department of Education Surveys of Earned Degrees Conferred. Doctorates: National Science Foundation, NAS/NRC Surveys of Earned Doctorates.

Figure 10: Special tabulations. Bachelors degrees: U.S. Department of Education Surveys of Earned Degrees Conferred. Doctorates: National Science Foundation, NAS/NRC Surveys of Earned Doctorates.

Figure 11: Special tabulation. National Science Foundation, surveys of Academic Science/Engineering: R&D Expenditures. Data for research-intensive universities for 1961-71 estimated from national totals.

Figure 12: National Science Foundation, *National Patterns of R&D Resources, 1990,* Wash., D.C., 1990, Tables B-2, B-3, B-4.

Figure 13: National Science Board, *Science & Engineering Indicators-1991,* Wash., D.C., GPO, 1991, Appendix Table 5-7.

Figure 14: Special tabulation. National Science Foundation, surveys of Academic Science/Engineering: R&D Funds, Fiscal Year 1990.

Figure 15: National Science Foundation, *Federal Support to Universities, Colleges, and Nonprofit Institutions: Fiscal Year 1990,* Wash., D.C., 1991. Table B-2.

Figure 16: National Science Foundation, *Federal Funds for Research and Development-Detailed Historical Tables: Fiscal Years 1956-1992,* Wash., D.C., 1991, Tables 30-A, 30-B, 33-A, 33-B, 40-A, 40-B, 43-A, 43-B.

Agency Perspectives

APPENDIX B

INTRODUCTION

Agency-specific relationships to the RIUs encompass several dimensions. As mentioned above, the Federal government uses many different funding mechanisms to sponsor research, extending from the "support" mode to the "procurement" mode.

Another dimension of the relationship is reflected by the kind of research unit that agencies typically support. The major science agencies support both individual investigators and small groups, but not in the same proportions. On the other end of the spectrum, some agencies, the Department of Energy for one, contract with RIUs to manage large research facilities, such as national laboratories.

A third dimension is the disciplinary distribution of funded research. NSF provides broad-based infrastructural support for all science and engineering disciplines, while most other agencies support or procure the services of a mix of disciplines, the mix being specific to each program.

Funding decision processes also vary widely. Federal agency research awards are predominantly competitive, but the practice varies by agency. For example, most of the Department of Agriculture's academic research funds are allocated by Congressionally-legislated formulae, though the share of competitive research support to individual investigators has grown from zero to over one-third in the last two decades.

Competitive awards are themselves determined by a continuum of methods across and within agencies, ranging from predominantly extramural peer review to, predominantly, the judgement of the internal research manager. For example, extramural peer review plays less of a role in funding decisions in DOD than in NSF and NIH. In addition, the weight of program officers' judgement varies.

Nearly all agencies provide some form of graduate fellowships. A number of agencies provide research assistantships. Across agencies, programs vary in terms of eligibility criteria, selection processes, objectives, and size and form of awards.

This Appendix provides more detail on agencies' relationships with RIUs.

AGENCY FOR INTERNATIONAL DEVELOPMENT (A.I.D.) PERSPECTIVE

General Description of the Current Relationship:

Currently, A.I.D. contracts for university technical services in agriculture, health, economics and other fields. A.I.D. recently established the Agency Center for University Cooperation in Development in recognition of the major resource they represent. The Center encourages A.I.D. use of universities and to help build new long-lasting ties with institutions in developing countries defined around development issues of joint interest and mutual benefit.

Under A.I.D.'s Thomas Jefferson Fellowship Program, the Agency presently supports about 8000 students from developing countries at over 700 colleges and universities, including nearly all of the research-intensive institutions.

It relies entirely on them for quality graduate degree programs. Through this training and educational sponsorship the A.I.D. Office of International Training is a sources of financial support for universities and a contributor to campus research manpower. It also adds to the international perspective on the U.S. campus and encourages professional ties with institutions in the developing world.

Several hundred million dollars per year of research are sponsored by A.I.D. This investment improves A.I.D.'s operational programs; more fundamentally it influences the research agenda of the international community. Research in such areas as tropical agriculture and tropical medicine receives very large investments worldwide, and A.I.D. seeks to catalyze and steer these investments to achieve U.S. objectives. The intellectual leadership of the U.S. scientific community, especially the leadership from the research-intensive universities, is critical to this effort, establishing the cutting edges of the research itself, training researchers, and providing technical assistance and external peer review.

A.I.D. Expectations/Requirements for Relationships with Universities:

A.I.D. has a charter to promote democratization, the development of free market economies, peace, and social and economic development in client states. Universities play a key role as modern states seek to achieve these objectives. The U.S. university system serves as a unique model and source of aid to A.I.D.s clients. Moreover, the international university community is an institution of world importance, and U.S. universities' participation in this world network is critical to the health of universities in A.I.D.'s client countries.

Of course, A.I.D. also calls on the university community for educational services, for the creation and organization of knowledge and technology, for the professional services of the scholarly community, and for institutional services including management of projects and programs.

Issues with Current Relationships/Barriers to an Effective Relationship:

- Is there a need for a stronger effort to catalyze and facilitate the role of U.S. universities in developing countries?
- Is the potential for U.S. university involvement in developing countries recognized and fully appreciated by policy, program, and technical staff of A.I.D. and other government agencies involved in our work?
- Are the universities sufficiently international in outlook? Can the government accelerate the universities' internationalization movement?
- Are the "markets" effective, so that developing country and A.I.D. staff "customers" seeking U.S. university services know of the offerings, and U.S. university know of the demand for their services?
- Does A.I.D. (U.S. government) need new mechanisms or authorities which recognize the special role and value of universities in our society and make it easier to obtain their services and participation?

Elements/Characteristics of a Productive Future Relationship:

- Mutual confidence and trust;
- Expanded information in each party (university staff, government staff, foreign nationals) as to the others;
- More interpenetrating personnel systems so that scholars and managers can move freely between government and university;
- Wider public, Executive and Congressional understanding of the benefits of a more international orientation among universities and a more effective partnership of government and university in development;
- More effective flow of information as to needs of scholarship from government to university, and much more effective flow of the scholarly information from university to government;

- Government/university relationships that serve as a channel for the university's wider community to internationalize.

Legislative/Executive Authorities for A.I.D.'s Relationship with Research-Intensive Universities:

Title XII of the Foreign Assistance Act provides special arrangements to strengthen and access Land-grant universities for agricultural projects in developing countries. Through cooperative agreements and grants it also supports research and related activity of importance to development at universities.

U. S. DEPARTMENT OF AGRICULTURE (USDA) PERSPECTIVE

General Description of the Current Relationship:

The U.S. Department of Agriculture (USDA) is the lead Federal agency for teaching, research, and extension in the food and agricultural sciences. USDA has a number of research and education agencies: the Agricultural Research Service, the Cooperative State Research Service, the National Agricultural Library, the Economic Research Service, the Forest Service, the Extension Service, and others with somewhat more limited research and education roles, such as the Office of International Cooperation and Development, the Soil Conservation Service, and the Agricultural Marketing Service, Office of Transportation, Agricultural Cooperative Service, National Agricultural Statistics Service, and Human Nutrition Information Service.

USDA works with all universities and colleges with programs in the food and agricultural sciences, but has a special relationship to the land-grant system. There are land-grant institutions in each State, the District of Columbia, and some territories. These institutions include Tuskegee University and 16 other institutions authorized in 1890 to serve Black Americans. There are more than 600 university teaching, research, and service programs in the food and agricultural sciences at the baccalaureate or higher levels.

As the lead Federal agency for higher education in the food and agricultural sciences, USDA works closely with the universities to assure excellence in U.S. higher education—curricula revitalization, faculty development, undergraduate research expansion, emerging technologies usage, etc. The Department also works closely with colleges and universities to assure the Nation an adequate supply of scientists and professionals with requisite expertise in the food and agricultural sciences. It provides graduate fellowships/traineeships and postdoctoral assignments in Federal laboratories as mechanisms to train personnel for critical positions with government, academia, and the private sectors.

A principal linkage between universities and USDA is through programs of the Cooperative State Research Service (CSRS), which has responsibility for extramural research and higher education. Hatch Act funds serve as the base upon which other Federal funds—including those for the National Research Initiative and Special Research Grants—and State and private support build. Also, within CSRS the McIntire-Stennis Cooperative Forestry Program funds forestry research at designated institutions. The Evans-Allen Program allocates funds for agricultural research at the 1890 land-grant institutions and Tuskegee University. The land-grant universities further relate to USDA through programs which involve continuing education and technology transfer through the Extension Service, funded largely by authority of the Smith-Lever Act. It is important to note that Hatch and Smith-Lever funds leverage more than twice the Federal investment from State and private sources. USDA's Agricultural Research Service and Forest Service conduct intramural research with extensive co-location on university campuses and with cooperative and coordinated programs of research.

This State/Federal partnership promulgates a unique system, not duplicated by any other Federal relationship, that is unparalleled in its impact on a major sector of the U.S. economy. The functional partnership between the States and USDA assures a close coupling with the users of the products of science and education. In particular, USDA has access to a continuing education network located in each county in every State. This unique system offers an opportunity for transfer of knowledge and technology aimed not just at production of food and fiber, but targeted to improve the quality of life of all citizens.

Historically, most USDA funding was provided to universities via formula grants. For the past several decades, however, the Department has moved increasingly toward competitive research and teaching grants programs. To assure excellence in its programs, grant recipients are selected by means of rigorous merit review of proposals by peers. Criteria used in merit reviews of competitive grants are tailored to the specific program. In addition, USDA often provides support via grants, contracts, and cooperative agreements to universities for conducting essential research that helps USDA and other Federal regulatory agencies meet their regulatory missions.

Public Benefits from Research-Intensive Universities/Federal Government Relationship:

America's food and fiber system is one of its greatest success stories. A major contributor to this success has been USDA's long-standing relationship to the university community. USDA conducts and sponsors research that covers the spectrum from very basic discovery level studies to applied research. Programs are driven by strategic planning in which perspectives on needs are solicited from the broad community of users of the products of research while scientific objectives are solicited from scientists with a vision of opportunities to address new needs. Research is directed toward addressing societal issues, such as (1) restoring and preserving the environment and natural resources, (2) assuring the dietary health and well-being of the populace, and (3) maintaining and enhancing the competitiveness of U.S. agriculture-based industry in the international marketplace. Further, USDA has invested in the future well-being of the country through excellence in science and education for over a hundred years. In particular, USDA benefits the public in the following areas.

- Environment and Natural Resources:

  Manage farm lands, range lands, and forests to assure protection and enhancement of the quality of soil and water resources, reduce erosion, and assure compatibility of production agriculture and forestry practices with sustaining and protecting the environment.

- Nutrition, Food Safety, and Health:

  Develop further knowledge of human dietary requirements for maintaining the health and quality of life for a population with diverse ethnic and income backgrounds; provide new knowledge and technology to assure the quality and safety of food; develop new sources of food with enhanced quality and safety.

