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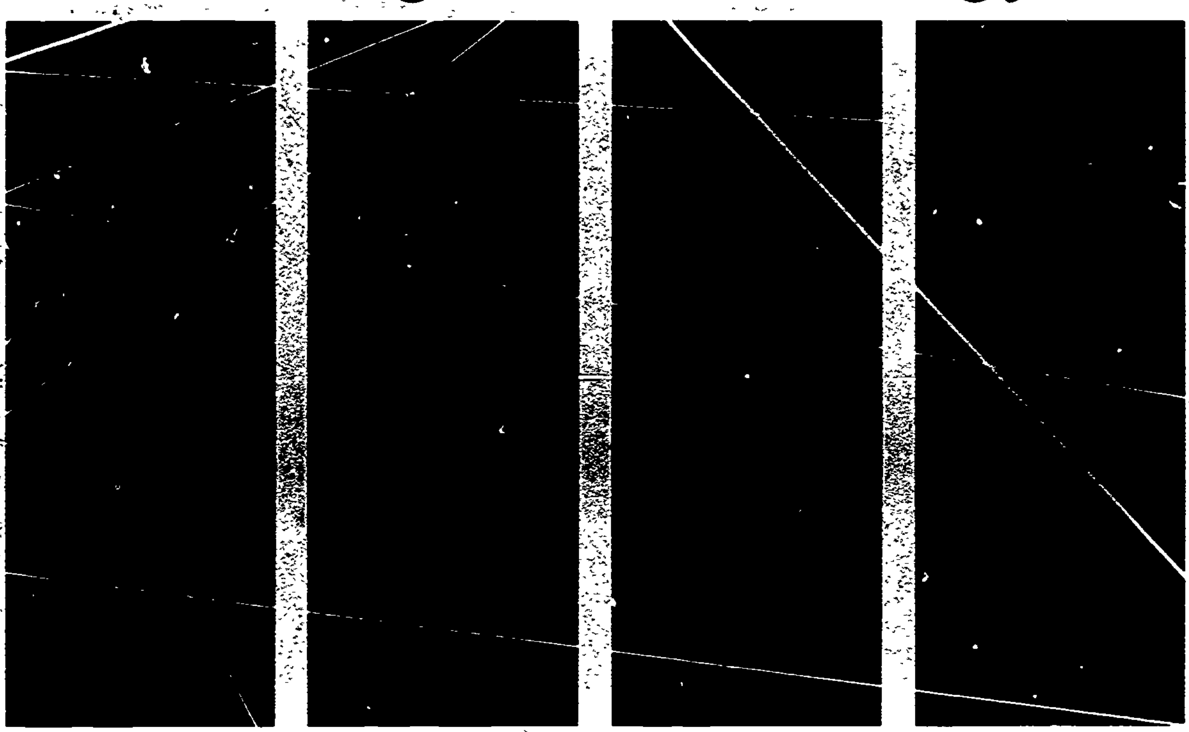
ABSTRACT

This report presents a strategic plan for the South to extend its recent success in economic development to incorporate research, manufacturing technology, and new employment opportunities demanding highly skilled workers. The report first lists a set of goals and related objectives, and these are followed by two sections discussing (1) technology and the state of the world economy in 1989 and (2) the South and the state of technology. A rationale for the strategic plan is then presented that is intended as a framework for action to spur growth by advancing technology. The plan's six broad goals are then described in detail. They are: (1) technically proficient new entrants in the labor market; (2) upgraded skills in the current work force; (3) improvement and expansion of research and development; (4) rapid commercialization of new ideas and new technologies; (5) widespread deployment and effective utilization of technology; and (6) integration of science and technology into state policy. Each goal has objectives essential to attaining that goal, and, under each objective, the plan enumerates specific actions that might be taken and by whom to help attain the objective. A discussion of the roles and responsibilities of various actors in the regional economy in bringing about change is provided next, followed by a chart that indicates lead actors for implementation of the objectives. A list of 34 resources is appended. (YLB)

A REPORT OF THE SOUTHERN TECHNOLOGY COUNCIL

Turning to Technology



A Strategic Plan for the Nineties

Southern Growth

Policies Board

THE SOUTHERN TECHNOLOGY COUNCIL

The Southern Technology Council is a newly formed, public/private advisory body to the Southern Growth Policies Board. The Council is composed of two members selected by the governor of each participating state, two members selected by the Executive Committee of the Southern Legislative Conference, and one member from each participating non-governmental entity. The Chairman-elect of the Southern Growth Policies Board serves as Chairman of the Southern Technology Council.

