RESEARCH MANAGEMENT REVIEW

The Journal of the
National Council of University Research Administrators

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Kenny's article presents a case study in the development of a university-associated research park. While each research park has its own idiosyncratic history, operation and expectations, we can learn from those differences as well as the commonalities. No matter what precipitant prompts the research park process, the planning efforts, particularly, develop common threads. Organizational and operational relationships go through iterative phases that probably apply beyond the research park situation and certainly extend to many of our efforts to improve university-community cooperation. The more interesting article may well be the one Kenny could provide five years from now about how the university measures its participation in the research park and what have been the problems as well as positive outcomes. We look forward to that article!

Under the Reports and Observations, we publish the paper on the role of research in universities with respect to technological competitiveness presented at a recent regional NCURA meeting. Koehler's comments were highly praised by those in attendance, and his points in support of the university's special role in this economic struggle, while not new information, are presented in an interesting format with some informative, supportive information about some of the other players in these efforts.

As always, responses to the manuscripts are welcome. The financing topic in particular is one that should generate some dialogue within the research community. Is there a federal-university partnership when it comes to facilities? Or is pork barrel an institutional practice becoming legitimate by default?

Mary Ellen Sheridan
Editor
January, 1991

Increased Cost of University-Based Research

Milton Goldberg and David J. Lyons

Abstract. The components of university-based research are people (faculty and supporting staff), instrumentation, facilities, materials, and the maintenance of an environment in which research flourishes. The costs of some of these components are rising rapidly due to the accelerated pace of science, the need for new and renovated research facilities, increased regulations and health and safety standards, and increased salary costs. The costs described are direct and indirect, both growing at nearly the same rate since 1984.

NEED FOR UNIVERSITY-BASED RESEARCH

The very success of past university-based research - and the resulting benefits - have accelerated the pace, complexity, and sophistication of current research efforts. A significant component of the U.S. Gross National Product (GNP) can be traced to relatively recent discoveries. Our competitive position in the world economy, our strength in defense, and our prospects for improved health, to cite just a few examples, can be traced to past investments in university research.

The return on such investments is impressive. The social rate of return on academic research was recently estimated at 28 percent? Various analysts have reported that technological innovation accounts for 44 to 77 percent of increased productivity.[2]

Our nation's future requires accelerated investments in research. Japan and West Germany now spend larger percentages of GNP on research and development (R&D) than the United States. If only nondefense

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R&D is considered, they have exceeded the United States for nearly two decades. U.S. investment in nondefense R&D as a percentage of GNP has declined for at least two years.[3]

ACCELERATED PACE OF SCIENCE

Major advances in science can still result from individual genius and from pencil-and-paper studies. Theorists work much as their predecessors did, but they solve exceedingly more complex problems, whose solutions require more complex techniques, more creative research, and purer materials and ever-more-sensitive instruments to experimentally confirm.

Per-unit expenditures for scientific research are going up due, in substantial part, to the higher costs of more sophisticated instruments and the facilities needed to house them. If one were to examine recent breakthroughs in science, one would see that the tools of science are inevitably new instruments and facilities - typically more complex and more expensive than ones used earlier. “Indeed, a good part of the excitement of science in the past year comes out of new instrumentation. The scanning tunneling microscope for visualizing atoms; the increasing set of ‘impossible experiments’ that can be done on supercomputers; techniques such as capillary electrophoresis that can follow chemical changes in single neurons; or an incredible set of new tools for deciphering DNA structure. Soviet scientists tell their leaders that without industry that can manufacture state-of-the-art equipment, they can never catch up to the West. Young Chinese scientists are reluctant to return home because their training will be almost useless without well-equipped laboratories.“4

Throughout the 1980's, U.S. academic institutions invested heavily in R&D instruments. Results of a survey of academic research equipment in selected fields showed that approximately 40 percent of all instrument systems in research use in 1985-86 had been acquired in the previous three years, and about 25 percent of instrument systems in use in 1982-83 had been retired from research by 1985-86. The median age of the national stock of scientific instruments (both in use and not in use) in 1982-83 and 1985-86 was five years. However, the median age of state-of-the-art instruments was two years, indicating the rapid pace of technological change in research instrumentation.[5]

ACADEMIC RESEARCH BUILDINGS, FACILITIES, AND INSTRUMENTS

The country's research universities also experienced large increases in investment in academic research buildings, facilities, and instrumentation during the 1980s. Recent surveys indicate that after an extended period of decreased federal support, nonfederal investment is now being made to upgrade and replace obsolete facilities and instruments. In addition to the $12.1 billion that universities spent for separately budgeted research activities in 1987, $1.8 billion was disbursed for capital investment in science and engineering facilities and fixed equipment for research and instruction. Nonfederal sources provided most of the funds for capital expenditures - as much as 92 percent in 1987 as compared with 81 percent in 1980 and 71 percent in 1970.[6] There is strong consensus that much greater investments must be made in the 1990s to modernize facilities. To the extent these investments are made, they will result in higher use charges in indirect cost rates.

Construction costs of academic science and engineering facilities were expected to reach $3.4 billion in 1988 and 1989. New construction projects are increasingly expensive - in 1986 and 1987, for example, the cost of new academic research space in current dollars was $206 per square foot, compared to $287 per square foot in 1988 and 1989.[7] Costs are estimated to rise an additional 35 percent for 1990-91 projects, to $311 per square foot.[8] Factors contributing to the markedly increased costs of facilities construction include the need for accommodating new instrumentation, better environmental conditions (e.g., clean rooms), containment facilities, more stringent standards for animal care, toxic waste disposal, and biohazard controls.

NEW REGULATION AND INCREASED HEALTH AND SAFETY STANDARDS

Academic research is often encumbered by the secondary or tertiary influence of regulations and policies intended to do something else. This encumbrance is manifested in delay, restraint, and costly compliance. In most instances universities are not quarreling with the need for regulation, rather with the seemingly unnecessary clerical and administrative requirements imposed as a means to demonstrate compliance. Enumerated below are recent examples of new regulations or policies which create additional administrative burdens, hence additional costs.

Misconduct in Science (1989)
Drugfree Workplace (1989)
Drugfree Workforce (1989)
Care of Animals in Research (1989)
Debarment and Suspension (1989)
Anti-Kickback Act (1988)
Nondelinquency of Federal Debt (1989)
Notice of Cost Sharing (1989)
Certification of Accuracy of Indirect Costs (1988)
U.S. Office of Management and Budget Circular A-133 - New Auditing Rules (1990)
Clean Water Standards (1988 / 90)
Right-to-Know Laws (1988 / 90)
Medical and Infectious Waste Disposal and Tracking (1988 / 90)
Low-Level Radioactive Waste Disposal (1988/90)
Clean Air Standards (1988/90)
Procurement Integrity (1990)
Anti-Lobbying Rules (1990)
Hazardous Waste Disposal (1988/90)

All the regulations enumerated here are products of the past three years. All of these regulations necessitate: increased staff; increased supplies and expense for recordkeeping, monitoring, testing and disposal; and, in many instances, the renovation of facilities to meet new standards. "Each new federal program carries with it substantial monitoring requirements that often lead to the establishment of new internal bureaucracies whose principal function is to create more work for others. Health and safety regulations are a prime example. Most research universities have had to increase their staff of health and safety inspectors fivefold or more. These inspectors then find problems that others must be hired to fix."[9]

Almost all of these costs fall into the category of indirect costs because they cannot be directly attributed to a particular project or activity that occurs within the university. Primarily, these federal regulations support activities within the university's organizational structure. They may be the result of specific federal statutes, or they may be administratively generated based on broad agency powers. In either event, although subject to interpretation by each university, they must be satisfied.

SALARY AND RELATED COSTS

The challenge is to attract and retain the "best and brightest" persons in research careers. As the gap between university salaries and salaries in other sectors widened, the perception among many talented young people was that university careers were not economically attractive.

From 1960-61 to 1970-71, a "golden age," faculty salaries increased 23 percent in real dollars. But, other sectors had comparable and even greater increases. From 1970-71 to 1983-84, faculty salaries declined almost 19 percent in real dollars. Salaries in manufacturing, government, and comparable private sectors, while relatively flat during this period, showed no such decline. From 1960-61 to 1983-84, earnings in real dollars showed no improvement for faculty salaries. For the same period, government salaries were up 27 percent, manufacturing salaries were up 21 percent, and salaries of private sector employees in jobs equivalent to GS grades 11 to 15 were up 20 percent. Disposable personal income was up 53 percent.[10]

Clearly, universities could no longer ignore market forces. Competition for academic researchers became keen. Between 1984 and 1988, salaries of faculty members involved in research increased at a rate greater than the Consumer Price Index or the Biomedical Research and Development Price Index. The Public Health Service Inspector General reported that salary increases for faculty working in research and instruction were greater than increases for faculty devoted primarily to instruction and that salary increases associated with retention of faculty were greater than normal merit increases. The inspector general also reported that federal research support became a resource partner in university efforts to attract and retain first-rate researchers!'