- New Products and Alternative Uses for Existing Raw Materials:

  Increase global competitiveness of U.S. agriculture by using new technologies to add value to raw material through processing and to develop alternative uses for current raw materials that contribute to environmental quality and provide new sources of agricultural income.

- Economic and Social Issues:

  Provide economic models to evaluate policy options for domestic and international market and trade policies; develop new knowledge to enhance the quality of life for families and rural communities; and assess the socioeconomic impact of changing technology.

- Efficiency and Sustainability of Production of Food and Fiber:

  Advance the quality of animal and plant products; reduce use of expensive chemicals that pose potential environmental threats; enhance performance through genetic improvements using modern biological methods; improve overall management strategies for effective and environmentally sound use of natural resources.

- Highly Qualified Scientific and Professional Work Force:

Provide expertise to fill key scientific and professional roles in the food and agricultural labor force, including the university, government, and business sectors.

USDA Expectations/Requirements for Relationships with Universities:

USDA has a unique partnership with land-grant universities to jointly plan and fund research, extension, and teaching programs. This integrated science and education system generates new knowledge, facilitates technology transfer, and assures an adequate and continuing supply of expertise essential to production of safe and nutritious food and fiber products, prudent use of natural resources, and the development of new products and alternate uses for existing raw materials, while addressing economic and social issues. Base programs of ongoing research are supported on a cost-sharing basis with funds that are awarded to States based on a formula driven by the size of agriculture and the number of farmers per State. The States themselves currently furnish by far the largest portion of this type of funding.

Other relationships to all universities are based on competitive award of grants—for fundamental research through the National Research Initiative and through special grants, as well as for strengthening the quality of food and agricultural academic programs through higher education initiatives. In recent years, the relationship with the academic community has broadened, as the missions of the Cooperative State Research Service and those of the State Agricultural Experiment Stations have expanded. Their current missions address a large set of societal issues for which new knowledge is needed, and they must use effectively the tools of modern science and engineering to address these issues.

Issues with Current Relationships/Barriers to an Effective Relationship:

- Adequacy of Federal and State funding to continue operating budgets, to meet expanding research needs, and to take advantage of unparalleled opportunities in science.
- The universities', industries', States', and Federal government's relative shares of costs of research.
- Increasing burdens on research universities of Federal administrative and regulatory requirements.
- Effective methods to coordinate environmental research across performing and sponsoring agencies.
- Adapting the current research and teaching disciplinary organization to a more cross-disciplinary focus, when needed, and achieving support for long-term, interdisciplinary research.
- Broad-based access to state-of-the-art research facilities and instruments through replacement, acquisition, or sharing.
- Lack of an accepted frame of reference to relate the contributions of basic science to societal goals and outcomes.
- Need to strengthen the global competitiveness of U.S. agriculture.
- Adequate provision in the Federal funding process to support development of scientific and technical expertise.
- Potential conflict-of-interest rules and the application of scientific discoveries, e.g., joint industry/university research.
- Need to strengthen minority institutions and incorporate underrepresented groups into the food and agricultural sciences work force in order to replace an aging scientific work force.

Elements/Characteristics of a Productive Future Relationship:

- Develop more effective strategic planning and goal setting for the U.S. science agenda, including linkages among agencies and methods to acquire support for emerging opportunities in science.
- Ensure a priority position for research and education in dealing with budget deficit reduction.

- Minimize regulatory and administrative burdens, consistent with accountability. Resolve the indirect cost question.
- Increase efficiency of teaching, research, and service by enhancing cooperation and collaboration among universities, creating more effective linkages between Federal and university laboratories, using modern communications technologies and new institutional arrangements.
- Increase international cooperation to solve global problems.
- Attend to precollege and college level education and student support programs to attract diverse, well-prepared American students to food and agricultural science careers.
- Encourage support of new researchers and researchers in emerging areas of science, as well as those in currently underfunded areas.

Legislative/Executive Authorities for USDA's Relationship with Research-Intensive Universities:

First Morrill Act, Act of July 2, 1862, ch. 130, 12 Stat. 503, 7 U.S.C. 310 et seq.

Hatch Act, Act of March 2, 1887, 24 Stat. 440, 7 U.S.C. 361a et seq.

Second Morrill Act, Act of August 30, 1890, ch. 841, 26 Stat. 417, 7 U.S.C. 322 et seq.

Smith-Lever Act, Act of May 8, 1914, ch. 79, 38 Stat. 372, 7 U.S.C. 341 et seq.

Bankhead-Jones Act of 1935, Act of June 29, 1935, ch. 338, 49 Stat. 436, 7 U.S.C. 427 et seq.

Research and Marketing Act of 1946, P.L. 79-733, 60 Stat. 1082, 7 U.S.C. 427 et seq.

Granger-Thye Act of 1950, as amended, P.L. 478, signed April 24, 1950, 16 U.S.C. 581i-1

Research Grants Act of 1958, as amended, P.L. 85-934, signed September 6, 1958, 42 U.S.C. 1891-1892

McIntire-Stennis Act, Act of October 10, 1962, P.L. 87-88, 76 Stat. 806, 16 U.S.C. 582a et seq.

Research Facilities Act, Act of July 22, 1963, P.L. 88-74, 77 Stat. 90, 7 U.S.C. 390 et seq.

Act of August 4, 1965, P.L. 89-106, 79 Stat. 431, 7 U.S.C. 450i

Rural Development Act of 1972, Act of August 30, 1972, P.L. 92-419, 86 Stat. 670, 7 U.S.C. 2651 et seq.

National Agricultural Research, Extension, and Teaching Policy Act of 1977, as amended, P.L. 95-113, signed September 29, 1977, 91 Stat. 981, 7 U.S.C. 3101 et seq.

Renewable Resources Extension Act of 1978, Act of June 30, 1978, P.L. 95-306, 92 Stat. 349, 16 U.S.C. 1672 et seq.

Cooperative Forestry Assistance Act of 1978, Act of July 1, 1978, P.L. 95-313, 92 Stat. 365, 16 U.S.C. 2101 et seq.

National Agricultural Research, Extension, and Teaching Policy Act Amendments of 1981, P.L. 97-98, signed December 22, 1981, 95 Stat. 1294

National Agricultural Research, Extension, and Teaching Policy Act Amendments of 1985, P.L. 99-198, signed December 23, 1985, 99 Stat. 1542

Food, Agriculture, Conservation, and Trade Act of 1990, P.L. 101-624, signed November 28, 1990, 104 Stat. 3703 et seq.

DEPARTMENT OF COMMERCE (DoC) PERSPECTIVE

General Description of the Current Relationship:

Throughout its history, the Department of Commerce (DoC) has built and enjoyed mutually beneficial relationships with the nation's research-intensive universities. The nature of this collaboration is currently undergoing a major transformation, in response to two global trends:

(1) growing international awareness of the strong links between technological advance, technology transfer, and economic prosperity, and

(2) increasing evidence that population growth, technological advance, and increased per capita resource consumption are interfering with the normal functioning of the Earth system.

In areas as diverse as climate prediction, biotechnology, high-performance computing, and advanced manufacturing technologies, DoC agencies are seeking increasing assistance and input from the university community. At the same time, constrained agency resources and pressures for high-level fiscal review and greater accountability have stressed the relationship.

The relationship is most strongly reflected in the activities of the National Oceanic and Atmospheric Administration (NOAA) and the National Institute of Standards and Technology (NIST). Agency scientists hold adjunct faculty positions and have created strong working-level relationships between agency and university scientists on numerous important collaborative projects.

In addition to these person-to-person interactions at the working level, the DoC agencies and the university community support several institutional arrangements that merit particular attention. Foremost among these is the National Sea Grant College Program, modeled after land-grant colleges and their interactions with USDA. Under these auspices, the twenty-nine Sea Grant Colleges and institutions now serve as the core of the program, which operates a network of over 200 participating university and marine research institutions throughout the nation. NOAA supplies two-thirds of the base funding of this program; states provide the remaining third.

The National Undersea Research Program (URP) also coordinates NOAA and selected RIU's in order to provide university researchers important access to manned and unmanned submersibles worldwide.

The Cooperative program for Operational Meteorology Education and Training (COMET), established by NOAA's National Weather Service and the University Corporation for Atmospheric Research (UCAR) enables NOAA to tap the expertise of nearly sixty universities in a fair, effective manner to train and educate its operational forecasters. In the modernized National Weather Service, a number of Warning and Forecast Offices will be collocated on university campuses, fostering opportunities for research and training on both sides of the NOAA-university interface.

In the 1960's NIST established a Joint Institute for Laboratory Astrophysics on the University of Colorado Campus, bringing together researchers from both government and the university to a single installation for collaborative, long-term research on a single topic under joint sponsorship. Hugely successful, this model has since been widely emulated by NOAA's Environmental Research Laboratories, which have created seven such institutes. NIST and the rest of NOAA have since established other such institutes. Today hundreds of university scientists and graduate students work side by side with their federal counterparts in these unique institutions.

A significant fraction of the NOAA research budget — over 40% — is allocated extramurally.

Public Benefits from Research-Intensive Universities/Federal Government Relationship:

The relationship between the Department of Commerce and research-intensive universities has resulted in a continuous stream of benefits to the American public:

- **Greater Public Safety**. NOAA collaboration with universities over the years has led to greatly improved forecasts of hazardous weather. Academic researchers have worked side by side with NOAA scientists to improve timely prediction of hurricanes, tornadoes, flash floods, and associated sea state and storm surge. NIST scientists and engineers have worked with the academic community to improve wind and seismic engineering of structures. NOAA-university research in areas such as seafood inspection have improved the safety of seafood products.
- **Enhanced National Prosperity**. NOAA-university collaboration on improved weather and climate prediction has promoted far more effective operational decision making in weather- and climate-dependent economic sectors such as aviation and other transportation, agribusiness, construction, and water resource management. NOAA-university cooperation has been vital to the health of commercial and recreational marine fisheries industries. Collaboration with universities has been important to NIST efforts to speed the transfer of science and technical advances into American industry, and enhance American economic competitiveness.
- **More Responsible Stewardship**. In its efforts to protect living marine resources, marine mammals, endangered marine species, the habitats on which they depend, and other coastal resources, NOAA has been greatly aided by insights gained from joint research investigations with university scientists.
- **Enhanced Educational Opportunities**. NOAA and NIST programs with research-intensive universities lead directly and indirectly to improved educational opportunities, at all grade levels, and for all demographic and ethnic groups.
- **Increased Intellectual Capital**. The collaboration has resulted in a faster pace of research advance and a stronger pool of scientists and engineers available across the entire gamut of science and engineering.