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Director, Southern Technology Council

Dr. Aqueil Ahmad
Senior Associate

Ms. Marybeth Dugan
Research Associate

A REPORT OF THE SOUTHERN TECHNOLOGY COUNCIL

Turning to Technology

A Strategic Plan for the Nineties

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PREFACE

Just over four years ago the Southern Growth Policies Board began to think about the formation of a group composed of bright, innovative and dedicated individuals to provide policy recommendations on the interrelationship of science and technology and economic development. The creation of this "think tank" was not a trivial concern, for the Board recognized and understood the impending impact that science and technology would have on our region's economic future. The Board also believed that the cooperation and pooling of appropriate resources among the southern states were keys to the development of a knowledge-based, resilient regional economy that could more effectively compete in dynamic world markets.

The vision of the Board materialized in 1986 when the Southern Technology Council held its first meeting.

Now, three years later, the Council has evolved into much more than the policy advisory body initially conceived by the Southern Growth Policies Board. It has expanded its mission by developing and activating innovative, experimental programs in communities throughout the South in furtherance of its adopted policies on the applications of science and technology for economic development purposes.

In recognition of its diligent and progressive efforts, the Council has garnered a well-deserved national and international reputation for its incisive thinking and action orientation.

This document, "Turning to Technology: A Strategic Plan for the Nineties," serves as an excellent example of why it has been my distinct pleasure to serve as chairman of the Southern Technology Council during this decade's final year. This strategic plan provides us with a very specific vision of what we as a region need to accomplish. It is my hope that it will serve as our point of embarkation for the century's final decade.

This plan focuses on the new great economic development triumvirate—education, technological innovation and technological diffusion. To say that education is a necessity is an understatement. Whether it's the factory floor, a government office or the research laboratory, an educated and competent work force is the prerequisite. Technological innovation—the development and commercialization of new technology-intensive products, processes and services—is the key to long-run wealth generation and job creation. And technological diffusion—the use of the most competitive, state-of- the-art manufacturing technology—must become common practice in the southern states. Because we have not modernized quickly and consistently, the South has suffered a loss of competitiveness in its traditional manufacturing base, much of which is located in rural areas. We must do better on all fronts. We must take the best aspects of our southern tradition and use them in non-traditional ways.

In keeping with the orientation of the Southern Technology Council as an activist organization, this plan presents specific action recommendations. However, it is not our intent that this document be accepted as a generic, "by the numbers" handbook for the attainment of economic prosperity. Rather it is our hope that, during the next decade, this plan will serve as a challenging guide—a demanding prototype to be refined, improved and acted upon according to each state's own aspirations and culture.

I would like to extend my thanks and congratulations to the members of the Council, and particularly the staff, for a job well done. Serving as the chairman of the Council has been both an honor and an opportunity for me and Louisiana. It is a pleasure to deliver this report to the Southern Growth Policies Board as my last act as chairman of the Council.

Governor of Louisiana
Chairman
Southern Technology Council
May 1989

ACKNOWLEDGEMENTS

This report is the culmination of two years' effort by the entire Southern Technology Council (STC) to identify the science and technology policies and programs that are most likely to benefit the people of the South. Both current and past members of the Council contributed to this process. In addition to the STC members listed in the front cover of this report, Linda Asay (Tulane University, Louisiana), James Miller (Technology Transfer Center, Mississippi), Ray Iannucci (High Technology Council, Florida), Don Beilman (Microelectronics Center of North Carolina), Ed Davis (Center for Innovative Technology, Virginia), and Mark Sanders (Office of the Governor of Georgia) played major roles in formulating the report. In addition, Gene Calvert (Center for Innovative Technology), Nancy Vasson (BellSouth), Lyle Wilcox (Facet Enterprises, Oklahoma) and William Wallenmeyer (Southeastern Universities Research Association, Washington, DC) participated in the retreat where the plan was developed. Brian Bosworth, then president of the Indiana Economic Development Council, served as a consultant to the group.