A NOTE ON INDIRECT COSTS

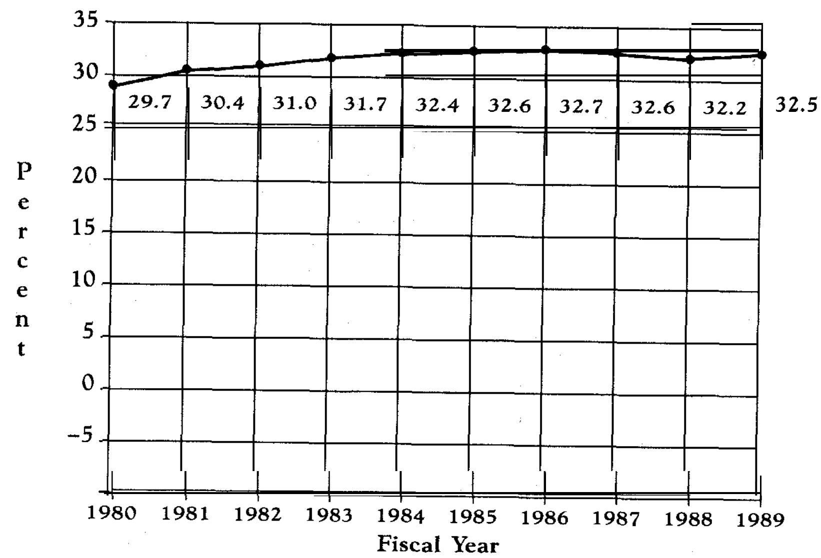
The increased costs described in this paper are both direct and indirect. Are indirect costs rising faster than direct costs? To answer this question, one can rely on data provided by the National Institutes of Health (NIH). The NIH data are significant because NIH funds about half of the academic science conducted in the United States.

Figure 1 displays indirect costs as a percentage of total costs for traditional research grants. The trend line rises from the base year 1980 until 1984. Thereafter, the trend line is almost level, not varying more than a few tenths of a percent between 1984 and 1989. Figure 2 displays the percent change in indirect and direct costs since 1984. Notice that the change in has been nearly the same since 1984, indicating that direct and indirect costs have been growing at nearly the same rate!*

What conclusions can one draw from the preceding? The authors believe that any effort to control the costs of university-based research must address both direct and indirect costs. Tinkering with only one element of this equation will merely shift costs, not control them. The cost of science is going up "because the cost of quality rises rapidly as research problems become more difficult and the infrastructure needed to support inquiry grows more sophisticated and expensive."[13] Education is needed - within both the federal government and the university community - on the total costs of research, how these costs are incurred, how they are distributed between direct and indirect categories, and the effects of changes in funding on the financial health of universities!'+

Figure 1

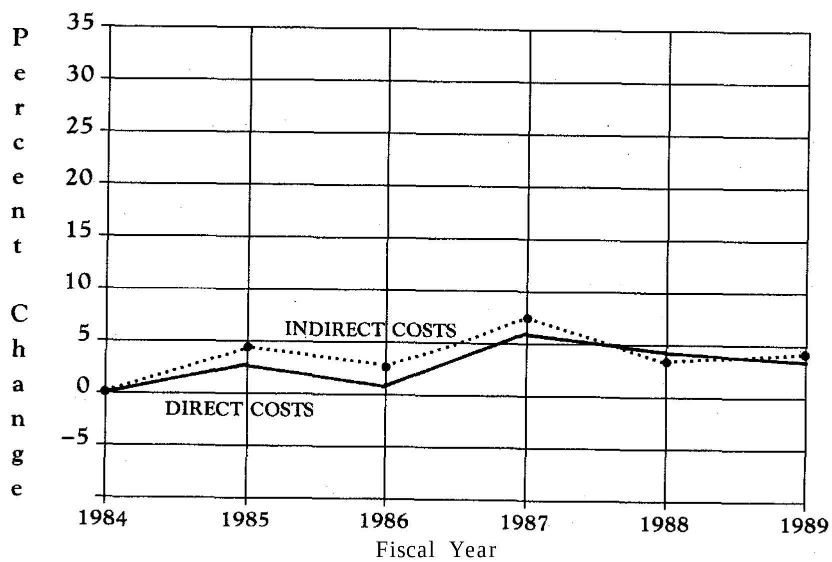
Indirect Costs as a Percentage of Total Costs for Traditional Research Grants



Source Data: NIH Extramural Trends FY 1980–89.

Figure 2

Direct Costs and Indirect Costs: Percent Change since 1984



Source Data: NIH Extramural Trends ***in FY 1980-89.***

SUMMARY

Some special factors have been responsible for recent and anticipated increased costs of university-based research: the availability of more powerful instrumentation, the replacement of obsolete facilities after years of neglect, the costs of new regulations, and the required increases in salaries that had been allowed to fall behind salaries in other sectors. The costs described are direct and indirect, both growing at nearly the same rate since 1984. Investment in university-based research, however, gives promise of greater dividends to society.

REFERENCES

1 Mansfield, Edwin, The Social *Rate* of Return from Academic Research, Preliminary Draft, 1988.

2 U.S. Department of Labor, Productivity and the Economy, *Bulletin of the* Bureau of Labor St&tics, No. 1926, p. 63; *Spectrum* (October 1978): 46.

3 National Science Foundation, *Science and* Engineering Indicators: 1989, February 1990.

4 Press, Frank, How *to* Run American *Science* Successfully, National Academy of Sciences, April 1989.

5 Science & Engineering Indicators: 1989.

6 Ibid.

7 Ibid.

8 National Science Foundation, Scientific and Engineering Research Facilities at Universities and Colleges: 1990, September 1990.

9 Pew Higher Education Research Program, *Policy* Perspectives, June 1990.

10 Bowen, William G., and Sosa, Julie Ann, Prospects for Faculty *in the* Arts and Sciences, A Study **of** Factors Affecting Demand and Supply, 1987 *to* 2012 (Princeton University Press, 1989).

11 Department of Health and Human Services, Office of Inspector General, Survey Report *on the Cost* of Research at Colleges and Universities, March 1989.

12 National Institutes of Health, NIH Extramural Trends FY 1980-89, August 1990.

13 Rosenzweig, Robert, Testimony to Scientific Advisory Panel, National Institutes of Health, December 17, 1990.

14 Association of American Universities, Indirect Costs Associated With Federal Support **of** Research *on University Campuses,* December 1988.

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Financing Academic Research Facilities: A National Need

Julie T. Norris

Editor's Note: This article is based on a report made by the *author* to the National *Science* Foundation (NSF) Research Facilities Office, Spring 1989, updated to include data from the NSF *study* on research facilities published *in* September 1990.

Abstract. The status of research facilities at colleges and universities has once again become a topic of concern. For more than 20 years there has not been a comprehensive federal investment in academic research. One result has been a deterioration of the research infrastructure; another has been an increased tendency toward earmarking for research facilities. This article contains a discussion of depreciation and use allowance and the difficulties of converting from the one to the other. There is also an argument on using current market value vs. acquisition cost as a basis for costing calculations and a discussion of splitting the indirect cost component into two rates. This article focuses on possible changes that might be considered to provide funding for research facilities.

INTRODUCTION

The research partnership between our national government and U.S. colleges and universities is rooted in the contract and grant procedures of federal agencies. This system has as its major components a process for merit review of proposals, funding for projects, and reimbursement (in theory, full-cost) of the expenses, both direct and indirect, of conducting the research. The reimbursement processes, particularly those reflecting indirect costs, have been subject to extraordinary scrutiny, partly because of their complexity.

Part of the problem facing the government and the academic community is that science in many fields has become "big science." To conduct research and training requires tremendous capital investment

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in facilities which must be constructed or renovated to meet stringent environmental standards as well as rigorous standards for health and safety and for handling and disposing of hazardous wastes. In nearly every field of science, further progress requires increasingly sophisticated facilities and equipment as scientists probe deeper into nature's processes.

State-of-the-art facilities and equipment are important determinants of what research can be done and how productive those efforts will be. A recent study by the Association of American Universities (AAU), stated succinctly, "Deterioration and obsolescence of the scientific equipment and facilities in the nation's universities is believed to pose a potential threat to research capability."[1] Most authorities believe that the scope of the facilities problem is so great that neither the federal government, state or private sources, nor colleges and universities can solve the problem alone. The Government-University-Industry Research Roundtable concluded in its 1986 report that "there is no combination of universities and industries that would have a substantive effect on the problem with only token federal government participation."[2] A similar conclusion was reached in the earlier (1985) study by the AAU, the National Association of State Universities and Land Grant Colleges (NASULGC), and the Council on Governmental Relations (COGR).[3]

PREVIOUS STUDIES

Between the mid-1950s and the late 1960s, the federal government invested heavily in academic facilities ("bricks and mortar"), especially those used for research, and in research equipment. However, by the late 1970s, with respect to new construction and renovation, the government had been essentially out of the picture for almost a decade. As early as 1983, concern was expressed about the nationwide funding need for both new and renovated facilities, estimating at that time a $1 to $4 billion need.[4] The following year, a survey of 25 institutions, who receive 38 percent of higher education's share of federal funds for research, estimated the need for construction, remodeling, and refurbishing was $495 million per year which, scaled upward to include all institutions of higher education, resulted in an annual need of $1.3 billion per year.[5] Although directed primarily at the equipment issue, the AAU-NASULGC-COGR study[6] commented on the ever-increasing deterioration of facilities at colleges and universities.