DoC's Expectations/Requirements for Relationships with Universities:

Over the years, the DoC has become increasingly dependent upon the universities for the success of its mission. In particular, the DoC expects:

- **Excellent R&D**. The DoC looks to the universities for research and development that improve the scientific basis underlying physical standards and the underpinnings of the entire range of national technologies. The DoC also looks to the universities for better fundamental understanding of the Earth system as a whole as well as its individual components.
- **Effective Transfer of Knowledge into National Benefit**. The DoC also looks to the universities for help in the rapid transfer of science and technology into operations. In NIST, the bottom line is the incorporation of technological advance into industrial practice. In NOAA the aim is rapid insertion of new knowledge into NOAA observations and predictions, national management of living marine resources, and environmental policy formulation and regulation.
- **A Highly-Skilled Professional Work Force**. DoC depends upon the RIU's to supply the scientists and engineers needed for its staff. For example, during the next few years, as the National Weather Service modernizes and restructures, it will be hiring one-third of the nation's output of bachelor's and master's level meteorologists.
- **External Peer Review**. The Department of Commerce is continually working to strengthen the peer review of university proposals, as well as ongoing university institutional programs conducted under DoC auspices.
- **Sound Administrative Procedures**. The Department of Commerce expects that the RIU's will maintain high standards of accountability and fairness in all their dealings.

Issues with Current Relationship/Barriers to an Effective Relationship:

Problems with the DoC/RIU relationship exist at several levels.

- **Administrative Procedures.** Department administrative procedures supporting the collaboration can be cumbersome and intrusive when compared with other Federal agencies. NOAA has recently completed a top-to-bottom examination of these procedures in an effort to cut the processing time for grants and contracts by a factor of two. It will take some time before this goal is achieved.
- **Variety of Funding Mechanisms.** In NOAA, for example, agency interactions with the RIU's are not confined to any single granting entity but are spread in diverse ways across the entire organization. This has many benefits; in particular, it ensures good working level interactions between Federal and university researchers across the entire organization.

There is, however, a negative side. While old-time university researchers who have grown up with the system have been able to cope, newcomers are confronted with a bewildering array of grants and contracts procedures and opportunities, with little coherence apparent in the rules governing one to the next. NOAA is beginning to bring more order to this picture, and to provide better guidelines to help researchers identify and work with the diverse funding sources.

- **Obstacles to Use of DoC Facilities.** For example, NOAA maintains a number of facilities of importance to university researchers, including research vessels, research aircraft, and high-performance computers. University access to these facilities is limited and less uniform than it might be.

Recently, NOAA has established an ombudsman function to provide some relief for researchers to cope with the worst of these problems. It will take some time, however, to make this a fully effective mechanism for addressing university concerns.

Elements/Characteristics of a Productive Future Relationship:

Department of Commerce Agencies recognize that the science and engineering under their authority is in a state of rapid change. Earth sciences are evolving from a focus on particular processes and expeditionary work of small scope and short duration, to broader, more comprehensive observation and predictive modeling of the earth system, including ecosystem modeling of its living component. Increasingly, NOAA's operational observing systems create data sets of research value. Researcher input to the design of these systems early in the planning process can mean substantial improvements in the research value of the operational system.

This is changing the nature of NOAA-university cooperation in fundamental ways. Formerly interactions at the working level, covering short periods of time, and small dollar amounts, were adequate. Increasingly, in the future, universities will need to participate in oceanic and atmospheric research at the institutional level, for sustained periods. This will require greater managerial attention and cooperation at all levels. Maintaining flexibility in the face of this managerial attention will be a challenge. NOAA's desire to accelerate technology transfer will also mean that larger numbers of university researchers will be invited into NOAA's operating environment.

Similarly, technology transfer from the universities into private industry is assuming greater importance as international economic competition increases and the strategic implications of such competition continue to grow. This will result in greater demands on NIST-university collaboration.

In the world of the future, university access to DoC data will become even more critical; the agencies will have to work to ensure open exchange of research data and information.

Legislative/Executive Authorities(s) for Agency Relationships with Research-Intensive Universities:

Numerous legislative/executive authorities govern these relationships.

U.S. DEPARTMENT OF DEFENSE (DoD) PERSPECTIVE

General Description of the Current Relationship:

Background. "Military preparedness requires a permanent, independent, civilian controlled organization, having close liaison with the [Military Services], but with funds direct from Congress and the clear power to initiate military research ... The job of long-range research involving application of the newest scientific discoveries to military needs should be the responsibility of those civilian scientists in the universities and in industry who are best trained to discharge it thoroughly and successfully."

These words were written not in 1992, but in July 1945 by Vannevar Bush in his famous report *Science, the endless Frontier*, subtitled *A Report to the President on a Program for Postwar Scientific Research*, at the close of World War II (reprinted by the National Science Foundation, July 1960, quoted from pages 33 & 34). This report has withstood the test of time.

Vannevar Bush had been Director of the wartime Office of Scientific Research and Development, and was responding to a letter from President Roosevelt. Largely as a result of the recommendations contained in this report, the first government research office was established by Act of Congress: the Office of Naval Research, established in 1946. It provided the model for research offices elsewhere, including the National Science Foundation (established in 1950). This was the beginning of a long and potent relationship between Defense and universities.

Current Status. Department of Defense research covers many disciplines. In some areas the DoD is the largest federal sponsor of research, for example in computers, electronics and materials; DoD is also a major federal sponsor of research in aeronautics (about equal with NASA), and mathematics (about one third of all federal support). Although the disciplines supported by DoD research offices are those that form the basis for cutting edge technologies on which superior military systems depend, history has shown that they also frequently result in dramatic and revolutionary benefit to the public in areas other than national defense.

DoD basic research offices (ARO, ONR, AFOSR, and DARPA) coordinate their programs with those of other agencies in the same research areas. DoD leverages research sponsored by NSF, DOE, NASA, DOC, and other research sponsoring agencies. Taking that into account, DoD fashions a carefully balanced portfolio of research. DoD is a mission agency, and the ultimate customers for its research are the operational military forces. Highly qualified scientists and engineers in DoD's research offices drive the research with the customers' needs in mind, with a view toward generating new knowledge and understanding, and a focus on long-term weapon system needs (including affordability, manufacturability, maintainability, and performance). This management paradigm has been a major contributor to the success, productivity, and strength of defense research throughout the years.

Research-intensive universities are a prolific source of new knowledge and ideas, and a training ground for future scientists and engineers in disciplines important to national defense. Universities perform about 60 percent of Defense's basic research, funded through the 6.1 Research program. When one includes applied research funded through the 6.2 Exploratory Development account, universities perform more than 25 percent of the Department of Defense Technology Base efforts. In 1991, universities received more than $800 million in Technology Base funds within the portion of the program that was competitively awarded.

Trends for the Future. This proven, strong historical relationship with research-intensive universities will be amplified by the new Defense Acquisition Strategy. Although the Cold War has ended, continued uncertainties require that a robust science and technology program be maintained as the foundation for future defense capability. It is no secret that increasingly sophisticated weapons are appearing in arsenals throughout the globe, and that future adversaries may possess more advanced systems than ever before. Consequently, it has become national policy to increase emphasis on Science and Technology (S&T) efforts to maintain future military advantage in all scenarios. The new acquisition strategy also calls for reduced development of new systems in light of reduced global pressure for near-term materiel modernization. Thus, as the total defense acquisition budget shrinks, the fraction of the budget dedicated to S&T will continue to grow; in real terms, it has grown about 20% in the period FY91-92.

It is important to note that the term "research-intensive" is understood to relate to any college or university which performs a significant amount of research as well as education. The perspectives in this paper do not necessarily apply to university-administered R&D laboratories. DoD considers these laboratories to be fundamentally different entities, since their primary mission is R&D rather than education, and the overwhelming percentage of their work is development and engineering, not basic research.

The Current Relationship. The DoD relationship to research-intensive universities is broad and diverse. It covers the full spectrum of goals to include research, education and training. The primary role of university research for defense is in what DoD defines as basic research; its purposes being to create knowledge and educate. Although the primary support mechanism is the grant, both contracts and cooperative agreements may be involved. Unless otherwise required by statute, almost all of these arrangements are achieved through competitive processes such as the Broad Agency Announcement, in which the goals and criteria for success are published prior to selection. Merit review is an integral part of the evaluation process. The main criteria are: 1. technical excellence, and 2. potential long-term military relevance.

The University Research Initiative (URI) is an example of the competitive, merit review process in action. The major facet of URI encourages multidisciplinary teams to accelerate research progress in areas suited to team effort.

Public Benefits from Research-Intensive Universities/Federal Government Relationship:

It is clear that the public benefits materially from defense research and the subsequent developments that result in fielded military equipment. In addition, defense-trained scientists and engineers contribute to the critical pool of skilled technologists and teaching cadre of the country.

Special defense research facilities also provide benefit, not just to the public in general, but to researchers in nondefense programs. For example, the defense-created MOS Implementation System (MOSIS) integrated circuit design and fabrication capability is available to circuit designers across the nation. Similarly, the ARPANET, the first electronic mail system in the country, revolutionized communications within the academic community. Innovative defense research and development has also contributed significantly to the highly profitable aerospace, electronics, and computer industries.

DoD Expectations/Requirements for Relationships with Universities:

DOD expectations are as diverse as the interactions it has with the academic community. For example, the URI fosters both multidisciplinary research and "people programs" that include graduate fellowships, research traineeships, and other opportunities that build infrastructure for future defense research.

Issues with Current Relationships/Barriers to an Effective Relationship:

The most serious issue is that of Congressional earmarks. The Department of Defense has long opposed earmarks because they present DoD with conflicting statutory directions. Some earmarks have required funding of projects that relate neither to current nor likely future defense needs. They are also in conflict with statutory provisions specifying merit competition. In addition, both noncompetitive earmarks and earmarks with restricted competitive fields tend to lower the standards of merit, and create segments of the university community that are dependent on federal funds, without improving their competitive stance. This potentially perpetuates dependence on earmarks. In FY92 earmarks rose to almost one fourth of the entire DoD research program.

Finally, the use of earmarks sends a signal to all researchers that it may be easier or more profitable to seek awards through influence rather than through work on proposals that other scientists agree have first rate merit. This attitude tends to sacrifice the viability of the long-term national technology base for local short-term gains.

Elements/Characteristics of a Productive Future Relationship:

Important factors that should improve our future research capability include:

- Elimination of noncompetitive programs and policies.
- Stable long-term policies and funding strategies.
- Streamlined, responsible administrative, review, and accounting processes for university research.
- Acceleration of the transition process from research to the marketplace.
- Greater cooperation and team effort on research between or among:
  - legislators and the executive branch
  - administrators and researchers
  - industry, service labs and universities
  - different universities with complementary strengths
  - researchers in different disciplines and university departments

Conclusion. The DoD paradigm, whereby Defense research offices, staffed by highly qualified scientists and engineers, act as the coupling between university researchers and operational military forces, has served the country extremely well. DoD's relationship with the RIU's has time and again paid great dividends in the form of superior technology pressed into national service. While the world has changed, and the threats are different, the new acquisition strategy reaffirms the need for a strong science and technology program, in which the research-intensive universities will continue to play a key role.

DEPARTMENT OF EDUCATION (ED) PERSPECTIVE

General Description of Current Relationship:

The Department of Education's (ED) relationship with research-intensive universities has primarily involved its Offices of Postsecondary Education (OPE) and Educational Research and Improvement (OERI). ED's focus in its support of research intensive universities, consistent with its primary mission, is to improve the quality of education and training available at these institutions. Through OERI, ED also funds research on improving the quality of American education.