Grants from the Carnegie Corporation of New York and the National Science Foundation made possible the process through which the plan was developed. Further, senior level experts from the NSF took part on both the planning meeting and the review process: Carlos Kruytbosch, Richard Schoen, Ken Starr, and Joyce Hamaty, NSF project officer.

The project itself was conceived, designed, and organized by STC director Stuart A. Rosenfeld, who shares authorship with STC staff members Aqueil Ahmad and Marybeth Dugan. Consultants Brian Bosworth and James Harvey contributed to various sections of the plan and helped craft the final draft into a readable document designed to appeal to technical and non-technical audiences alike. Paul Waugaman of Wake Forest University, Dana Hamel of the Virginia Center for Public-Private Initiatives, Jess White, executive director of the SGPB, and SGPB staff also reviewed drafts and offered advice which was incorporated into the final product.

Finally, Robert Donnan contributed a substantial final edit and Marilee Martin designed the final report. Alan Dehmer and others contributed photographs.

J. Trent Williams,
Co-chairman
Southern Technology Council
May 1989

FOREWORD

For the last five years, leaders of the 12 southern states have been wrestling with the policy problems of integrating new scientific discoveries and fresh approaches to technological innovation with traditional thinking about economic development.

In December 1984, the Southern Growth Policies Board (SGPB) brought representatives of the governors of the southern states to Austin, Texas for a discussion of the potential for regional approaches to technology-related development. Most of the new southern public and quasi-public organizations set up to foster technology and technology-based development participated: the Arkansas Science & Technology Authority, the Florida High Tech Council, the South Carolina Research Authority, Virginia's Center for Innovative Technology, and the Oklahoma Science and Technology Council.

A proposal for the formation of a regional science and technology organization emerged from those discussions. Its mission would be to serve as a forum for new ideas, to facilitate cooperation and sharing of information among member states, to represent the region on national technology matters, and to advise southern policymakers concerning the ways that science and technology policy affects economic development. At their 1985 annual meetings, both the Southern Growth Policies Board and the Southern Governors' Association passed resolutions to form such a body on a five-year trial basis. By the spring of 1986, the Southern Technology Council (STC) was formed by 12 governors under the SGPB. The Council originally consisted of two members appointed by the governors and two members appointed at large by the executive committee of the Southern Legislative Conference.

About the same time, the SGPB convened the third Commission on the Future of the South to formulate a set of regional objectives for the South. The Commission's chairman, Arkansas Governor Bill Clinton, instructed the group to produce a short, readable report that governors, legislators, and other leaders could use to mobilize support for a range of public and private initiatives that would increase the per capita income, reduce poverty, and reduce unemployment for Southerners by 1992. Emphasizing the importance of technology issues to these goals, the Commission appointed a Committee on Technology and Innovation. The first meeting of the STC was held in May 1986 in conjunction with a hearing of this committee.

The Council quickly turned to a number of complicated issues important to the future of the region: saving manufacturing jobs by modernizing industry through the use of new technologies, increasing R&D capabilities and resources, and improving communications with federal agencies. Together with the Southeastern Universities Research Association (SURA), it rallied regional support for STC member states' bids for the Superconducting Super Collider. These activities helped the Council evolve into a cohesive regional organization able to work for the common good as well as the benefit of individual states. The Council gradually became accepted nationally as the science and technology "spokesperson" for the region.

By the time the Council entered its third year in 1988, three changes had occurred. First, it became self-supporting. Second, its Articles of Organization were altered to permit corporate membership, with BellSouth, Middle South Utilities, and the Institute for Technology Development in Mississippi joining the states as charter corporate members. Third, the Council decided to develop a clearer plan of action for the future of science and technology policy and programs in the region.

One of the first actions of the expanded Council in 1988 was to schedule a fall retreat to reassess its programs and to generate ideas for a strategic plan for science and technology in the South. The National Science Foundation and the Carnegie Corporation of New York—each increasingly intrigued by states' roles in science and technology—agreed to support the plan's development. In late October, the Council—joined by experts from the National Science Foundation and the president of the Southeastern Universities Research Association—met for two and a half days in Olive Branch, Mississippi to discuss and develop suggested approaches to science and technology for economic development. This document represents the product of those deliberations.