The following year saw two significant studies relating to the facilities issue. The first, A Renewed Partnership: *Report of the White House Science Council: Panel on* the Health *of* U.S. Colleges and Universities,[7] provided a perspective on the health of U.S. universities. In the overview, the report commented:

> The health of U.S. society is uniquely coupled to that of its universities. To a greater degree than any other country, this Nation looks to its universities both for new knowledge and for young trained minds prepared to use it effectively. But just at the time when much is expected of our universities, after more than a decade of retrenchment and belt tightening, they find themselves with obsolete equipment, aging facilities, and growing shortages of both faculty members and students in many important fields.6

As a parallel endeavor, in 1986 the National Science Foundation Authorization Act (P.L. 99-159, section 108) directed the NSF

> to design, establish, and maintain a data collection and analysis capability. . . for the purpose of identifying and assessing the research facilities needs of universities and colleges. . . . The Foundation, in conjunction with other appropriate Federal agencies, shall conduct the necessary surveys every 2 years and report the results to the Congress.[9]

The 1986 report, Science *and* Engineering Research Facilities at Doctorate-Grunting Institutions, was the first of a planned biennial assessment prepared by the NSF for Congress. NSF based its report on two quick-response surveys conducted that spring. Numerous university officials expressed serious reservations about the survey instrument and its methodology.[10, 11] For the next survey (1988),[12] the Foundation developed the survey instrument in cooperation with several higher education associations, university representatives, and an advisory panel with membership primarily from the university community. The scope was expanded to include information on both predominantly undergraduate institutions and historically black colleges and universities. Quantitative and qualitative data were collected for specific science and engineering fields to provide a detailed picture concerning the amount and condition of available research space, planned construction and repair/renovation activities, and sources of funds for these projects for each year from 1986 through 1989 (projected). In addition to an Executive Summary which was distributed separately,[13] a concise summary of the document can be found in the November 1988 C&E News.[14] In January 1989 the National Institutes of Health (NIH) published a document entitled The *Status of* Biomedical Research Facilities: 1988 [15] which used data collected in the same survey as the data for the NSF study. The methodology and the analytical techniques were the same in both the NSF and NIH studies.

The most recent document, and the most wide-ranging, is *Indirect* Costs Associated *with* Federal *Support* of Research *on* University *Campuses:* Some Suggestions **for** Change.[16] This report, developed by the AAU Ad Hoc Committee on Indirect Costs, examines a full range of issues connected with indirect cost reimbursement by the federal government and makes a number of recommendations for change. Published in December 1988, it has quickly become a focus for efforts in the area. Other pertinent publications appear in the References.[17]

CURRENT STATUS OF ACADEMIC RESEARCH FACILITIES

That a problem exists in research facilities at colleges and universities is clear. One writer has stated, "The general decline of research facilities at U.S. universities into a state ranging from shabby to unsafe is widely acknowledged." [18] The extent of the problem is clear in the following statistics:

- The federal government provides only 8-11 percent of the direct funds for research facilities at colleges and universities[19]
- As a percent of federal research and development (R&D), federal outlays for the R&D plant have declined from about 7 percent in 1965 to less than one percent in 1983
- With regard to *adequacy* of space, the range is from 51 percent in engineering to 67.5 percent in psychology[20]
- With regard to *condition* of space, almost 40 percent of general research space requires renovation to be suitable for most research programs; [21] a smaller percentage of the current space in biomedical facilities needs repair/renovation to be used effectively[22]
- Annual spending on academic research and development facilities and equipment, in constant dollars, fell 78 percent during 1966-1983[23]
- Deferred repair and renovation is an increasing problem. The 1988 NSF report on research facilities at universities and colleges found that "for every $1.00 institutions plan to spend for facilities repair/renovation in 1988-89, there is an additional $3.60 of repair/renovation that is needed but is being deferred to some future time"[24] The 1990 report indicates that deferred construction increased from $5.8 billion in 1988 to $8.0 billion in 1990.
- As previously noted, estimates project the cost of replacing obsolete and worn out equipment and facilities to be between $1 and $4 billion.[25]

In summary, then, available evidence points to the need for the federal government to help in the replacement and renovation of research facilities and equipment.

That the problem has been aggravated by budgetary constraints and inflation is undeniable. Prior to considering ways to address the problem, however, some fundamental questions need to be asked. Chief among these is the question of what the government is "buying" when it is supporting university research. It appears there are at least three answers:

1. The government is supporting general research enterprises at colleges and universities and helping to sustain their general good health.
2. The government is acquiring research to address a specific need.
3. The government is providing needed facilities and equipment to prepare the next generation of research scientists and engineers, another cited national need.

The view that the government is supporting the general research enterprise provides a strong argument for federal funding of research equipment and facilities at academic institutions. In addition, the construction and renovation of modern research facilities, especially those for science and technology, are vital to the future well-being of our nation. These facilities are essential, not only to the quality of our education and research, but also to our industrial competitiveness and national security.

Other fundamental questions which must be considered include the following:

1. Is the need sufficient to warrant massive and sustained federal action on the side of either direct or indirect costs?
2. Should funding by the federal government to colleges and universities include specific measures to ensure the adequacy of the institution in carrying out the research so necessary to maintain international scientific and technological leadership?
3. Should - and, if so, how - can the research community reconcile the direct versus peer-review funding approaches to the facilities problem?
4. Is it appropriate to talk of the government bearing its full share of the cost of the university research it supports?

Currently, university and government officials are attempting to identify strategies to deal with a wide range of indirect cost (IDC) issues, including the reimbursement to universities of facility and equipment costs.

In addition, several senators have recently joined Sen. Terry Sanford in asking the White House and its science advisor to become proactive in solving the research facilities problem, which they call "a critical national problem."[26]

THE CURRENT REGULATORY ENVIRONMENT

Office of Management and Budget (OMB) Circular A-21, "Federal Principles for Determining Costs Applicable to Grants and Contracts with Colleges and Universities," establishes the principles and procedures for determining applicable IDC based on actual costs. Key to the document is the principle that each university's federally sponsored research is to be reimbursed by the government on the basis of an indirect cost rate individually determined for each institution and using cost principles designed to ensure that research sponsors pay only their fair share of indirect costs, i.e., those which can reasonably and equitably be allocated to research activities of the institution.

The concept of IDC reimbursement is more than 40 years old, beginning in 1947 when the Office of Naval Research, then the major federal funding source for university research, negotiated the first formal principles for such recovery.[27] In 1958, the Bureau of the Budget revised and issued these principles as Bureau of the Budget Circular A-21. Significant for the purposes of this article is the fact that this 1958 issuance established the amortization schedules for facilities and equipment used for research. (Following this issuance, the circular was revised six times between 1961 and 1983, including transfer to OMB's responsibility. The amortization schedules were not addressed in any of those revisions.) The circular states:

> Institutions may be compensated for the use of their buildings, capital improvements, and equipment; provided that they are used, needed in the institutions' activities, and properly allocable to sponsored agreements. Such compensation shall be made by computing either depreciation or use allowance.[28]

In both the depreciation and use allowance approach, the computation is based on the *acquisition* cost of the asset. In depreciation, the government indicates that:

> The period of useful service or useful life established in each case for usable capital assets must take into consideration such factors as type of construction, nature of the equipment, technological developments in the particular area, and the renewal and replacement policies followed for the individual items or classes of assets involved.

Further,

> When the depreciation method is used for buildings, a building "shell" may be treated separately from other building components, such as plumbing system and heating and air conditioning system. Each component item may then be depreciated over its estimated useful life. On the other hand, the entire building, including the shell and all components, may be treated as a single asset and depreciated over a single useful life.[29]

In the use allowance method, however, the government specifies the percentages which institutions may apply:

> The use allowance for buildings and improvements (including improvements such as paved parking areas, fences and sidewalks) will be computed at an annual rate not exceeding two percent of acquisition cost. The use allowance for equipment will be computed at an annual rate not exceeding six and two-thirds percent of acquisition cost.[30]

The basis for establishing the fifty-year life of buildings (at 2 percent per year it takes fifty years to recover the cost of the building) and the fifteen-plus years for equipment is not clear. One presumes that the numbers were reached by deciding what was in 1958 assumed to be the lifetime of buildings and equipment. Further,

> In contrast to the depreciation method, the entire building must be treated as a single asset without separating its "shell" from other building components under the use allowance method. The entire building must be treated as a single asset, and the two-percent use allowance limitation must be applied to all parts of the building.

Significant to universities is the fact that the cognizant audit agency for most research universities, the Department of Health and Human Services (DHHS), has stringent rules on how a university calculates its assets if it wishes to convert from use allowance to depreciation (see the section on Conversion from Use Allowance to Depreciation).

FULL COST RECOVERY

Circular A-21 is anchored in the principle of full cost recovery. However, the reality is that institutions do not recover full costs, either for direct or indirect expenses. The issue is highly charged emotionally, but one cannot discount a number of factors when looking at the principles involved. Although the academic community argues that indirect costs have not grown faster than direct costs,[31] the government argues that indirect costs are taking an increasing percentage of the research dollar and that funding constraints and budget realities dictate a limit on the total funds allocated for research by colleges and universities. With current federal funding difficulties (particularly the specter of Gramm-Rudman-Hollings), these constraints become even more pronounced. Universities, on the other hand, point to the ever-increasing cost of research, to the increasing obsolescence of research equipment and facilities, to the faculty-administrative conflict over indirect costs, and, most importantly, to the inextricable relationship between the federal government and the university community in furthering the research enterprise. The 1986 White House Science Council (WHSC) report concluded:

> Our universities today simply cannot respond to society's expectations for them or discharge their national responsibilities in research and education without substantially increased support.[32]

To address the support issue, the WHSC recommended:

- [that] the federal government make substantially greater investments in our centers of learning in the 1980's and 1990's than in the 1970's. The recommendations set forth in this report, if they are to be implemented fully, require significant increases in financial support. The source of such funding in these times of fiscal stringency is not obvious. Reallocation of R&D appropriations appears to be the most probable source, but we believe that incremental new funding will be required.
- [that] the federal government bear its full share of the cost of the university research it supports.[33]

INCREASING INSTITUTIONAL RECOVERY

Prior to examining specific costing issues related to research facilities, it is important to recognize that variances exist in indirect costs related to space, facilities, and equipment. The AAU-NASULGC-COGR document, referenced earlier, is perhaps the most definitive study to date on this issue. The percentage of space costs in the indirect cost rate varies generally from approximately 19 percent to 25 percent of the rate. This range is due to primarily the location, age, operation, and maintenance of facilities, methods of financing, use allowance versus depreciation recovery, mix of research, intensity of space use, and unit cost of utilities. Because of these variances and because institutional situations differ, there are a number of possible options and approaches to increasing institutional recovery.