The specific relationships between research intensive universities and each of these offices differ greatly.

OPE:

- provides grants for the improvement of science and technology curricula, instruction and student services, and for the purchase of supplies and equipment, especially at minority institutions;
- provides loans or grants for rehabilitation, construction and purchase of college housing and rehabilitation of academic facilities;
- provides program support to research institutions, through for example, a program in the Center for International Education;
- provides fellowships to graduate students pursuing degree programs leading to teaching or research careers in science and technology, through such programs as Harris Graduate Fellowships, Javits Fellowships, and Graduate Assistance in Areas of National Need; and
- affects accreditation of research universities through its recognition of accrediting agencies and its determination of institutional eligibility and certification.

OERI:

- mainly supports research-intensive universities by awarding funds to OERI-supported research and development centers located at those institutions and also funds a small number of individual field-initiated research projects;
- seeks assistance from faculty at research-intensive universities to help develop and implement world-class curriculum standards and assessments for elementary and secondary schools and to improve teacher education; and
- collects a wide range of educational data from research intensive universities as part of its education statistics gathering activities.

ED Expectations/Requirements from Relationship with Universities:

Educational and social expectations from, and purposes for, the expenditures include:

- improving research and teaching at national, regional, state and institutional levels;
- improving the training, and increasing the number, of scientists and educational analysts;
- increasing access to higher education; and
- developing and maintaining a large body of educational data and statistics.

Requirements and restrictions imposed on the institutions that receive these funds include:

- compliance with all Federal guidelines and regulations and provision of the high quality of research and services needed to improve American education;
- submission of proposals that promise to strengthen research and teaching at national, regional, state and institutional levels and which include data to support statements of project need and evidence of past achievement of project objectives;
- submission of meaningful performance reports, which include evaluative data that identify project-related achievement of project objectives; and
- compliance with requirements of eligibility, fiscal and administrative capability, and program administration set forth in the statutes and regulations governing the Federal student aid programs.

Issues with Current Relationships/Barriers to Effective Relationship:

OPE has found that some proposals lack objective program-need data and some reports lack valid evaluative data on accomplishments. In addition, an accretion of differing statutory requirements on a program-by-program basis over time has resulted in unnecessary complexity and administrative burden for institutions participating in the Federal student aid programs. Regulatory and statutory requirements intended to curb abuse particularly in the proprietary sector are generally applied to all institutions (as ED does not have authority to regulate by sector), thus unnecessarily adding to the administrative burden placed on research institutions.

OERI is working closely with its grantees and contractors at research intensive universities to guarantee the production of high quality research and other services. OERI is especially concerned with increasing the proportion of its funds that goes directly to research and school improvement activities rather than to indirect costs or other administrative expenses.

Elements/Characteristics of a Productive Future Relationship:

With respect to OPE, a productive future relationship will involve the development of a consensus agenda for action, the cooperative establishment of relevant data bases and the cooperative establishment of priorities with regard to academic fields and levels. In addition, ED has initiated and is expanding a project of using performance-

based standards for administering the Federal aid programs, thus reducing the administrative burden inherent in regulations that prescribe step-by-step procedural requirements.

OERI intends to continue and build upon its close collaboration with researchers and education specialists at research-intensive universities, and is working to increase attention paid to training of future analysts and to increase efforts to attract minority scholars to educational research, statistical data gathering and improvement activities.

DEPARTMENT OF ENERGY (DOE) PERSPECTIVE

General Description of Current Relationship:

The Department of Energy (DOE) has had a long tradition of supporting university-based scientific and technical research going back to the Manhattan Program in World War II and the subsequent establishment of the Atomic Energy Commission (AEC). The AEC was given three principal responsibilities: the support of research in the fundamental nuclear sciences; the pursuit of commercial application of nuclear power; and the continuation of responsibilities to conduct nuclear weapons R&D.

Research Intensive Universities (RIUs) were deeply involved with the AEC from the outset conducting research and related graduate education in nuclear and related scientific fields and this tradition continues today. The AEC was also the first Federal agency to rely heavily on Government-Owned, Government-Operated laboratories to conduct much of the agency's scientific and technical missions. Many of these laboratories are administered by universities or university consortia.

All DOE laboratories have significant relationships with and provide benefits to university researchers. In FY 1992 DOE supported over 3500 active university research grants/contracts totalling $520M. Over 90% of these awards were to RIUs; 80% of DOE's funding for universities is provided through the basic research programs in the DOE Office of Energy Research (ER), with the remaining funds provided through the DOE technology program offices. University scientists have made significant contributions to DOE mission needs in such critical areas as combustion modeling, photochemistry and photovoltaic cells, ceramic and composite materials, genetic damage research, multiphase flow phenomena, plant biochemistry, and in many other fields. Over 20 Nobel prizes have been awarded in the last 30 years to scientists solely or partially supported by DOE or its predecessor agencies.

Most DOE university projects are investigator-initiated (single or dual investigators) averaging about $125K/year for three years; approximately 20 awards are multi-investigator, large ($3-4M/yr) projects in high energy/nuclear physics and in fusion energy research. University research supported by DOE is peer reviewed (either by mail or by panels) and research areas of opportunity are developed through such mechanisms as scientific workshops, research conferences, advisory committees, collaborative meetings between DOE laboratory and university scientists, etc.

DOE support for university research is also characterized by significant funding ($500M/year) support for user research facilities at the DOE national laboratories. There are some 50 designated user research facilities at the DOE laboratories ranging in size from the National Synchrotron Light Source at the Brookhaven National Laboratory to the National Center for Electron Microscopy at the Lawrence Berkeley Laboratory. Each user research facility represents combinations of unique scientific instruments and associated support equipment that are available for use by university faculty members and their students. Collaborative research programs between DOE laboratory scientists and their university counterparts are also commonplace and are encouraged.

In addition to funding on-campus research, significant support is also provided by DOE for pre-and postdoctoral research programs. For example, DOE supports ten predoctoral fellowship programs in disciplines and fields with predicted future shortfalls of advanced degree professionals such as nuclear engineering, health physics, environmental restoration, etc.

DOE Expectations/Requirements from Relationships with Universities:

DOE expectations for university research vary by sponsoring program office:

- Office of Energy Research: world-class scientific research which advances scientific understanding and knowledge of energy-related phenomena; research results should also lead to new technical concepts or approaches for future energy technologies; preparation of next generation of scientists and engineers.
- DOE Technology Program Offices: assistance in solving mid-term energy technology problems/issues, e.g., biomass conversion, coal desulfurization, etc.
- High Energy Physics/Fusion Energy Programs: construction (and operation as appropriate) of large, complex detectors, fusion devices, etc.

Other expectations include ensuring that DOE-sponsored university research is of the highest scientific and technical merit and that such research is relevant to DOE mission needs and that results are rapidly disseminated to interested users including industry.

Issues with Current Relationships/Barriers to an Effective Relationship:

There are several key issues which currently affect the DOE-university research partnership. These are as follows:

- Limited funds significantly reduce number of meritorious research projects that can be supported;
- Continued need to ensure strong and positive research relationships between DOE national laboratories and university research community within context of static research budgets and changing laboratory roles and missions resulting from defense build-down;
- Oversupply of Ph.D's versus available funds in selected research areas, e.g., condensed matter physics, etc.,
- Increasing demands for accountability and oversight leading to excessive administrative burdens on both the agency and the university;
- Congressional direction of funds (over $100 million in certain fiscal years) has undermined merit review process and has adversely impacted funding for research;
- Interdisciplinary nature of many important problems in energy not easily dealt with by disciplinary structure of most universities;
- DOE programs often need research results/information on a "predictable" schedule, while university manpower development requires a more flexible schedule;
- Different standards on environment, safety and the conduct of technical operations can exist between DOE and those universities responsible for managing large, DOE-sponsored programs and facilities;
- The incompatibility between agency funding and planning cycles and the university environment can lead to communications difficulties and potential funding gaps;
- Support for agency specialized mission needs can distort the academic balance;
- The decentralized nature of DOE programmatic support can lead to administrative inconsistencies between DOE programs in support for university research.

Elements/Characteristics of a Productive Future Relationship:

The essential elements of ensuring a strong and productive relationship between DOE and the academic research community include:

- Rebuild sense of partnership between DOE and the RIU community by sharing views on major priorities in research and on the balance of funding among research fields;

- Ability to effectively switch among priorities including initiation of support for new fields/new researchers without unduly affecting established fields/researchers;
- Minimal requirements for administrative oversight consistent with the university's ability to effectively manage their own affairs.

Legislative/Executive Authorities for DoE's Relationship with Research-Intensive Universities:

DOE has substantial legislative authority to support university research and related education programs, as follows:

- Pub. L. 83-703, the Atomic Energy Act of 1954; Section 31 et. seq. Authorizes support for fundamental research and training in the nuclear sciences including support for the construction and operation of university research reactors and the provision of equipment to universities for research and other purposes.
- Pub. L. 93-438, the Energy Reorganization Act of 1974; Section 103, et. seq. Authorizes support for research and education in all energy-related disciplines and fields and for ensuring adequate supply of manpower for accomplishment of current and future energy R&D programs.
- Pub. L. 95-91, the Department of Energy Organization Act of 1977; Titles II and III. Provides for continuation of research and education programs conducted by predecessor agencies.
- Pub. L. 101-510, the Department of Energy Science Education Enhancement Act of 1990; Section 3161 et. seq. Amends basic DOE organization act to include support for education as one of the major missions of the Department and authorizes the development of research/educational partnerships between DOE laboratories and facilities and educational institutions at all levels.

DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT (HUD) PERSPECTIVE

General Description of the Current Relationship:

The Department of Housing and Urban Development has not maintained a consistent direct relationship with universities, research-intensive or otherwise. It has relied on the results of research accomplished at universities for the conduct of its affairs, but more often than not that research is revealed through other organizations, such as contractors.

The Department is now in the initial phase of organizing a network of colleges and universities to work with Public Housing Authorities, resident management corporations, and resident organizations. Those institutions are expected to provide or find resources to promote all forms of resident initiatives, such as resident management, home ownership, self-sufficiency education and training, small business development, and child and youth development. These efforts are aimed to support the AMERICA 2000 strategy but there is little that can be construed as science.

Engagement of research-intensive universities in this network is possible, but it is not the chief aim of the project.

The Department has an active program with Historically Black Colleges and Universities, giving them almost $1.5 million in FY90 through a Technical Assistance Program of the Community Development Block Grant program. Sometimes these are technology based projects.

Public Benefits from RIU/HUD Relationship:

There is little doubt that greater awareness by HUD administrators of the activities of the research-intensive universities will be required as demands for greater technological literacy increase. A well-schooled work force is fundamental to the effective functioning of all agencies of government.

Expectations/Requirements from HUD/University Relationships:

Currently there are few expectations with respect to the relationship of the Department to universities.

Issues with Current Relationship/Barriers to Effective Relationship:

The chief barrier to widespread relationships with universities relates to the ingrained practice of dealing primarily with non-university contractors when research questions must be answered. Future relationships will require greater effort by HUD.