In February 1989, after reviewing a draft report of the suggested approaches, the Council decided on the final set of goals and a plan for implementing them, which is described in this report. The six goals are:

• Technically Proficient New Entrants in the Labor Market

• Upgraded Skills in the Current Work Force

• Improvement and Expansion of Research and Development

• Commercialization of New Ideas and New Technologies

• Widespread Deployment and Effective Utilization of Technology

• Integration of Science and Technology into State and Regional Policy

This report and the plan it incorporates were presented to the Southern Growth Policies Board for approval at its annual meeting in July 1989. It represents our best thinking about how the South can extend its recent success in economic development to incorporate research, manufacturing technology, and new employment opportunities demanding highly skilled workers.

And the report represents something else, as well: a pervasive new trend in the South toward greater collaboration to achieve common goals and objectives. Governments are increasingly willing to work not only with other states but also with business; universities are joining forces and working with industry; buyers are developing new relationships with suppliers; and businesses are working more closely with labor *and* with each other. These consortia and partnerships are growing out of competitive necessity, to achieve greater economies of scale without giving up autonomy and independence. The formation of the Southern Technology Council, a cooperative concept itself, reflects this trend. Collaboration does not eliminate competition; it is aimed at making those who live and work in the South even more competitive as the playing field widens and more contenders enter the game.

The southern states must now review these recommendations in light of their own needs and priorities and decide what actions to take. But as this report makes clear, unless southern states are willing to expand their thinking about economic development to include technology, they will continually play catch-up with the rest of the nation and the world.

SUMMARY OF GOALS AND OBJECTIVES

GOAL 1

Technically Proficient New Entrants in the Labor Market

- To raise levels of math and science competencies by high school graduation.
- To increase the participation of women and minorities in scientific and technical occupations.
- To produce more flexible, adaptable, and innovative technicians.
- To increase the number and quality of scientists, engineers, and technicians.

GOAL 2

Upgraded Skills in the Current Work Force

- To expand and improve continuing education for more technically demanding work.
- To improve the private sector's technical education and training.
- To encourage workers to invest time and resources into upgrading and expanding their skills.

GOAL 3

Improvement and Expansion of Research and Technology Development

- To attract and retain distinguished researchers in the region.
- To target state resources on research and technology development in strategic areas.
- To increase total public and private spending for R&D.
- To enlarge multi-institutional collaboration and international exchange.
- To expand R&D opportunities for small firms.

GOAL 4

Rapid Commercialization of New Ideas and New Technologies

- To encourage more entrepreneurial behavior on the part of universities and their faculties.
- To accelerate the dissemination of research results.
- To increase access to equity capital for early stage financing.
- To expand special support services to new, technology-based businesses.

GOAL 5

Widespread Deployment and Effective Utilization of Technology

- To make the "best" management and production practices as "routine" practices among all manufacturers in the region.
- To increase access to debt financing for modernization and expansion.
- To increase cooperation among firms and industries to achieve economies of scale and scope.

GOAL 6

Integration of Science and Technology into State Policy

- To improve states' science and technology policy and planning
- To change public perception of technology from "threat" to "opportunity."
- To adopt a more responsible management and stewardship of technology.