Increase *in* Use Allowance **for** *Facilities and Equipment*

Clearly a popular choice is an increase in the use allowance for facilities and equipment. This suggestion appeared first in the AAU-NASULGC-COGR study,[34] then in the White House Science Council study, which first recommended that reimbursement be based on realistic useful lifetimes:

- Useful life of buildings and facilities should be reduced from the present level of fifty years to twenty years.
- Useful life of equipment and instrumentation should be reduced from the present level of fifteen years to five-to-ten years, depending on the class of equipment.[35]

Most recently, the AAU endorsed the WHSC study, noting that the equipment /instrumentation life should be reduced to four-to-seven years, depending on the type of equipment.[36]

A rationale for the increase in use allowance generally includes the following points:

- Use allowance has been set at 2 percent per year for buildings and 6% percent for instruments since 1958 - more than thirty years.
- According to the WHSC report, federal policies should recognize that the costs of university research facilities and equipment are a necessary part of federally sponsored, university-based research costs.
- Facilities investment by means of the use allowance puts funds where the federal research is conducted. That is, use allowance is computed on the university's stock of nonfederal instruments and facilities currently in use for support of federally funded, merit-reviewed, individual investigator-initiated research grants.
- A more realistic use allowance would give colleges and universities the *option* to obtain some limited relief for modernization and replacement of research facilities and instruments. However, only colleges or universities that are willing to justify and apply increased indirect cost rates could take advantage of an increased allowance.
- Since the bulk of the federal capital investment for science facilities last took place in the 1960s and the chance of substantial direct federal investment is poor, an increase in the use allowance may be the most viable avenue for assisting in facility upgrading.
- When colleges and universities find it necessary to upgrade or replace research equipment and facilities, they find they are still recovering costs for many of them because amortization schedules do not match the speed with which these instruments and facilities become technologically obsolete. Universities are reluctant to sink

funds into instruments, facilities, and buildings where the liquidation of debt for those items will outlast the life of the asset.

Of major concern when considering an increase in use allowance is the cost. DHHS places the cost of the current 2 percent on facilities and 6% percent on equipment at $200 million, and it feels that a use allowance of 5 percent on facilities and 15 percent on equipment would increase the government's cost to $500 million, a conclusion also reached in the recent AAU study.[37] Such an increase would raise indirect cost rates (perhaps as much as five points) and widen the rate variation among institutions. Friction between faculty and administrators on college and university campuses might occur and might result in an institution's making a conscious decision not to take advantage of the possibility of increased recovery. How the federal agencies would view the change is also unclear since it would, by definition, cause greater strain on awards to individual investigators. In addition, an increase in the use allowance does not address the issue of repair, renovation, or maintenance of facilities or equipment purchased with federal funds since such items are not subject to recovery via either use allowance or depreciation.

Conversion from Use Allowance to Depreciation

Section J.9. of OMB Circular A-21 provides regulations for reimbursement of depreciation or use allowance for buildings, facilities, and instrumentation. As colleges and universities become more interested in modernizing their research infrastructure, many want to use the amortization method that recognizes a realistic useful life and assures recovery of the total acquisition cost of the assets. This approach requires a switch from the use allowance method, which amortizes buildings over fifty years, to the depreciation method. The switch in accounting practices must be negotiated with the university's federal auditor. The DHHS, which is the federal auditor for 95 percent of all colleges and universities, contends that future depreciation of each asset should be computed as if the asset had been depreciated over its entire useful life, i.e., from the date the asset was acquired to the date it is expected to be withdrawn from active use.

An example of how this works is the following: A university currently has a building which, after taking use allowance for twenty years (2%x 20 yrs. = 40% of cost recovered), it wishes to convert to the depreciation method. A qualified appraiser sets the life of the building at thirty years. Under the DHHS interpretation, the building has reached 2/3 of its life and thus, had depreciation been used since inception, the university would have realized recovery of 67 percent of its cost. Although the university can switch to depreciation for the last ten years, the difference (67 % -40 % = 27 %) is not recoverable by the institution. Under the DHHS interpretation, universities cannot recover depreciation that would have accumulated during the period the use allowance was taken. The effect of this interpretation is that many buildings, facilities, or instruments will already be fully depreciated but the full acquisition cost will not have been recovered. This disagreement is, in large measure, one barrier to conversion to depreciation.

The 1985 study of facilities and instrumentation[38] recommended that federal agencies permit universities to recover the full cost of nonfederally funded equipment (and facilities) when converting from use allowance to depreciation. The report added that depreciation schedules had to be realistically and objectively established and that funds recovered in this way be dedicated to replacement and renovation of research facilities and equipment. The recent AAU study also endorsed this recommendation on conversion to the depreciation method without penalty on the part of the institution.[39]

Current Market Value vs. Acquisition Cost as a *Basis* **for** Costing Calculations

As stated before, technological obsolescence is becoming a serious problem for colleges and universities. Both aging facilities and obsolete equipment are a challenge to universities as they seek to maintain a technological edge over competitors. Circular A-21 currently allows an institution to use only the acquisition cost and not current market value of facilities and equipment in an attempt to recover costs of doing federal research, regardless of the expense of replacing the worn and obsolete items. Reliable cost estimates for this change are not available, but based on estimates in the 1985 AAU-NASULGC-COGR study, this change could raise the government's cost in facilities and equipment by three-to-five percentage points.

Development **of** a *Facilities-Related IDC Component*

As mentioned earlier, indirect cost recovery is an emotionally charged issue which normally pits the government against the university - and the university administration against the faculty. Some of the components which make up the rate are highly subjective and, thus, serve as the lightning rod for criticism. These components include departmental and general administration, library, sponsored project administration, and student services. Far less controversial, because of their bases, are the facilities and equipment components. One source has stated:

> . . . laboratories are not often used for both research and instruction, allowing for the clear allocation to research of the cost of running the laboratory. There are, however, real differences in the costs associated with facilities, depending on the nature of the work, density of use, age of buildings, mechanisms of financing, etc. There are sound practices underlying reimbursement for facilities-related costs on the basis of documented and allocated costs incurred, and the outcomes should reflect each university's special circumstances.[40]

One option would be to split the indirect cost rate into two rates: one component for space and facilities, including operation and maintenance expenses, and one for all other indirect cost elements. Splitting the current IDC rate into two rates does not affect the recovery of costs, but it does clearly identify the source(s) of the rates. To the extent the IDC rate changes on the basis of any of these possibilities or merely as a natural time-dependent phenomenon, clarity in the components of the rate may help diffuse some situations. This approach would be of benefit to both the universities and the government.

Use Allowance or Depreciation on Federally Funded Equipment and Facilities

NSF statistics show that almost 60 percent of the value of academic research instruments was purchased with federal funds. The concern from an institutional viewpoint is how to maintain equipment and facilities once they have been purchased. Maintenance costs can vary from 20 to 50 percent of the acquisition cost per year, and the maintenance of a building and its infrastructure increases with the building's age. Often an institution may be able to tap federal, state, or even the bond market for new or replacement facilities, but funds for repair and renovation are far more elusive. Circular A-21 prevents institutions from recovery of IDC on equipment and facilities acquired with federal funds. The rationale is simple: the government does not wish to pay for the facilities or equipment more than once, i.e., through direct funding and via the indirect cost route. However, to permit a college or university to utilize the use or depreciation mechanisms (after some reasonable period) to acquire funds dedicated to the replacement or repair of the asset could be of significant value to the institution. For example, if federally funded equipment remained in use five years after its acquisition, an institution could include a set percentage (say, 3 percent of its value) in its indirect cost proposal to allow for continued maintenance of that equipment.

OTHER THOUGHTS

Dedicating Facilities-Related *IDC Recovery to Specific Purposes*

IDC recovery is a reimbursement to an institution for the expenses it has previously incurred in performing research activities. Under normal practices at most institutions, IDC reimbursements go into the general fund and are not dedicated directly to a specific purpose (such as repair and renovation). An alternative would be for institutions, in exchange for more realistic depreciation and use rates, to dedicate the incremental recovery from those rates to replacing, upgrading, and maintaining facilities.

Building "Shell" VS. infrastructure

When universities use the depreciation option with respect to facilities, Circular A-21 gives the institution an option of separating the "shell" (i.e., bricks and mortar) of a building from its infrastructure (plumbing, fume hoods, etc.). No such option exists for institutions which recover costs based upon use allowance. Providing institutions utilizing the use allowance method with the option of separating the shell (recovery at the building rate, currently 2 percent) and the infrastructure (recovery at the equipment rate, currently 6% percent) would more accurately reflect true costs.