DEPARTMENT OF THE INTERIOR (INTERIOR) PERSPECTIVE

General Description of Current Relationship:

- The Department has many current contracts and cooperative agreements with universities in many States, a majority of which are located in Western States.
- Cooperative research includes: dam safety, geotechnology, hydraulics, water-related studies, public lands administration studies, global change, wetlands, coastal erosion, natural hazards including earthquakes, environmental studies, and geologic studies.

Public Benefit(s) from Research-Intensive Universities/Federal Government Relationship:

- Improved scientific management of Departmental programs through development of new approaches, methods and equipment.
- Cooperative research leverages research funds to the benefit of the participants and the public.
- The ability to share scientific talent and specialized equipment, and take advantage of (and advance) leading-edge research.
- Enhancement of the educational opportunities of graduate students and Federal employees; taps the low-cost, highly motivated pool of the Nation's graduate students; trains the graduate-level managers of the government.
- An opportunity to promote research at universities which are not normally the recipient of significant research grants.

Interior's Expectations/Requirements from Relationship with Universities:

- Research to support the Department's various missions.
- Provision of shared physical facilities, laboratories, office space, and administrative support.

- Opportunities for scientific interaction between government scientists and university researchers in an academic atmosphere.
- Technical advice and assistance through utilization of faculty expertise and through task orders facilitating the use of non-university experts.
- An opportunity to use a cooperative research program to educate the public.

Issues with Current Relationships/Barriers to an Effective Relationship:

- Perhaps the main problem is that the funding share available to some of the Interior bureaus for university research has shrunk over time in real dollars—there exists a reciprocal problem at a number of universities.
- An unrealistic resolution of the "overhead issue"—by imposing an unrealistic arbitrary limit—could affect the long-term relationship between universities and the Government.
- The perennial complaint by universities about the elaborate Government procurement process and extensive reporting requirements.

Elements/Characteristics of a Productive Future Relationship:

- On the whole, the Interior bureaus are satisfied that they have constructive and productive relationships with universities.

Legislative/Executive Authorities for Interior's Relationship with Research-Intensive Universities:

- The legislative authority of Interior bureaus is usually based on their respective organic acts, and subsequent legislation.

STATE DEPARTMENT (STATE) PERSPECTIVE

General Description of Current Relationship:

- State relies on other agencies to evaluate the technical merit and implementation of specific projects by university researchers.
- State oversees S&T agreements that can facilitate cooperation between U.S. university researchers and foreign researchers. Under our S&T agreement with Japan, for example, provisions exist to allow U.S. researchers to conduct research in Japan under an NSF program.
- State is active through bilateral S&T agreements in promoting exchange of information with other governments on general issues of university research and training. For example, part of our annual consultations with the European Community focuses on comparative assessment of university training.

Public Benefits from Research-Intensive Universities/Federal Government Relationship:

- Research-related cooperation can, in addition to advancing scientific knowledge by providing access to foreign talent and unique data, sites and facilities, contribute to a wide range of U.S. interests, including strengthening bilateral relations and mutual understanding, dealing with national development and global

problems (e.g., energy, health, and environmental challenges), and strengthening U.S. economic ties (including export promotion activities.)

State Department Expectations/Requirements from Relationship with Universities:

- Although the State Department does not fund university research directly, it does provide policy and occasionally financial support for international research activities of other agencies that may involve university researchers.
- State's primary interest in examining the Federal government's relationship with research-intensive universities is to help foster opportunities for beneficial collaboration between U.S. university researchers and foreign counterparts on topics of mutual interest and concern.

Issues with Current Relationships/Barriers to an Effective Relationship:

- As scientific research becomes more global, U.S. universities will increasingly benefit from cooperation with foreign counterparts. U.S. universities can make valuable contributions to inter-governmental cooperation projects aimed at advancing basic knowledge and solving global scientific, health and environmental problems.

Elements/Characteristics of a Productive Future Relationship:

- A range of international programs at U.S. universities (examples: programs focused on Japanese technology, on arid lands agriculture, or on tropical forest research) can substantially contribute to U.S. interests mentioned above. Desirable characteristics include sustained excellence in the subject area, identification of complementary mutual benefits, and exchange of research visits for young researchers as well as experienced or senior researchers.
- U.S. universities will continue to seek Federal financial support to conduct cooperative research with other countries. It is unlikely, however, that in the foreseeable future the Federal government will be able to fully satisfy university requests for international research funds. We should recognize, therefore, that foreign funding of research collaboration and of U.S. university research often plays a valuable role by allowing research collaboration that cannot be funded by the Federal government.

Leadership Role of the State Department in Fostering International Contacts of Research-Intensive Universities:

- State through its Science Counselors serving at U.S. Embassies abroad, is in an ideal position to continue to act as a leader in fostering international cooperative programs by identifying major research policies, directions and centers in the world. Because of the oversight and coordination role of State with regard to international activities of the Federal Agencies, State is in a position to act as a channel for the flow of information and thereby enhance international research cooperation and strengthen the capabilities of Research-Intensive Universities.

Legislative/Executive Authorities for State Department Relationship with Research-Intensive Universities:

Omnibus Trade and Competitiveness Action of 1988 (P.L. 100-418): reconfirms the Secretary of State's primary responsibility for coordination and oversight with respect to science and science and technology agreements and activities with foreign governments and international organizations (codified at 22 U.S.C. 2656f). Other federal agencies are required to inform the Secretary of international science and technology activities; under the Case Act, 1 U.S.C. 112, agencies are required to obtain the concurrence of the Secretary before negotiating or concluding international agreements.

Title V of Foreign Relations Authorization Act for FY 1979 (P.L. 95-426): requires an annual Presidential report to recommendations and information on equity of access by U.S. public and private entities to research and development opportunities and facilities of major U.S. trading partners (codified at 22 U.S.C. 2656(c)).

National Science and Technology Policy, Organizational, and Priorities Act of 1976 (P.L. 94-282): in additional to establishing the Office of Science and Technology in the Executive Office of the President (OSTP), Title IV of this law established the Federal Coordinating Council for Science, Engineering and Technology (FCCSET) to consider problems in the field of science, engineering and technology, inter alia, to recommend policies to further international cooperation in this area. The law provides for State representation (typically the Under Secretary for International Security Affairs) on FCCSET, which is chaired by OSTP (codified at 42 U.S.C. 6601). A subcommittee of FCCSET on International Science, Engineering and Technology (CISET) is chaired by State/T.

E.O. 12591 (April 10, 1987): provides for the creation of a central mechanism for the prompt dissemination of science and technology information developed abroad on a fee-for-service basis. This Executive Order requires that negotiators of international science and technology accords determine, in consultation with USTR, that contracting countries give reciprocal access to U.S. researchers and businesses and provide for the protection of intellectual property. It requires the Secretary of State to develop a recruitment policy to seek qualified scientists and engineers to serve in U.S. embassies abroad.

DEPARTMENT OF VETERANS AFFAIRS (VA) PERSPECTIVE

General Description of Current Relationship:

The Veterans Health Administration (VHA) of the Department of Veteran's Affairs has close affiliations with 104 of the Nation's University Medical Schools and over 1400 Associated Health Professionals Schools. Through these public-private sector partnerships, VA hospitals participate in the education of health care professionals for VA and provide a suitable laboratory environment for such faculty. Approximately 7,000 VA physicians and some 2,000 other hospital personnel held faculty positions in 1991. VA's research and development program not only responds to the perceived needs of veterans, but also identifies needs that require a research response. Thus, many of the current research projects deal with complex special problems such as those of Vietnam veterans as well as those of older veterans.

Public Benefit(s) from Research-Intensive Universities/Federal Government Relationship:

The Nation's veterans receive first class health care and benefit from research advances; the quality and standards of excellence of academic medicine are provided to veterans. Integration of health professions training insures a single national quality standard for education, and affords all health professions students the opportunity to participate in federal health care during their training.

VA/University partnerships contribute to the diffusion of scientific and clinical research. The academic collaboration of VA hospitals and their partner research universities and academic health centers promotes biomedical, prosthetics, and health services research of benefit to the health of all Americans. The list of VA research accomplishments includes such milestones as pioneering work in:

- drug therapy for tuberculosis and mental illness;
- organ transplantation;

- artificial limbs and prosthetic devices such as the Seattle Foot;
- cardiac pacemakers and CAT scanners; and
- Nobel prizewinning efforts in the areas of radioisotopes and endocrine disorders.

Department of Veterans Affairs' Expectations/Requirements for its Relationship with Universities:

The VHA enters into affiliation agreements with over 1400 health professions schools across the Nation. Under these agreements, VA provides the venue for a portion of health professions training in its hospitals and clinics. Universities provide the students and faculty and supervise education programs. VA clinical and research staff become faculty members at the appropriate health professions schools. Conversely, VA-based research faculty are fully enfranchised members of the university faculty with access to its research support services and educational resources.

The quality and rigor of educational opportunities is maintained at the same level throughout each public-private sector training program. Both VA and their academic partners adhere to a rigorous scientific peer review process.

VA enters into sharing agreements with universities for joint purchase, use and maintenance of high technology medical and research equipment. Sharing of high technology resources such as computational and diagnostic tools and specialized scientific expertise allows both VA and its academic partners to maximize results of expenditures for research activities.

Issues with Current Relationship/Barriers to an Effective Relationship:

Changing requirements for federal indirect costs reimbursement, as well as new Medicare reimbursement policies, pose a serious financial threat to major university teaching hospitals, and may limit the teaching and research programs in which VA hospitals participate. At the same time, direct federal funding for research and patient care is growing at a slower than historic rate, contributing to financial instability and retrenchment at research universities.

The steadily increasing burden of federal regulation of biomedical research and health care shifts valuable resources away from the conduct of research and the delivery of care. Recent requirements to provide the exact daily work schedules of all residents to HCFA, and the extension of the honoraria ban for federal employees to university faculty with even a part-time affiliation with a VA hospital, are examples.

Elements/Characteristics of a Productive Future Relationship:

A coordinated effort to prepare the future health care and scientific workforce for America 2000 is much needed. Any such effort should emphasize the continued need for collegial collaboration on education of health professionals and for coordinated and non-duplicative biomedical research support. Increased emphasis should be placed on collaborative efforts to strengthen clinical/human subjects research programs. Objectivity in the scientific review process must be preserved if we are to maintain a position of worldwide leadership in biomedical research.

Legislative/Executive Authorities for Department of Veterans Affairs' Relationships with Research Intensive Universities:

The authority for VA's relationship with research intensive universities is established in 38 United States Code—Veterans Benefits, as amended. Section 7302 authorizes Veterans Health Administration (VHA) health care personnel education and training programs. Section 7303 authorizes the functions of VHA research programs.

ENVIRONMENTAL PROTECTION AGENCY (EPA) PERSPECTIVE

General Description of the Current Relationship:

Current research relationships between EPA and the RIUs has the following principal features:

- Competitive investigator initiated grants.
- Competitive grants in response to requests for application in specified research areas.
- Competitive and noncompetitive cooperative agreements with RIU investigators.
- Research centers of various kinds.
- Peer review and advisory functions.