TECHNOLOGY AND THE STATE OF THE WORLD ECONOMY IN 1989

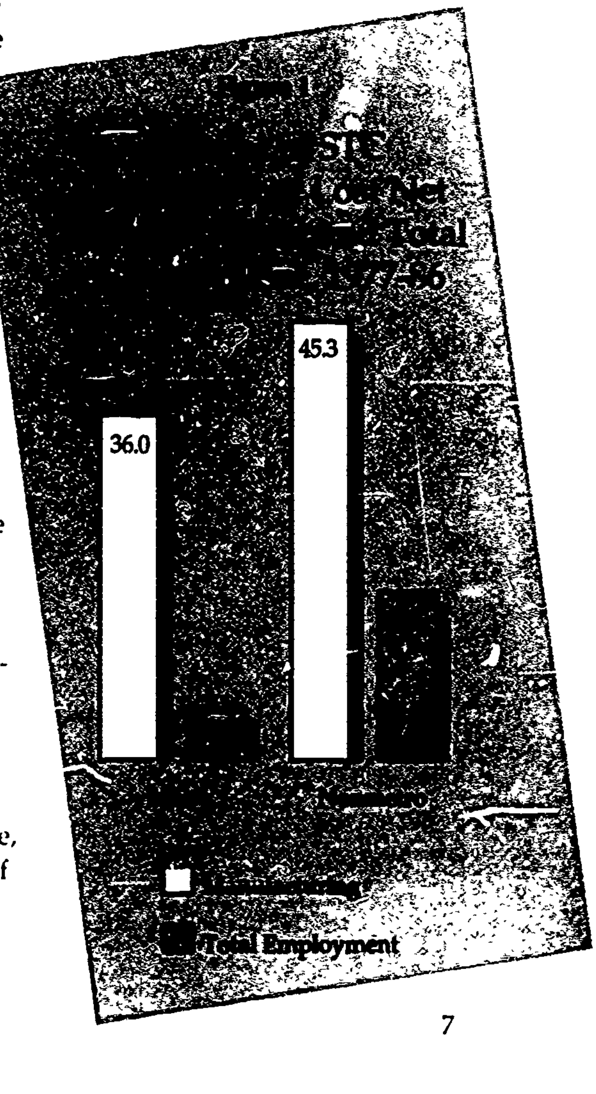
The United States has been caught up in a whirlwind of social, technological, and economic change. This decade has been characterized by massive global shifts in economic fortunes, the rise and fall of international currencies, stock market surges and a hard crash, accelerating mergers and buyouts, double-digit unemployment and labor shortages, dizzying rates of innovation in products and services, and intense competition in an increasingly interdependent global economy.

The so-called "Japanese Miracle" is all too well known. Following the Japanese example in technology acquisition of "borrowing before inventing" and "buying some, making some," other nations on the Pacific Rim—notably South Korea, Taiwan, and Singapore—are seriously challenging both the United States and Japan in world markets. Other relatively poor but technologically advancing nations such as China, Brazil, India, and Mexico are on the verge of becoming industrialized. In 1992, the European Community (EC) plans to band together as a huge common market of more than 300 million consumers, with free trade, technology transfer, and possibly even common money and banking systems.

These global developments have profound implications for both national and regional economies in the United States. The U.S. has accumulated huge trade deficits with almost all its major trading partners, including Canada. In one decade, we have moved from the largest lender nation in the world to the largest debtor. Our steel industry has lost a large share of its market. The textile, garment, tire, and shoe industries are faced with intense competition from producers in other nations. American automobile manufacturers have staged a remarkable comeback in the domestic market, but they do not match up well in international markets. The electronics consumer goods market is dominated by the Pacific Rim nations. The Japanese government has made a long-term commitment to develop an aerospace industry—one of the few remaining bastions of American leadership in manufacturing. Even the American construction industry—previously insulated from foreign competition—is beginning to feel the pinch from abroad. Foreign investment in real estate, the automobile industry, banking, and hotels continues to increase steadily. Foreign students receive the largest share of advanced degrees in science and engineering awarded by American universities.

The domestic effects of these global changes have been wrenching. In 1970, for instance, the U.S. pro-duced 90 percent of the world's phonographs, 90 percent of the color television sets, and all computer-numerically-controlled machines. In 1987, the nation produced one percent, 10 percent, and 35 percent, respectively, of each.

The loss of manufacturing competitiveness has particularly hurt the rural South, where nearly three out of 10 rural southerners were employed in manufacturing in 1980. But between 1977 and 1986, nearly half of the South's non-metro counties lost net employment in manufacturing. Much of that loss can be attributed to the failure of the region's traditional manufacturing sector



to modernize and make effective use of available process technologies. The emergence of higher concentrations of technology-dependent industries signaled major changes in growth patterns everywhere. The region's cities, better positioned to attract and support technology-dependent growth, suddenly blossomed. But rural areas, the major beneficiaries of past successful development policies, became especially vulnerable to competition from newly developed countries with low wages and from cities with new higher-tech business. Many parts of the rural South began to show signs of stagnation and decline.