A Combination **of** Approaches

At the present time, Circular A-21 requires that an institution select either the depreciation or the use allowance method and use that method exclusively. One possible option might be a system whereby an institution could choose to combine use allowance with depreciation. For example, an institution might depreciate newly constructed or acquired facilities and equipment, while retaining the use allowance mode for currently existing equipment and facilities. In theory, an institution using this methodology would still recover its acquisition costs, but would do so in an accelerated fashion. There would be some upward pressure on IDC rates, but the effect would not be as dramatic as a full conversion, without penalty, to the depreciation mode. Such an approach could be seen as an incentive to modernize facilities and equipment, and not be viewed merely as increased recovery. Parallel arguments could be made for institutions choosing the use allowance process: new facilities and equipment could have cost recovery based upon higher use allowances than currently existing facilities and equipment.

institutional Variations

One of the problems inherent in a study of facility costing issues is the difference between the top fifty R&D institutions and those below the top fifty. The top fifty institutions represent significant proportions of all R&D expenditures (61 percent) and space (50 percent). Even if the rates and bases for IDC calculations for facilities and equipment were changed, many of the schools below the top fifty (or top one hundred) would not realize enough increase in their IDC recovery to address successfully the research facilities problems on their campuses. Therefore, a combined approach for schools ranked below the top one hundred, allowing increased recovery via the IDC route and participation in a peer-reviewed competitive grants program for facilities, might be advantageous.

Setting Priorities

The research activities of colleges and universities have increased substantially in recent years. However, the potential for a recession, cited by Gramm-Rudman, and the deficit problem are phenomena which must be considered. Questions being posed now often include "Has the university research enterprise grown too large?" "Are there sufficient resources to accomplish everything we hope for?" "Are states providing enough support, at least to their public institutions?" These questions are related to the subject at hand and may pose a fruitful area for a future paper.

CONCLUSIONS

Underestimating the shortage of up-to-date academic research facilities has direct consequences for the federal government and the nation's colleges and universities. The government is and will remain the largest funder of basic research, and the universities are the major performers of that research. To fail to deal constructively with the eroding university infrastructure supporting science and technology research programs has direct economic consequences for the health of the nation's research endeavors.

Cutting-edge research is increasingly dependent upon a more and more sophisticated and expensive infrastructure. The construction and renovation of modern research facilities - especially those for science and technology - are vital to the future well-being of our nation. These facilities are essential, not only to the quality of our education and research, but also to our industrial competitiveness and national security. The cost of facilities and equipment used in research is a necessary part of the total cost of research.

As stated in the AAU report,

> Because of federal budget constraints, no one expects. . . federal initiatives to solve all facilities and equipment problems. Therefore, with or without the federal government, the universities and their benefactors and supporters will have to invest significantly in construction of new facilities, refurbishing of aging plants, and investment in new equipment. These actions are likely to cause universities to incur substantial debt. The costs of that debt and the reasonable depreciation of new facilities and equipment will have to be borne by instruction and research, to the extent that each enjoys the new or refurbished capacity. Inevitably, this will lead to legitimate pressure for further recovery of costs and, thus, increased indirect cost rates.[41]

In summary, absent direct federal or private-sector financing programs for facilities and equipment, the only currently available, feasible approaches in the near term are improved use allowance, switching to depreciation, and use allowance for federally purchased items. In dealing with facilities and equipment problems in the long term, three approaches appear feasible: direct federal funding, through peer review, of facilities and equipment; mechanisms to increase recovery in the space-related components of indirect cost; and increased participation by the private sector in academic facility construction. Institutions, federal and state governments, and the private sector need to consider these (and perhaps other) approaches to address this issue in the near future.

REFERENCES

1 Bruer, Ruth; Schmidt, Richard E.; and Bell, James, Issues *in* Biomedical Research Facilities: Financing and Development, Association of American Universities, March 24, 1989, p. 1.

2 Academic Research Facilities: *Financing Strategies*, Government-University-Industry Research Roundtable, 1986, p. 3.

[3] Financing and Managing University Research Equipment, Association of American Universities, National Association of State Universities and Land Grant Colleges, and the Council on Governmental Relations, Washington, D.C., 1985, p. 1.

4 Strengthening the *Government-University Partnership in Science: Report of the Relationships in Support of Science of the National Academy* Complex, National Academy of Sciences, National Academy of Engineering, and Institute of Medicine, Washington, D.C.: National Academy Press, 1983, p. 1.

[5] Adequacy *of* Academic Research Facilities. A Brief Report of a Survey *of Recent* Expenditures and Projected Needs *in Twenty-five* Academic *Institutions.* Prepared under the direction of the Ad Hoc Interagency Steering Committee on Academic Research Facilities with the assistance of the National Science Foundation Task Group on Academic Research Facilities, April 1984, p. 1.

[6] *Financing and Managing University Research Equipment.*

7 A Renewed Partnership: Report of the White House Science Council: Panel on *the Health of* U.S. Colleges and Universities, Office of Science and Technology Policy, Executive Office of the President, 1986.

8 A Renewed Partnership, p. 3.

[9] *Scientific and Engineering Research Facilities at Universities* and Colleges: 1986, National Science Foundation, 1986, p. 1.

10 Barnes, Dennis (consultant), *The* Research Facilities *Needs of Universities: A Critique of the NSF Report Science and Engineering Research Facilities at Doctorate-Granting Institutions.* Prepared for the American Association of State Colleges and Universities, American Council on Education, American Society for Engineering Education, Association of American Medical Colleges, Association of American Universities, Council of Graduate Schools in the United States, Council on Governmental Relations, National Association of Independent Colleges and Universities, and the National Association of State Universities and Land Grant Colleges, September 1986, March 1987, p. 2.

11 Bricks and Mortar: *A Summary of Proposals to Meet Research Facilities* Needs on *College* Campuses, Congressional Research Service, Washington, DC.: U.S. Government Printing Office, September 1987, p. 4.

12 Scientific and Engineering Facilities at Universities *and Colleges: 1988.*

13 Scientific and Engineering Facilities at Universities *and Colleges: 1988.*

14 Hanson, David, “Many University Research Facilities Need Repairs,” Chemical and Engineering News (November 4, 1988): 28.

15 The Status **of** *Biomedical* Research *Facilities:* 1988, National Institutes of Health, January 1989.

16 Indirect Costs Associated *with* Federal Support **of** Research on University Campuses: Some Suggestions **for** Change. Report of the AAU Ad Hoc Committee on Indirect Costs to the Executive Committee of the Association of American Universities, December, 1988.

17 Other publications of interest to the reader include the following:

a. Academic Science /Engineering R&D Funds, Detailed Statistical Tables, National Science Foundation (various years).

b. Academic Research Equipment *in the* Physical and Computer *Sciences* and Engineering: 1982 and 1985, National Science Foundation, October 1987.

c. Federal Funds **for** Research & Development, Detailed Statistical Tables, National Science Foundation (various years).

d. National *Survey* **of** Academic Research Instruments and instrumentation Needs, National Science Foundation: Division of Science Resource Studies, 1984.

The reader is directed, especially, to the Detailed Statistical Tables issued by NSF, which are a source of considerable information.

18 Walsh, John, 'Congress Considers Upgrading Labs," News and Comment (July 24, 1987): 351-52.

19 Scientific and Engineering Research Facilities at Universities and Colleges: *1990*, p. xix.

2o Scientific and Engineering Facilities at Universities and Colleges: 1990, p. 5-5.

21 Scientific and Engineering Facilities at Universities and Colleges: 1990, p. 5-8.

22 The Status **of** Biomedical *Research Facilities: 1988*, p. x.

23 Financing and Managing University Research Equipment, p. 3.

24 Scientific and Engineering Research Facilities at Universities and Colleges: 1988, Executive Summary, National Science Foundation, 1988, p. 4.

25 *Issues* in Biomedical Research *Facilities*, p. 1.

26 July 26, 1990, letter from Sen. Terry Sanford, with 26 congressional cosigners. Distributed as "Dear Colleague" letter to university research community.

27 Indirect Costs, p. 4.

28 Office of Management and Budget (OMB) Circular A-21: Cost Principles **for** Educational Institutions, section J.9.

29 OMB Circular A-21, section J.9.

30 OMB Circular A-21, section J.9.

31 Science 249 (July 16, 1990): 10-11.

32 A Renewed Partnership, p. 3.

33 A Renewed Partnership, p. 5.

34 Financing and Managing University Research Equipment, pp. 9-10.

35 A Renewed Partnership, p. 5.
36 indirect Costs, p. xiii.
37 issues in Biomedical Research Facilities, pp. 17-18.
38 Financing and Managing University Research Equipment, pp. 9-10.
39 Indirect Costs, p. xiii.
40 Indirect Costs, p. 3.
41 Indirect Costs, p. 40.

TechnaCenter: A Case Study in Research Park Development

James T. Kenny

Abstract. With the growing interest in developing university-related research parks comes a number of questions deserving careful consideration. For example, should such ventures be university or privately owned? What are the more promising financing strategies? Should more than one university be involved? What strengths should the host environment or community possess to ensure the first-stage development of a park? The following article looks at the genesis of one such project, Alabama TechnaCenter. The pattern of university-community cooperation characterizing the planning and implementation of this central Alabama project suggests some strategies that might prove useful for those who would move institutional ambitions “from concept to concrete.”

INTRODUCTION

Alabama TechnaCenter, a privately owned, university-affiliated research park currently under construction in Montgomery, grew out of a three-year planning effort involving officials of Auburn University at Montgomery (AUM), area business leaders, city representatives, and state officials. As local momentum gathered and deliberations proceeded during early 1988, a directional proposition emerged connecting the success of TechnaCenter and the future vitality of the central Alabama economy with focused efforts at attracting more technology- and science-based industry to the area. In particular, planners wanted to stimulate the in-migration of major software-development firms.

The Montgomery working group was interested in accelerating the pace of modernization and growth in their urban center and in exploiting

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its potential as a commercial and technological hub of the New South. It was taken as an article of faith that local institutions of higher education would cooperate to fuel these aspirations and fill an important leadership role in helping to attract, and later serve the research and training needs of, the sought-after technology-based firms.