Public Benefits from Research-Intensive Universities/Federal Government Relationship:

The public benefits from the RIU/EPA relationship are basically two.

- Improved understanding of the current state of the environment, how it works, the deleterious effects from its degradation, threats to it and ameliorative possibilities, enabling EPA to navigate between inadequate protection and expensive overregulation.
- The production of people trained in the environmental sciences needed by our society for environmental management and research.

EPA Expectations/Requirements for Relationships with Universities:

EPA expects that all research it funds in RIUs meet the following:

- Contribute to EPA's mission of environmental standard setting, regulation, and enforcement.
- Be of high quality and published in the peer reviewed literature.
- Be carried out in a cost effective manner and in accordance with applicable federal laws, rules, policies and procedures.

Issues with Current Relationships/Barriers to an Effective Relationship:

Currently the major source of strain in the EPA/RIU relationship is the lack of funds for RIU research leading

(i) to low probability of success in the competitive applications, and (ii) to EPA being a sporadic and unreliable sponsor.

Elements/Characteristics of a Productive Future Relationship:

EPA needs to be a larger and more consistent sponsor.

The RIUs need to develop ways of moving research, particularly engineering research, into practice.

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA) PERSPECTIVE

General Description of Current Relationship:

There is no monolithic university "program" at the National Aeronautics and Space Administration (NASA). Instead, it is an aggregate program made up of a variety of relationships.

Research is a cornerstone of NASA's relationship with universities. NASA missions rely heavily on basic and applied research from the university community in space science and aerospace technology. The universities involved in such research, in turn, look to NASA to help maintain the health of aeronautics and space-related disciplines.

In FY 1991, NASA awarded $595,426,000 to approximately 330 U.S. colleges and universities (this amount excludes the award to the California Institute of Technology for the operation of the NASA Jet Propulsion Laboratory). This figure represents hundreds of grants, contracts, and cooperative agreements awarded to colleges and universities around the country in award sizes ranging from several thousand to several million dollars.

Education is another key component of the program. NASA and the aeronautics and space communities rely on the pipeline of students produced by the various university departments to fill the Nation's staffing needs. The universities, in turn, rely on NASA for fellowship opportunities for students and faculty that provide critical financial support, valuable research experience, and potential contacts for a continuing research relationship.

In addition to research and education, the university program also includes an advisory role for individuals within the university community. Frequently members of the university community participate in peer review activities and serve on advisory committees and panels for the agency. NASA, in turn, makes individuals available as course lecturers, speakers, and mentors as the need arises.

The NASA/university relationship is a vital one that, in its aggregate form, is mutually beneficial.

Public Benefit(s) from Research-Intensive Universities/Federal Government Relationship:

The benefits from this relationship are many. Universities develop and train the future scientific and technical work force that NASA needs to stay on the cutting edge of aerospace-related technology. Universities also provide a significant amount of the research needed by the agency to conduct its scientific missions. NASA provides funding to support both the actual research and the research infrastructure within the universities and makes available first class research facilities that are not cost effective for universities to build and maintain.

NASA Expectations/Requirements From Relationship with Universities:

The university community has been a critical partner in NASA's mission since the agency's beginning. NASA looks to universities to develop and nurture the expertise the nation needs for current and emerging science and technology research. This expertise should be available in a cadre of principal investigators who will add to our knowledge base through research and in a student body who will be trained to supply the country with the skills needed for the future. Faculty and students should reflect successful efforts at gender and ethnic diversity.

To keep this partnership viable, NASA has an obligation to the health of these institutions. Thus in furtherance of this mutually beneficial partnership, NASA has established the following policies and guidelines in regard to universities. They are documented in NASA Management Instructions (NMI) 8320.1C, most recently revised in December, 1990 and 1392.1B signed December 31, 1991.

The basic policies are:

- Universities will be strongly involved in the NASA mission. This involvement will take place primarily through NASA's research and education programs.
- Academic scientists and engineers will conduct a substantial portion of the basic and applied research in all disciplines of the NASA program and will participate directly, or through advisory groups, in all phases of the basic and applied research activity: conception, planning, programming, execution, analysis, and interpretation of the data and publication of results.
- NASA's education programs, directed toward helping to meet the National Education Goals and ensuring a sufficient talent pool to preserve U.S. leadership in aeronautics, space science, and technology, will direct a substantial portion of resources to universities. These programs will support, through active participation in NASA research, undergraduate and graduate student support and faculty preparation and enhancement.
- Basic research opportunities using NASA aircraft and spacecraft or instruments connected to such craft will be available on the basis of open competition, peer review, and selection by Headquarters. NASA research facilities will also be available. Cooperation between academic research groups and NASA in-house groups will be encouraged.
- Continuing research programs will be subject to peer evaluation at least once every 3 years involving reviews by academic and in-house scientists and engineers.
- NASA's relations with the university community will be conducted in a manner that reflects concern and understanding for the role of universities in education and research, avoids undue imposition of burdensome requirements, and does not stress a university's financial resources.

Guidelines for implementing these policies include:

- Sponsored projects should be pertinent to the NASA mission and generally compatible with the interests, activities, and capabilities of universities, normally avoiding short-term, sub-professional, or job-shop types of work which do not directly or significantly contribute to the educative or research process.
- Academic scientists/engineers will be encouraged to present unsolicited proposals or to respond to announcements of opportunity. Information will be widely disseminated and will require the least burdensome type of response.
- University students will be encouraged to pursue scientific knowledge and/or pursue NASA related careers through a variety of programs. These programs will generally include summer research experiences, scholarships, traineeships, fellowships, career guidance materials, lectures, workshops, design projects and others. Recruitment for participation in these programs will emphasize underrepresented women, minorities and persons with disabilities.
- Academic efforts of a continuing nature should be supported by suitable long-term funding arrangements, providing continuity through a variety of ways, as simply as possible.
- Terminations will be on an exception basis, and will take into account consequences to graduate students working under those grants/contracts.
- Officials-in-Charge of Headquarters Offices are responsible for contributing to the overall health of the academic establishment required to support the long-range goals of their program. In general, this means assuring that there exists an academic establishment involved in the forefront of basic and applied research, producing scientists and engineers interested in and knowledgeable of the appropriate aerospace disciplines and capable of maintaining the Nation's leadership in science and technology in the decades ahead.
- The Associate Administrator for Human Resources and Education is responsible for coordinating university-related policy and activities among NASA program offices, installations, and advisory bodies and, to that end, will be kept appropriately informed.

Issues with Current Relationships/Barriers to an Effective Relationship:

Just as there is no monolithic NASA university program, there are often differing views of universities and of NASA. Recently the NASA Advisory Council appointed an ad hoc University Relations Task Force to look at the health of the NASA/university relationship. The Task Force was composed primarily of representatives from "research-intensive" universities so their concerns are relevant to the task of this Ad Hoc FCCSET Working Group. Their major concerns are outlined below:

- In the space science disciplines, there is a perception within the university community of reduced flight opportunities because of the perceived emphasis on big science (Great Observatories, EOS) versus smaller science opportunities.
- In the aeronautics and space technology disciplines there is concern about the perceived imbalance between in-house and external (university) research.
- At the policy level, there is a perceived need for an explicitly stated and uniformly followed policy outlining NASA's responsibility for maintaining the health of its university base.
- At the practical level, there is a feeling that the diversity in NASA's university activities has led to a cumbersome, often confusing, administrative interface.
- There is concern that both the Federal government and the academic community must take more aggressive action to develop researchers who are women, underrepresented minorities and persons with disabilities
- There is an expressed desire for policy level planning for specific future work force projections that will be regularly communicated to the university community.
- There is also concern that an emphasis on increased competition or the broadening of research participation opportunities is leading to an increasing number of small, short-term grants.
- Others express concerns about the general economic situation that results in universities having less money in general and the Federal government having less to give to universities. This, in turn, produces significant anxiety about the state of the Nation's research infrastructure; equipment and facilities on university campuses are in a serious state of decline.

NASA, too, has some concerns:

- Given recent allegations concerning university overhead practices, the agency wants to obtain the best value for its expenditures and to trust that overhead rates are fair and reflect the true cost of doing business with the agency.
- Much has been written recently about the state of undergraduate education. NASA is concerned about the preparation and qualifications of its future workforce.
- NASA (or any other Federal agency) cannot be responsible for rebuilding the entire university research infrastructure. Universities must understand that Federal research expenditures are limited.

Elements/Characteristics of a Productive Future Relationship:

The NASA University Relations Task Force developed a set of suggestions for an improved relationship:

- A uniform, well-thought-out set of policies should be developed that govern the selection of university collaborators agencywide.
- A single point of contact for universities should be established within the agency.
- The use of multi-year grants should be increased for broader based research programs.
- The agency should continue its emphasis on simplifying administrative processes related to procurement.
- Policies should be developed to improved the mission mix, including both small and large flight opportunities for university research.

Additional suggestions from NASA include:

- Universities should develop realistic budgets that maximize the amount of actual research being conducted.
- Universities should produce timely evidence of completed work.
- Universities should be held accountable for quality work.
- Universities should intensify efforts to recruit and retain women, minorities and persons with disabilities into science and engineering courses and majors.

Legislative/Executive Authorities for NASA's Relationship with Research-Intensive Universities:

The Authority for NASA's relationship with the university community is derived from the National Aeronautics and Space Act of 1958, as amended. Sec. 203(a)(2) of the Act calls on the agency to:

> ... arrange for participation by the scientific community in planning scientific measurements and observations to be made through use of aeronautical and space vehicles, and conduct or arrange for the conduct of such measurements and observations.

NATIONAL ENDOWMENT FOR THE HUMANITIES (NEH) PERSPECTIVE

General Description of Current Relationship:

The National Endowment for the Humanities (NEH), as a discretionary grant making agency, has no ongoing nor entitlement programs. All awards are made for specifically defined projects; and if further support is proposed after one grant has been finalized, the project is considered anew, assessed on its own merits and competes with other proposals in a given round. NEH supports no research and development activities; and because it does not support the purchase of equipment nor building costs associated with a project, NEH makes no awards to support infrastructure costs. Whatever compensation an RIU receives for its overhead expenses is received through indirect cost allocation.

NEH's relationship with research-intensive universities mainly involves its support of humanities research. Authoritative texts, editions, bibliographies, as well as projects that investigate humanities topics, are almost all located at research universities. Further, archaeological projects that NEH supports are generally administered by a university, and RIUs provide the overhead and administrative support for scholarly conferences as well as preservation and cataloguing activities.

Because RIUs generally do not place much emphasis on firm, coherent, integral undergraduate curriculum, they are not frequent nor often successful applicants for higher education support. NEH supported curriculum and faculty development projects are mostly located in two- and four-year colleges. These projects are designed to assist institutions in their efforts to enrich faculty understanding and to bring coherence to their humanities curricula. Research intensive universities, however, are often sites for national institutes which bring together faculty from many colleges and universities to study humanities topics. For example, this summer (1995) the University of California, Berkeley, is hosting a six-week institute for twenty-four college and university faculty on the question of ethics in literature and in philosophy.

Public Benefit from Research-Intensive Universities/Federal Government Relationship:

Among the Congressional declarations that provided reasons for establishing the National Endowment for the Humanities in 1965 was the finding "that a high civilization must not limit its efforts to science and technology alone but must give full value and support to the other great branches of scholarly and cultural activity in order to achieve a better understanding of the past, a better analysis of the present, and a better view of the future." Thus, from the beginning, NEH's charge has been linked with high civilization in which there is general and profound knowledge. Accordingly, all of the NEH programs that support research and education in the humanities are designed to increase the public's understanding of important events, of ideas and their consequences, as well as the people who have influenced and have been influenced by ideas and events.

Just as research in theoretical science seeks its justification in what it does to enhance general human understanding, so research in humanities gains federal support only insofar as it argues for the expansion and/or transmission of knowledge. By requiring NEH applicants to provide a statement about the broad significance of their proposed projects, NEH keeps the public purpose central to the evaluation of proposals. NEH supports projects in research and education that assure upcoming generations access to significant works and accomplishments in literature, history, foreign language, philosophy and other humanities subjects.

NEH Expectations/Requirements for Relationships with Universities:

NEH expects that there be a strong institutional commitment to the projects it funds. The degree of commitment can be assessed in several ways but is indicated most directly in the amount of the cost of the project that will be shared by the university. Although the percentage of cost sharing varies by program and type of project, the Endowment's contribution to a project normally will not exceed 80 percent of the project's total costs. Cost sharing consists of the cash contributions made to the project by the university and in-kind contributions, such as donated services and goods. The university's cost sharing may include both direct costs and indirect costs. Cost sharing also includes gift money raised to release Federal matching funds.

Issues with Current Relationships/Barriers to an Effective Relationship:

RIUs by their very nature are geared to cutting-edge research. Grants and contracts awarded to departments of science and technology are major revenue-enhancing ventures. The general atmosphere at RIUs encourages progress, innovation, daring. Research in the humanities, in contrast, is ruminative, deliberative, and painstakingly thoughtful. A research team editing the papers of one of the Nation's founders, for example, does not attract significant numbers of students nor does it attract similar projects. And most important, the amount of money such a project is able to bring into the institution is minimal in comparison to science and technology projects. Consequently, RIU commitment to humanities research is often meager.

Erosion of institutional support for a humanities research project serves to undermine an effective relationship between NEH and RIUs. There have been instances when a project director discovers that university endowment revenues have been over committed; and in those cases, if the cost sharing declared in the project proposal is heavily weighted with matching funds, the researcher often is asked by the institution to raise the matching funds. In these cases, the researcher's activities are diverted away from the project to fund raising.

Elements/Characteristics of a Productive Future Relationship:

The National Endowment for the Humanities continues to challenge research-intensive universities to strengthen their commitment to undergraduate education. Although research in the humanities is important as a continuous investment in civilization, education in the humanities is vital for the immediate future of the humanities. At RIUs it is often the case that elementary and secondary teachers are prepared with little experience in the subject matter they intend to teach; often the advisor-to-student ratio is 1 to 1000, making sheer luck or extraordinary acumen factors in a student's coherent education; often loose distribution requirements leave students to accumulate a hodgepodge of courses to satisfy graduation requirements; and often too few faculty teach required undergraduate courses, resulting in students having to return an extra semester or year to fill requirements.

Because so many of our Nation's undergraduates are enrolled in RIUs, the stakes are high. A productive long-lasting relationship between the Federal government and large universities must necessarily be built on the continuous improvement of the transmission of knowledge and the nurturing of the intellectual vitality of the Nation.

DEPARTMENT OF HEALTH AND HUMAN SERVICES (HHS), NATIONAL INSTITUTES OF HEALTH (NIH) PERSPECTIVE

General Description of Current Relationship:

The relationship between the National Institutes of Health (NIH) and the research-intensive universities has been vital to accomplishing NIH's mission to improve the health of U.S. citizens. The relationship has evolved into a partnership over the last half-century. NIH uses many mechanisms such as grants-in-aid, contracts, and cooperative agreements to support research, to procure directed research, to conduct cooperative research, and to support education and training. The bulk of the research dollar is expended as grants-in-aid which are awarded through a two tiered peer review process which judges the scientific and technical merit of investigator initiated applications.

The ties between the NIH and research-intensive institutions through grants-in-aid are long standing, reflecting the healthy interdependence that characterizes the conduct of science in the United States. In terms of physical infrastructure and intellectual base, they represent a national resource that is critical to the conduct of research. The NIH is committed to maintaining a strong partnership with these institutions and, in so doing, to nurturing the pool of scientific talent that makes possible exciting and promising breakthroughs in research. It is recognized that physical infrastructure such as facilities, equipment, shared instrumentation and research resources are necessary for the nurturance of scientific talent.

NIH transfers substantial funds to public and private institutions, requiring proper stewardship and accountability. For example, in FY 1990, the NIH made awards of $6.3 billion. Of this amount, United States institutions of higher education received a total of $4.6 billion (73.4 percent) in grants and contracts. The grants are for fundamental research to increase the knowledge base of health related processes, while the R&D contracts are, in general, for applied research and development.

A profound change in the relationship has occurred over the last ten years. University faculty have become increasingly dependent on funding for their research from sources in the private sector, such as industry and other organizations. The Federal share of total health R&D support declined from 50 percent in 1985 to 42 percent in 1991. During the same period, industrial support grew from 40 to 47 percent of the total. Simultaneously, NIH funding of research has become increasingly competitive. These trends have and will continue to have an impact on research advances in the public domain.

As the rate of growth in Federal funding for health research may decrease, the universities, as recipients of this funding, will be impacted. This may require an assessment of how available funds should be partitioned between direct research funding and infrastructure, for example. Additionally, it may be necessary to determine whether funding policies should be established which keep as a priority scientific merit but tend more to a distribution of funds over a wide range of institutions or result in more concentrated funding limited to centers of excellence.

In the past, a rapid rate of growth in funding could result in both enhancement of existing programs and institutions as well as expansion of research through the development of new academic centers. As funds become more limited, however, the choice between expansion versus enhancement will have to be addressed explicitly, with all of the issues and problems that this type of choice will bring about.

Public Benefits from the Research-Intensive Universities/Federal Government Partnership:

All NIH supported research is aimed at improving health and health related quality of life, from basic research to the development of new technology. However, ancillary benefits have also resulted. The following are examples of some of the additional public benefits that have accrued over the years from the NIH/university partnership:

- **NIH-supported research has been a major contributor to development in other fields, such as the biotechnology industry and agriculture.**
- **NIH research and training grants provide for a major increase in the public's "intellectual capital."**
- **Biomedical research has been a crucial component of medical cost containment, a serious challenge now facing the American economy.**
- **NIH research grants support a large number of individuals and have a large "multiplier effect."** A recent study estimated that in FY 1990 NIH supported at least 53,000 full-time equivalent scientific and technical positions.

NIH/DHHS Expectations/Requirements from its Relationship with Universities:

The implementation, through technology transfer, of research advances to the improvement in the health and productivity of the Nation's citizens and, consequently, the economic benefit of the public is the paramount goal. Subordinate goals are: training scientists in health-related research to enhance the supply of personnel; the provision of education and the promotion of scientific literacy for informed decisions about health-related and science technology-related issues; and the provision of an environment to promote equal opportunity for participation in the effort. When the NIH provides funds to the recipient institutions, it expects that a good faith effort will be made to accomplish the scientific purposes for which the funds are expended, that proper financial safeguards will be in place, and that applicable laws, rules, and regulations will be followed.

Additionally, the ability of the Federal government and university partnership to respond quickly to perceived research needs (as in AIDS) can be expected to assume greater importance.

Requirements and restrictions imposed on the institutions that receive these funds include:

- Provision of a creative environment along with safeguards to promote scientific integrity and avoid conflict of interest;
- Provision of administrative and financial checks to ensure the proper stewardship of Federal funds; and
- Provision of a system of assurances that implement social, legal, and ethical programs to include concerns such as civil rights, protection of the rights of human research subjects, proper care and management of animals utilized in research, and a drug-free workplace.

Issues with Current Relationship/Barriers to an Effective Relationship:

Tensions between academia and the Federal Government.

Tensions exist between the Federal Government and academia as both partners struggle with the fundamental problem of creating and supporting an environment conducive to the conduct of science. Among such strains are concerns such as innovative versus "safe" research, "big" versus "little" science, mandated research versus investigator-initiated ideas.

As demands for both scientific and administrative accountability increase, while, at the same time, fiscal resources remain constrained, the capacity of both partners to carry out their mutual responsibilities has come under stress. Although difficult, a state of equilibrium between sufficient accountability and unproductive administrative burden is imperative. In the absence of equilibrium, overregulation can occur, with an adverse economic impact that affects both the costs and the timeliness of discovery and application of research.

Policy

No policy exists to define the current relationship between national research goals and the research partnership. Instead, the relationship is defined by a mosaic of administrative and fiscal rules that specify the support mechanisms of assistance and procurement without any guiding or overarching principles of research policy. As a result, the relationship runs the risk of being defined administratively rather than programmatically.

Perceived/Real Barriers

While there are no major barriers to the NIH maintaining an effective relationship with University *contractors,* for *grants,* current barriers to a more effective relationship include:

- A perceived lack of coherent Government policies;
- Different expectations regarding the primary purposes of universities (research and research training versus a broader educational and intellectual milieu);
- Perceived excessive and burdensome requirements, e.g., human subjects, animal welfare, biohazards, and safety. NIH acknowledges its interest in simplifying the reporting and administrative burden, while maintaining — or even strengthening, where needed — the issues of welfare and safety;
- Conflict of interest;
- Indirect cost issues;
- A perception that the NIH is continuing "downward negotiations," a term applied to a process, no longer practiced by most of the awarding components, of reducing post-award budgets;
- Concern about handling of cases of reported misconduct; and
- Failure by Government to pay full research costs, e.g., the expectation for supplementation of trainee stipends, matching funds for construction, etc.

Elements/Characteristics of a Productive Future Relationship:

The primary goal of Federally-supported research should be to reflect the missions of the agencies involved. Priority setting and future plans for Federally funded research should include both the attainment of specific research goals as well as overall strengthening of the research base to increase the research capacity of the Nation. Means to identify approaches to foster innovative, high risk research versus safe, less risky research are needed.

The challenges that lie ahead for the Federal government's relationship with academia are considerable, in that each expects the other to pay a greater component of costs for programs that are vital to both. The high costs of equipment and laboratory renovation are particularly salient. One can anticipate a need for much greater scrutiny of priorities and a decline in the practice of demanding new programs and initiatives without providing accompanying funds to support them.

With continued tight money, balancing the interests of supporting science versus scientists, and research-intensive institutions versus other institutions, will present an increasing challenge. Balance must be found between funding of senior investigators and the support of new opportunities for young investigators. A balance must be found between meeting these needs and those of individual research project grants.