As a result of the initial planning and related community developments, a task force building from the early planners meeting at the AUM campus in June was able to offer a specific set of recommendations. These recommendations called for the implementation of a development strategy to hasten construction on a technology and research park near local higher-education resources. The idea moved closer to reality as a private developer, a member of the AUM campus advisory board, offered a comprehensive "footprint" for a multistructure facility on an initial allotment of 300 acres of private land near the campus.

The "concretization" of the plan intensified interest in the project at all levels and signaled the need for additional organizational resources and thinking. Prompt efforts were made to expand the working group of university, state and city officials, and developers. A larger cooperative venture soon came to include a local investment banking firm, a credit enhancement institution, the State Finance Office, the site's land donor, the mayor, members of City Council, the Montgomery Area Chamber of Commerce development cadre, and representatives of the Montgomery state legislative delegation. Members of Alabama's congressional delegation were also kept informed of developments.

This broadening of the base of support helped to ensure an enhanced understanding of, and greater state and federal participation in, the research park endeavor. However, broadened participation also led to a plurality of interests that had to be accommodated. For example:

1. The university tended to view the proposed park as a research and degree-focused educational facility.
2. State development officers were more interested in showcasing the breadth of Alabama industrial support services.
3. The Chamber of Commerce viewed the attraction of industry to the local area as a primary concern.
4. The state Data Systems Management Division (connected with the State Finance Office) was preeminently concerned with the site's potential for aggregating computer hardware which might serve that agency's software-development needs.

The balancing of these diverse interests and their political overtones presented some throny problems. No less so was the need to bring about expanded cooperation among local institutions of higher education. Less formidable, but certainly problematic, was the reconciliation of political differences as these affected both the planning and financing of the project.

After some trial and error, a number of mechanisms were developed that accommodated particular interests and fostered adhesion and greater unity of purpose. These mechanisms included: the Alabama Institute for Advanced Information Systems, for corporate relocation; the Montgomery Educational Building Authority, for bond issuance; a Chamber of Commerce office site, for administrative development; and a proposed Montgomery educational services consortium, for educational cooperation. In spite of the apparent diversity of community interests, there was common ground or consensus in the general awareness of all involved of some of the research park "success stories!'

The Montgomery project reflected a national trend that has attracted much attention over the last decade. Today, no less than 115 research parks are found nationally, providing innovative vehicles for joint programming between campuses and corporations. Doubtless, there is something unique and mutually beneficial in this emerging model of university-business cooperation.

THE PARK PERSPECTIVE

Vigorous academic growth, stimulated by economic development, is a planning proposition that has gained acceptance and credibility at an increasing number of American universities. Growth, stimulated by economic development, also has proven to be the case in a number of communities that host academic and research facilities.' Those who planned TechnaCenter had in their Southern "backyard" three important examples of successful and evolutionary university-business partnerships. These were the Research Triangle in North Carolina, the Research Corridor in Knoxville, Tennessee, and the Central Florida Research Park in Orlando. In these examples, progressive universities, poised for growth, sought affiliation with major industries in the development of joint research facilities and programs. Correspondingly, the science-based industries they allied with made the commitment to locate close to a university to secure campus-based scientific and technical expertise in their research and product-development efforts.

The benefits for industry in this type of university connection are significant. Working in close partnership with a major source of scientific talent (faculty and graduate students), corporations are able to accelerate the process of new product development. Proximity to laboratories and specialized university units also enables corporations to realize a faster pace of technology transfer, that is, the flow of creativity from the laboratory to the production line.* Insofar as research parks are property ventures, their potential as magnets to attract new businesses seeking a nurturing environment is great. The aggregation of science-based companies in a cooperative milieu provides opportunities for tenants to share in an abundance of information on technology, production, management, and marketing.3

At the same time, the advantages for the affiliated university are numerous:

1. The Association of University Related Research Parks notes that campus-sponsored grants and contracts tend to increase in number and dollar value with the development of parks.
2. Faculty and graduate students very often find themselves challenged with new and exciting research opportunities.
3. The university often attracts additional scholars because of their interest in specific technologies.
4. As corporate tenants increase in number, so do undergraduate internship possibilities.
5. Donations to scholarship programs, endowed professorships, lectureships, and laboratory equipment funds also may increase as the benefactions of corporate partners add strength to campus private-giving programs.
6. In most cases, employment opportunities for students in the local market increase as the new high-tech companies expand their human resource bases to meet production challenges. In fact, access to college graduates - and degree programs for employees - are major motivators in corporate decisions to locate operations near university campuses.[4]

The mutual benefits for the university and its allied industry could be enormous. However, they do not accrue automatically, and the success of all parks is not ensured. For the process to have a meaningful beginning and a sustainable value, there must be a catalyst or two. While the university serves as advocate, a science-related industry is a prime requisite for success. One also would hope for the proximate location of a large federal research laboratory or facilities administering a series of related, long-term federal projects. Such activity stimulates research and, of course, is also capable of attracting a critical mass of private vendors or contractors to the area. In the case of the TechnaCenter project and AUM, the catalyst was a U.S. Air Force computer division at Gunter Air Force Base in Montgomery.

THE GUNTER CONNECTION

The Air Force first revealed its decision to "privatize" its software design and development on November 16, 1987, when the Standard Systems Center issued the *Modernization* Plan *for Standard Air* Force *Information Systems* on Phase IV Base-Level *Computers.* The Modernization Plan outlined the Air Force's need to match its diversified computer hardware inventory with comprehensive software redevelopment. A fifteen-year evolutionary acquisition strategy, beginning in 1987, envisioned a modernization and integration plan, a software services project, a system software project, and a transition program into the target hardware and software environment.

The announcement of the Modernization Plan brought to central Alabama a number of the larger software-development firms. These firms quickly positioned themselves to compete for the billions of dollars in federal software contracts that will be issued under the plan, and they began to secure federal contracts in early rounds of the modernization work. This Air Force project and the private-sector business it is capable of generating was, without doubt, the single most important stimulant to the growth of TechnaCenter.

The years of productive work and the lucrative specialized contracting promised by the Gunter project will intensify the interest of software-development firms in the Montgomery area. As a university-affiliated research park, TechnaCenter is expected to encourage a long-term commitment on the part of these firms to central Alabama and to stimulate the growth of a major software industry in the area. A number of related developments have heightened this probability. During its 1988 special session, the state legislature approved funding for a special training project related to the Air Force and TechnaCenter activity. Soon thereafter, the governor signed an executive order creating the Alabama Institute for Advanced Information Systems. This unit, working in close cooperation with state development agencies, businesses, and institutions of higher education, is authorized to provide training and technical services to assist corporations locating in Montgomery in support of the Air Force project.

The Institute, through the Alabama Industrial Development Training program, has assisted in the development of a cooperative employee training project with Harris Corporation, one of the first Air Force contractors under the Modernization Plan. The decision to work with Harris was conditioned by two factors: first, the desire to get that corporation into the park as a tenant, and second, to encourage Harris to enlist a local work force - thereby keeping the economic benefits of its contract in the Montgomery community. Another example of the way the Institute has been able to use the training program for the benefit of the TechnaCenter has been the training of university faculty in fourth-generation computer language. These faculty have now become more effective TechnaCenter participants, and their skills will strengthen all subsequent training programs.

The Institute, as a policy-formulating body representing state, university, and business interests, is becoming an excellent vehicle for the airing of, and reconciliation of, divergent views on the development and direction of TechnaCenter.

BUILDINGS AND FOUNDATIONS

The February 7, 1989, passage of a Montgomery City Council ordinance creating the Montgomery Education Building Authority was a milestone in the development of TechnaCenter. The Authority, with its license to issue municipal bonds, provided the funding mechanism for construction of the first building at the site. With this important development - and a substantial donation of land, a 33,000-square-foot "anchor building" was planned to be completed in early 1991. This first building would house the Cray supercomputer node, other mainframe hardware, a university research and training center, a state research and development project in software development, and a developmental robotics laboratory.

The Authority, which issued municipal bonds for the full amount of this first building, would supervise the University's servicing of the bonds under a twenty-five-year debt schedule. Thereafter, by deed, the structure and its land were to become the property of Auburn University at Montgomery. Correspondingly, as lessee during the debt service period, AUM was authorized to sublease portions of the building to various tenants including research units of neighboring universities, the Alabama Industrial Development Training program, and the research and development wing of the Alabama State Data Systems Management Division. As a locus for both research and training activities, this first building would provide working space for Auburn and other area institutions of higher education on a project-oriented, as-needed basis. Research activities would include software development and its testing and evaluation.

THE BACKGROUND WORKERS

The unique and bonding character of TechnaCenter has been multilevel cooperation among government, business, and university agencies. Some strategic considerations were: the willingness of the city of Montgomery to provide all arrangements for water and sewer; the enthusiasm of the City Council for rezoning the site and creating, by resolution, a municipal bonding authority; and the interest of the state in providing resources for organizational infrastructure and development, asphalt for roads, and supercomputer access.

The task force, made up of talented, middle-level professionals from a plurality of institutions, worked long hours in ironing out the differences among the respective interests they each represented. As a result of members' diligence and sensitivity, their recommendations, at each stage, were based on solid and supportable planning, well-executed local "salesmanship," and an appreciation of the state's political realities. At each step of initial development, the task force established and maintained contact with state legislative and executive leadership, congressional supporters, a variety of local business interests and business lobby groups, local educational service providers, and the U.S. Air Force and probable defense vendors, contractors, and subcontractors under the software Modernization Plan. Time-consuming but regular communication enabled park planners to move through crucial action stages and troublesome junctures. It also served to broaden the basis of consensus, "ownership," and participation in an endeavor that promised jobs, growth, and economic vitality.

During the implementation phase, it became apparent that maintaining a broad base of cooperation and support could not be accomplished by a planning group acting alone, regardless of how well intentioned and informed such a group might be. Far too many operational decisions were required, and the expanding network of interagency communications necessitated an organizational focus point. It was therefore decided that an administrative office under the development wing of the Montgomery Area Chamber of Commerce would best carry out the goals of everyone involved.

The Chamber was well suited for providing this organization. Given its minimal financial exposure and lack of political involvement, the organization was trusted by all to provide consistency and objectivity in setting action agendas and mobilizing institutional participants. This confidence was well placed as the Chamber, through its Special Projects/ Economic Development Division, proved itself to be a source of sustaining energy and imaginative effort in providing staffing, interview scheduling, group travel and itinerary organization, the coordination of architectural planning, and political agenda development.

THE EDUCATION CHALLENGE

The mobilization of area educational services presented yet another challenge. For TechnaCenter to have durability and long-term value to technology-based industry, a single mechanism was needed for matching educational and research services with the needs of the Air Force and its numerous contractors. Although Auburn University at Montgomery worked with the developer in the origination of TechnaCenter, early planners recognized that a research park should make special efforts to mobilize all institutions of higher education in its area to provide the greatest variety of research and instructional services. To date, the creation of an integrating mechanism for program development has proven illusive. The three degree-granting universities in Montgomery - Alabama State University, Troy State University, and Auburn University at Montgomery - have not worked together historically. However, a proposed strategy for linking the universities is now on the table, i.e., the creation of a Montgomery educational services consortium.

A consortium was first discussed in the wake of a June, 1989 briefing at Standard Systems Center (SSC), Gunter Air Force Base. AUM officials had earlier asked the SSC, since it was in the beginning of its fifteen-year Modernization Plan, to provide a presentation that would better enable higher education representatives to understand the research and training needs of the SSC staff.

In preparation for the work ahead, the Air Force said its immediate concern was upgrading the educational and training competencies of the 1,800 or so civilian and uniformed employees at the SSC. SSC personnel would need to be more effective participants in evaluating and participating in the enormous volume of contract activity related to the software acquisition strategy.

The SSC overview provided an analysis of its manning and educational profiles, long-term educational requirements, current initiatives aimed at upgrading staff competencies - and some recommendations on ways area institutions of higher education could respond to Air Force needs at the undergraduate and graduate levels of instruction. Specifically, the SSC requested educational programs in artificial intelligence/expert systems, relational database management systems, software engineering, information engineering, fourth- and fifth-generation languages, and CASE tools training. In addition, SSC required the delivery of Carnegie-Mellon University course materials from that institution's Software Engineering Institute.

Because of the variety of SSC educational needs, a formal agreement, such as the proposed Montgomery educational services consortium, seemed to offer an effective mechanism to identify responsibilities, establish relationships, outline procedures, and set in place a body of university officials who could work on a regular basis with SSC staff. When that accord is reached, the cooperating institutions should agree to:

1. Assist SSC in further refining its assessment of the educational requirements of its military and civilian work force;
2. Engage in joint planning activities with SSC toward improving educational access for SSC staff;
3. Develop, if indicated, joint and individual educational programs in the fields of computer science, mathematics, information systems, software engineering, and other subject areas to meet identified needs;
4. Explore information systems needs with other segments of the Montgomery community, including business and government, with a view toward the further development and extension of computer-based credit and noncredit courses; and
5. Appoint cognizant representatives from each of the participating campuses to meet regularly with SSC personnel and others toward implementing the agreement and ensuring the coordination, scheduling, and communication of course offerings in the relevant academic disciplines.

Although such an agreement will not outline future research relationships between the Air Force and local institutions of higher education, it could help meet the SSC's most immediate educational goal, that is, the competencies upgrading of its human resource base. In any event, it is the intention of Auburn University at Montgomery to provide research and instructional space at TechnaCenter for Alabama State and Troy State universities. This is pledged even if the formal agreement continues to take more time to secure. However, AUM officials hope the agreement will happen sooner rather than later as a consortium would demonstrate the willingness of area universities to mobilize their resources in support of the SSC mission. A consortium would also show that TechnaCenter could be a primary community resource for the Air Force.

THE TENANT MIX

In addition to the publicly financed building, the TechnaCenter master plan also envisioned, under Phase I, the simultaneous construction of three commercial buildings totaling 90,000 square feet. The latter were planned as speculative facilities, offering flexible lease arrangements to software corporations working for the Air Force and in the private sector. The buildings were also designed to provide low-cost space for university spin-off businesses. The particular attraction of such incubation facilities at TechnaCenter was the likelihood of start-up business locating near larger technology-based industries, university support services, and supercomputer access. Tenancy contracts have been signed for two of the three facilities, and construction will begin shortly. In addition, a major software company has recently called for the creation of a 70,000-square-foot information processing center for federal, state, university, and business use, and a regional power company has indicated some interest in the funding of an additional speculative facility.

This high-occupancy assurance is a distinguishing characteristic of the Montgomery park venture. Visits to numerous research parks and analyses of their management plans led to the observation that the failure of some parks could be traced to their lack of prioritization of tenancy. Early commercialization, vigorous recruitment of tenants, and the provision of low-cost and flexible lease arrangements helped to ensure near-full occupancy of the Phase I buildings at TechnaCenter.

During the planning stages and start-up stage, university officials accompanied developers, Chamber of Commerce officials, and representatives of state development offices on a series of recruitment trips and national presentations. These joint visits emphasized important features of the park: the operational philosophy of TechnaCenter; the research, programs, and resources that the university could provide for tenants; the commitment of the state to the project and its plans for meeting the needs of lessee corporations; the availability of sites for lease and sale; the configuration of lease arrangements to federal contracts and time schedules of individual activities; park amenities; and community and Chamber of Commerce support services.

These visits also enabled officials of AUM's Office of the Vice Chancellor for Research to make an initial assessment of the research and training requirements of prospective tenants and to orient company professionals to campus research units, teaching staff, and support services. These contacts helped in the first-round marketing of park sites and, predictably, had a salutary effect in establishing new sponsored-research agreements between higher education and prospective park tenants. Perhaps surprisingly, not all of these sponsored-research agreements were for technical software services. In fact, the first such agreement involved a nine-state market feasibility study that the AUM Center for Business and Economic Development conducted for a firm considering relocation.

Another advantage to TechnaCenter providing a common ground for high-technology corporations, start-up science-based businesses, and university research is its position to be a stimulant to technology transfer. TechnaCenter planners therefore recommended that Auburn University and other area research institutions see the park as an infrastructural support system for extant efforts in patent disclosure in park-related technology, invention commercialization, and the licensing or capitalizing of university technology.

As part of its commitment to technology transfer, the Montgomery campus of Auburn plans to house its Center for Business and Economic Development at the park. The Center, coordinating the resources of Auburn and other interested institutions of higher education, will assist start-ups and university technology spin-off businesses through low-rental office and work space, clerical support services, business plan development, the initiation of commercialization and marketing strategies, Small Business Innovation Research (SBIR) proposal development, commercial loan procurement, equity financing, and venture capital procurement assistance. An investment banking firm associated with TechnaCenter is currently considering establishing a local seed venture pool.

THE OUTLOOK

The development of Alabama TechnaCenter has opened a rich and exciting chapter in the history of Montgomery. However, much remains to be done to promote cooperation among area institutions of higher education in this important endeavor; securing the basic educational services agreement will continue to be a priority. Attracting additional and diversified federal research activity will also be important, and a new round of planning focuses on this set of concerns.

A sustaining element in the development of the research park has been official response. The level of state and community support expressed in appropriations, legislation, executive order, and city ordinance bespeaks the commitment of Alabama's public servants, its civic leadership, and its people to this endeavor. It seems, too, a strong affirmation of higher education's promising role in the state's economic development.

REFERENCES

1 Kysiak, Ronald, "The Impact of Research Parks on Regional Development," Real *Estate Finance* Journal 5, No. 2 (Fall 1989): 64-69.

[2] Lingle, Dyan, and Duong, Duc, "A High Technology Development Initiative: The Case of Montgomery County, Maryland," *Economic* Development Review 7, No. 2 (Spring 1989): 25-28.

[3] Main, Jeremy, "Business Goes to College for a Brain Gain," Fortune 115, No. 6 (March 1987): 80-89.

4 Hunt, Mary, "Research Parks: Haven or Hype," *Corporate Design and* Reality 4, No. 9 (November 1985): 32-35.

Reports/Observations

Technological Competitiveness: The Role of Research in Universities

William H. Koehler

Editor's Note: This paper was presented by the author at the NCURA Region V spring meeting, 1989, in Tulsa, Oklahoma.

Abstract. The technological competitiveness of America is a much-discussed issue on the public agenda. Economic indicators such as the balance of payments and productivity rankings lend support to claims that America has lost its competitive edge. Indicators such as literacy estimates, patents issued, and market share lend further support to such claims.

To reestablish preeminence in global competitiveness will require a national effort. There is a major role for education in general, and research in universities specifically, in this effort of national renewal. Examples in this paper support the premise that scientific research conducted in universities decades ago has provided the knowledge base for most technological advances we realize today. Only in universities is curiosity-driven research supported, and the results of today are critical to technological developments in the future.