Future challenges will include the following:

- **Determining the Primary Goal of Federal (NIH) Research**

  For NIH, research goals developed within the draft NIH Strategic Plan and the individual Institute and Center Strategic Plans should be the driving force with regard to research funding. Funding mechanisms should be used which best fit the attainment of these goals. NIH-based funding support will evolve as the mission of NIH evolves.

- **Determining the Best Model for Federal Research Agency Coordination**

  A more integrated approach needs to be fostered in common areas of research. Such complementary efforts are both cost effective and result in stimulating development of new research areas. Because of the high cost of specialized research facilities it is imperative that there be an evolution in Federal Agency partnerships. For example, the cost of developing high technology facilities necessitates prospective planning not only to address the specialized needs of an array of research disciplines but also to address cost sharing of that approach.

  Plans must be developed by individual research agencies in concert with the academic community, much as the NIH developed its Strategic Plan. Federal Agency coordination is imperative for those research areas with complementary missions. Priority setting through the FCCSET process provides for coordination of agency plans and priorities. This is particularly important in light of the trend toward greater interdisciplinary research of progressively greater complexity.

- **Determining the Best Model for Academic and Federal Interaction**

  NIH has used a variety of funding mechanisms for support of research and it is important to maintain diverse funding mechanisms to ensure a strong research capacity. As research costs continue to increase, creative cost-effective approaches for shared instrumentation facilities and other resources need to be carefully integrated within academia as well as across Federal agencies. Whenever possible, concentrated academic centers of excellence as well as distributed regional, national or international centers need to be considered vis-a-vis individual research project approaches to funding research. Neither need be exclusive and, in fact, they should be complementary to the research missions of NIH.

  There has been a recent emphasis on support of interdisciplinary research that includes diverse departments within an institution and collaboration among institutions. High speed computer links potentially provide a greater capacity and a faster transmission of data for these interdisciplinary efforts. Cross training of students as well as senior investigators in disciplines needed to conduct interdisciplinary research will be a necessity.

  The funding of large scale projects can be remarkably efficient and can produce great success. A recent example is the funding of large scale centers in the Human Genome Project. A concern with this approach is the potential limitations on individual creativity.

  The role of industry and the Federal government in support of academia to meet research goals, technology transfer and economic competitiveness needs to be clarified and plans made to develop and strengthen such efforts.

- **Determining the Cost of Research**

  More accurate data need to be generated to provide estimates of the cost of research. For example, the indirect cost of research is the largest growing segment of research. Personnel costs (salaries and benefits) are the largest component of the direct cost line and this segment continues to rise.

- **Determining Bioethical, Legal and Social Research Concerns and Their Impact on Public Health**

  Advances in research pose many legal, social and ethical issues to the Nation. For example, the impact of information regarding predisposition to disease, gene therapies, and handling of genetic information needs to be addressed. This may be the greatest challenge that NIH faces in the next ten years.

Legislative Authorities:

Public Health Service Act, Title III, Sec. 301 and Sec. 405.

NATIONAL SCIENCE FOUNDATION (NSF) PERSPECTIVE

General Description of Current Relationship:

The National Science Foundation (NSF) was established to support science and engineering research and education, to monitor the health of the research enterprise, and to encourage national policies to promote science and engineering in the United States. NSF performs no research itself. Its responsibilities are carried out primarily by funding academic institutions for research and education projects.

Although NSF-funded research is only 3% of the Federal R&D budget, NSF is a major Federal sponsor of science and engineering R&D activities at research-intensive universities (RIUs) across a wide array of science and engineering fields. Principally through its support of academic research, NSF is a lead contributor to major national science and technology initiatives in education, high performance computing and communication, advanced materials and processing, global change, environmental science and technology, advanced manufacturing, and biotechnology. NSF also funds various centers, research facilities, and programs operating outside an academic research setting. NSF is a major contributor to mathematics and science education at all levels of the education system, and directly supports promising science and engineering students on the undergraduate and graduate levels through fellowships and traineeships and research assistantships on NSF grants.

NSF enjoys a unique relationship with the science and engineering community. It is the only agency with a policy-making board, the National Science Board, composed of external professionals serving on a voluntary, part-time basis. The Board consists of twenty-four Presidentially-appointed and Senate-approved members, plus the Foundation Director, ex officio. Members must be eminent in the fields of the basic, medical, or social sciences, engineering, agriculture, education, research management or public affairs; selected solely on the basis of established records of distinguished service; and must provide representation of the views of scientific and engineering leaders in all areas of the Nation.

The involvement of outstanding scientists and engineers, many from RIUs, permeates all aspects of NSF program operations. They review research proposals and serve on advisory committees on a voluntary basis, and—as "visiting scientists and engineers"—occupy temporary professional positions in the Foundation. In addition, NSF permanent professional staff are encouraged to remain active in the communities they serve. This unique collaboration has enabled the relatively small NSF budget to catalyze the growth of academic science and engineering capability in a broad spectrum of fields, some of which otherwise receive little external support.

The primary mechanism for researchers to obtain funding from NSF is the investigator initiated grant. Cooperative agreements also are gaining importance as funding instruments. Excellence in the quality of the proposed research, determined through merit review by peers, is the principal criterion for award. The system is highly selective, funding only a fraction of the best proposals. For the researcher and institution, an award from NSF indicates superior accomplishment and contributes to their standing, and that of their associated academic departments, in the scholarly community.

The NSF/RIU relationship is a fundamental component of the U.S. academic research enterprise, internationally acknowledged as the best in the world. In FY 1992 NSF's research funding included about $1.6 billion to institutions of higher education, principally the RIUs. This accounted for about 82% of the total NSF research budget. Over 16,000 senior academic researchers, nearly 4,000 post-doctoral researchers, and 16,000 graduate research assistants were supported under NSF-funded projects.

Public Benefits from Research-Intensive Universities/NSF Relationship:

- Support for academic R&D as a long-term national investment in science and engineering infrastructure, for example in:

- Support for unique facilities, such as the University consortium-administered multidisciplinary centers, e.g., the National Center for Atmospheric Research (NCAR);
- Enhanced scientific information exchange, e.g., through advanced communications technology, represented in NSFNET, which connects more than 4400 university, industry and government research networks, and, through Internet, links more than 350,000 host computers worldwide;
- Collection and dissemination of data on R&D expenditures, science and engineering personnel, and research facilities and instrumentation, in cooperation with institutions and with other federal statistical agencies;
- General physical plant research infrastructure support through indirect costs associated with individual grants, and direct awards for facilities and major research instrumentation;
- Direct fellowship and traineeship support for outstanding graduate science and engineering students and research experiences for undergraduates.

- Expansion of the base of knowledge, for example by:
  - Supporting new scientific and technical discoveries by academic scientists and engineers, which contribute to emerging technologies such as fiber optics, superconductivity, polymers, medical imaging, biotechnology, and neuroengineering;
  - Providing unique research facilities to enable frontier research, such as the Arecibo telescope, the Laser Interferometer Gravitational Wave Observatory (LIGO), the National Magnet Laboratory, and U.S. Antarctic Program (USAP).
- Preparation of highly skilled technical work force necessary to support an advanced technology-based economy, for example in:
  - Scientific research project support, enabling university faculty researchers to prepare a highly skilled technical work force exposed to cutting-edge research in a wide range of academic science and engineering fields;
  - Innovations in science and engineering curricula and the organization of research to increase relevance to work force needs and emerging fields.
- Improvements to the quality of life by transfer of knowledge to other sectors and the general public, for example in:
  - NSF projects and facilities to encourage cross-sectoral communication and cooperation in research, for example in NSF-sponsored Industry-University Cooperative Research Centers, Engineering Research Centers, Science and Technology Centers, and Supercomputing Centers;
  - Major contributions to Federal initiatives in High Performance Computing and Communication, Global Change, Mathematics and Science Education, Advanced Materials and Processing, and Biotechnology.

NSF Expectations/Requirements from its Relationship with the Universities:

- Generation of new knowledge and its dissemination to appropriate communities;
- Contributions to human resource development on all levels in the educational process;
- Appropriate balance between research and education;
- Adherence to the highest standards of conduct, accountability;
- Cost sharing for unsolicited research proposals and for upgrading research facilities and instrumentation.

Current Issues Regarding Relationship/Barriers to an Effective Relationship:

- Public benefits from NSF research and education support:
  - How to maintain the vitality of academic fundamental research and enhance other national goals, e.g., quality of life and competitiveness;
  - Need to encourage greater cross-sectoral and inter-institutional collaboration in science and engineering research and education programs;
  - Improvement of quality of precollege, undergraduate and graduate education.
- Appropriate support to advance the knowledge base:
  - Adequacy of funding to support current research and education responsibilities, including adequate grant size and support across core disciplines and for emerging opportunities;
  - Support for new faculty members.
- Adequate, appropriate research organization and physical infrastructure:
  - Need for continued adaptation of the disciplinary organization structure of NSF and universities to multidisciplinary research and emerging fields;
  - Need to expand opportunities for access to increasingly expensive frontier research facilities and equipment;
  - Need to reduce the burden of the merit review process on the expert communities, particularly in small fields; and
  - Need for constructive management of conflict-of-interest in context of stronger university-industry collaboration.
- Effects of NSF/RIU relationship on the health of the research and education enterprise:
  - Need to reevaluate the principles and consequences of cost sharing by RIUs and NSF;
  - Need to better understand the impact of NSF research funding on the balance between research and education at RIUs.

Elements/Characteristics of a Productive Future Relationship:

- Enhanced public benefits of research and education support:
  - Continued excellence of U.S. science and engineering research and education;
  - Improved dissemination of knowledge within technical communities including academic researchers, educators, government researchers, and high technology businesses;
  - Effective and productive cooperation in NSF supported research and education activities among academic, government, and industry sectors;
  - Increased contributions by NSF supported research and education programs and projects to areas of strategic importance to the nation.
- Appropriate support to advancing the knowledge base:
  - An appropriate balance between disciplinary and multidisciplinary research;
  - Enhanced support of researchers through adequate award size, with special focus on new researchers and emerging areas.
- Adequate, appropriate research organization and physical infrastructure:

- Minimized burden on the community through more effective management and greater efficiency in the merit review process;
- Increased efficiency in the use of research instruments and facilities through sponsorship of major advances in communications technology and new institutional arrangements;
- Increased efficiency in the use of research funds through interagency collaboration, longer-term grants.

- Enhanced benefits of NSF/RIU relationship on the health of the research and education enterprise:
  - Systematic and equitable investments in the physical infrastructure that supports academic research and education;
  - Increased participation of U.S. citizens in science and engineering through NSF/RIU contributions to curricula reform and to other innovative programs;
  - Expanded benefits from the synergy between NSF funded science and engineering research and education at RIUs;
  - Increased usefulness and efficiency of information collection and dissemination through stronger partnerships and coordination with institutions, with NSF assuming the leadership role in taxonomic standardization.

Legislative Authority

The NSF Act, as amended (42 U.S.C. § 1861-75),.

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