To ensure the future of technological innovation in this country, we must adopt an agenda which includes: increasing support for research conducted in universities, reexamining our national policies concerning the transfer of technology to foreign interests, and reeducating Americans to decrease immediate demands and accept the longer view.

Technological competitiveness has become a topic of much concern in this nation. We hear every day in the news that we have lost our technological edge. We are told that America is falling behind, that

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we better wake up - we are no longer the leader of the free world. Although I do not agree with everything I read, the evidence supporting such conclusions cannot be ignored.

We, as a nation, need to improve our competitiveness, and there is a crucial role for higher education. True, we must do more in science, math, and technology education, but we also must produce a better understanding of and support for research.

The subject of research often causes many to yawn and some to ask, "What does research have to do with the future of this country's economy?" I use the word research to mean investigating, discovering things never before known. We have all heard of students writing "research" papers or an attorney doing legal "research." Although consistent with Webster's definition of research, these activities do not produce new knowledge. Research is the activity which generates knowledge - an activity largely responsible for the clothes we wear, the food we eat, the medication we take, the technology we use; all aspects of our lives are impacted by research.

I shall limit my remarks in this article to scientific research, but not because social research, medical research, educational research, business research, or other types of research are unimportant. Research, in all its forms, is the key to the future of this country. It is the primary means by which we can regain a position of prominence in the world.

That America has lost its competitive edge is no secret. With the national debt so large that we cannot comprehend the numbers, a trade imbalance that is staggering, and foreign ownership that is increasing, we as a nation must face a sobering reality. We have fallen behind, and it will take a national effort to turn the situation around.

The United States is no longer the most productive nation on earth. According to the U.S. Department of Labor, the United States ranks in the bottom quartile of the most productive countries in the free world.

We are no longer the richest nation on earth. Of course there are assets, but the national debt at the end of fiscal 1988 was about $2.6 trillion. The 1990 budget estimate of the *interest* on the national debt is about $170 billion - an expenditure of over $5 thousand per second! As you read this article, the interest accrued on the national debt will be in excess of $0.5 million.

We in America are no longer the best-educated people on earth. The Business Council for Effective Literacy estimates that 15 percent of the U.S. work force is functionally illiterate, meaning that, although there is some capability, the individual worker or citizen cannot function alone in the everyday world. Other estimates of illiteracy run as high as 1 in 5 Americans or 27 million people.

As if these facts were not troubling enough, consider the following, which appeared in the January 9, 1989, issue of the New York *Times.*

> Japan's annual share of U.S. patents has grown from 4 to 19 percent over 15 years, while America's has slid from 73 to 54 percent. The companies with the most U.S. patents in 1987 were (1) Canon, (2) Hitachi, (3) Toshiba, and (4) General Electric.
>
> Furthermore, the U.S. market share of world electronics has dropped from 50 to 40 percent in just the last three years.

We must not only stop the current erosion, we must reclaim lost ground if this nation is to reestablish preeminence as a world leader.

I submit that there is a major role for higher education in this effort of national renewal. Simply put, we must prepare a better educated work force, and we must maintain a research capability second to none.

Most Americans understand and support the need for better education. Most know that our young people are behind their peers in other countries in math, science, and computer technology. Most agree that we must be more effective in educating students from kindergarten through grade 12 so that the labor force is better educated and universities can be more effective.

Do most Americans understand the need to increase the country's research capability? Increasingly, universities are criticized for requiring too much research of their faculties. The claim is that research detracts from teaching. Even some of our congressional leaders ridicule university research as too "basic," too "pure." They contend that it is impractical, irrelevant - that it does little to address our immediate problems.

At times I am concerned because many Americans have come to the point of regarding universities as cloistered communities of overpaid, underworked faculty who are out of touch with reality. I am sometimes frustrated, not so much by these opinions, as by the apparent inability of those of us in higher education to effectively communicate the extraordinary potential universities have for helping this nation solve problems.

Is scientific research conducted in universities too basic, too pure? Is it impractical, irrelevant? Are the results unimportant to American business? Consider the following events, occurring from the late 1890s to just prior to the beginning of World War II, was a period of unparalleled discovery and insight into the structure of the atom, insight into the very nature of matter.

The basic understanding of the atom began to unfold in 1896 when J. J. Thompson, working at Cambridge University, discovered that a negatively charged particle, which we know as the electron, was a fundamental particle in all matter. Approximately a decade later, Ernest Rutherford, also working at Cambridge, provided us with an understanding of the nucleus of an atom. By 1936, with the discovery of the neutron, a fundamental particle in the nucleus, our understanding of the atom had become fairly sophisticated. In only four decades, scientific research in universities had led to an understanding of the basic structure of matter.

During this same time, university mathematicians and physicists were exploring new frontiers, primarily by rejecting Newtonian physics, the laws of physics which govern our macroscopic world. Scientific giants like Bohr, Planck, de Broglie, Heisenberg, Schrodinger, and Einstein were formulating and refining a revolutionary branch of physics called "quantum mechanics," which would lead to future discoveries unimaginable at the time.

A couple of decades later, William Shockley and his coworkers at Bell Laboratories were investigating semiconductors, materials whose preparations were the direct result of research in atomic and quantum theories. During one of the studies an unexpected phenomenon was observed - which led to the development of a device we now know as the transistor. In 1956, Shockley and his coworkers received the Nobel prize in physics for this work.

The basic, seemingly irrelevant, research in quantum theory provided the scientific knowledge - the foundation for the development of semiconductors, transistors, and integrated circuits - for all of today's modern electronics. Research in quantum theory provided the body of knowledge that supported the discovery of superconductivity and the development of the high-speed particle accelerators much in the news today. Our understanding of atomic theory led to the discovery of lasers, which form the basis of the much-discussed strategic defense initiative as well as make possible radically new surgical procedures.

Chips, lasers, superconductors. The important point to remember is that these extraordinary technological achievements had their beginnings as fragmented research projects in university laboratories decades ago. From a seed of basic research, a tree of technology has grown.

Crises seem to make things happen in this country. When there is a national need, the American people have almost blind faith and boundless optimism that we will always be able to find an answer.

For example, thirty years ago, Sputnik stimulated the space race. The Soviet Union surprised us; they were in the lead. Our national pride was wounded. Quickly, this country's technology closed the gap, then moved ahead. America's collective will wanted this to happen. The urgency of the moment demanded progress. But do not forget that those engineering leaps were possible largely because the basic knowledge required was available. Earlier research had laid the foundation.

As we as a nation debate issues on the public agenda - defense requirements, AIDS, the greenhouse effect - let us not forget lessons learned. Future technological triumphs will become realities only through a combination of collective will and available, accessible knowledge. Research being conducted in American universities today is laying the foundation for tomorrow's technological successes.

Almost all the technological research in this country is done by three entities: private industry; state and federal agencies, including government-supported research organizations; and universities. Industrial research is overwhelmingly product-driven, and that is appropriate. Corporate research and development departments are focused to develop new products and services and improve old ones. Unfortunately, Japanese corporations, which conduct two-thirds of that country's research, are presently increasing research spending at three times the rate of U.S. corporations.

The research conducted or sponsored by government agencies is frequently reactive and almost always mission-oriented. As taxpayers, we want our government to be responsive and accountable; **we want to** know our money is being well spent. But, is it not time to ask if there is a coherent strategy governing our government's research and development funding? Is there a long-term plan?

Universities, on the other hand, are the only institutions in which curiosity-driven research is conducted. Universities are places where bright, talented people come together to teach and to follow freely their intellectual impulses and curiosity.

Universities probably have the best environment, maybe the only environment, to support this type of intellectual inquiry. Why? Because sometimes such research is inefficient. Often, it appears unproductive. Occasionally, results forthcoming seem to be less than the resources committed. Universities probably have the only environment that can support an activity in which the outcome may not have applications for decades, if ever. Would you as a stockholder support a management decision to fund such futuristic ventures at the expense of dividends? Would you as a taxpayer reelect a member of Congress who voted to fund such probabilistic activities?

But in what other environment are fundamental questions addressed? How else do we go about developing the body of scientific knowledge on which tomorrow's technology hinges? It's the curiosity-driven research being conducted in our universities today that makes future technological advances possible.

What is the future of technological innovation in America? 1 think the future of technology in this country is very bright. But, there are things we must do if we are to regain our technological competitiveness in the world:

1. We must increase private, corporate, and government support for basic research in American universities. The quality of research in American universities exceeds that in most universities around the world. American universities are the primary source of basic scientific knowledge in this country.
2. We must examine carefully national policies concerning the transfer of technology to foreign interests. Such technology is both expensive and, more importantly, time-consuming to develop. Since 1950, this country has sold the licensing rights to, among other things, DuPont's nylon, Bell Lab's transistor, and RCA's color television. The competition purchased this technology for only $17 billion.

   And this technology transfer continues. As an example, aerospace technology is one of the few areas in which this country enjoys a technological advantage. Yet, one cannot help but wonder how long our aerospace industry will be able to withstand the foreign competition which may emerge as the result of recent technology transfer.
3. Finally, we need to change one aspect of our culture. We as individuals and as a nation must become more patient; we must learn to take the longer view. We want instant success, immediate gratification. Such impulsiveness can lead to demands for immediate profits - at the expense of future production capabilities and inventories - and has prompted some leveraged buyouts, resulting in the dismantling of major industries, unemployment, and bankruptcies.

This country is engaged in a Faustian-like struggle for prosperity, defense, and progress. Technology, ingenuity, and America's collective will are the keys to success. This country currently has the scientific knowledge base and the entrepreneurial genius to be the world leader in technological innovations. But we, as a nation, must commit ourselves to an agenda which will ensure our triumph in this struggle.

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