The Economic Transition

These changes have come with such bewildering speed that we have had great difficulty in understanding their causes and seeing the opportunities they bring. Changes are most commonly perceived as threats from other "competitor" nations. We are called upon to "rise to the challenge" and somehow to reassert our position of leadership in the global economy. But while development policies based solely on chauvinistic appeals may make our citizens feel better, they are no substitute for a sober understanding of the changes and challenges underway in the world. Technology development policy must respond in a more fundamental and rational way.

It is helpful to understand the current economic transition as the convergence of four interrelated trends. They concern markets, products, technological processes, and business structure.

Markets

The dominant changes underway in the marketplace for goods and services are segmentation and internationalization. Markets for both goods and services have become increasingly fragmented. Articulated demand resulting from divergent consumer tastes and rapid changes in communication, transportation, and information processing have produced a niche-oriented market. This segmentation of the marketplace offers an opportunity to those who can differentiate their product to suit the specialized demand.

Accompanying this trend toward market niching has been the globalization of the market. Goods and services produced in the southern states now compete with goods and services from around the world. Businesses in the South can elect not to export their products, but they can't opt out of worldwide market competition. Products from other nations compete right here in our regional markets. Increasingly, those businesses that cannot compete in an international market—whose competitive edge has not been honed by the fine grindstone of foreign competition—may not be able to survive in a domestic regional market.

Products

For several decades, the growth of the southern economy was based largely on our comparative efficiency in the production of standard goods destined for a mass market. Homogenous products for homogenous markets were produced in larger and larger batches through the routinizing of the production process. With the onset of foreign competition, many manufacturing businesses sought further economies of scale. The relative advantage of the South in the cost of production led temporarily to the relocation of facilities from the North to the South.

But manufacturers now have the mobility to seek out still cheaper production costs in other parts of the world, and the South needs to find new solutions to reviving its manufacturing base. Our advantage now has shifted to customized production—toward products that require higher levels of skills, knowledge, and technology to produce. In addition, customized products tend to have short life cycles. They compete on the basis of quality, precision, and reliability. Short life cycles, short production runs, specialized applications, and the need for high quality all combine to discourage economy of scale as the principal factor in cost control. The quality requirements of customized products can be satisfied only by advanced technology, highly skilled workers, and rigorous management of design, production, and marketing.

Processes

Changes in technological processes have been crucial to the emergence of customized products and niche markets. Hard automation techniques of the past emphasized capturing "know-how" and building it into single-purpose machines and production systems. Flexibility was traded off for efficiency. But the new technology aims to produce for segmented markets. It seeks to produce multiple products off the same machine or system of machines and with the same set of workers. Microelectronic, reprogrammable controls put the emphasis on economies of scope, not scale. Variety and flexibility have become the cornerstones of the competitive business; they will become the cornerstones of the competitive regional economy.

Business Structure

These changes in markets, products, and processes, in turn, are driving enormous changes in the structure of business itself. The globalization of the market encourages the movement of production and support systems across national borders. Component goods can be designed, engineered, assembled, and marketed in a number of countries. Businesses will continue to try to move closer to their market however they can. As a result of this trend, manufacturing technologies are not limited to a few traditionally industrialized countries. They have taken root all over the world. Early signals also suggest an increasing willingness of small enterprises to cooperate and network among each other to attain the economies of scale of large firms while still retaining the economies of scope of small firms.

Businesses, moreover, are slimming down, slashing management layers, and trimming overhead. They are decentralizing to smaller units of production and moving to far greater autonomy in the management of various facilities. The number of smaller businesses should continue to increase rapidly as a result of these trends. Smaller firms may have advantages over big ones in the speed with which they can respond to shifts in the volatile, segmented marketplace and to improvements in technology.

Implications for the South

These worldwide economic trends toward market niching and internationalization; toward customized, quality-based products; toward flexible processes and advanced skill requirements; toward decentralized, nimble business structures; and toward smaller business establishments must redirect technology policy in the southern region. They require a development strategy that promotes growth from within—growth built upon new investment by indigenous firms and entrepreneurs, and upon value added by highly skilled workers and technological innovation and adaptation.

In today's technology-dependent business environment, small improvements in quality and performance of engineering products can make huge differences in market share and profits. The market has become the real motivator of technological change. The market is the true gauge of technological success. And since the stakes are so high, governments and business organizations have no option but to jump in, set priorities, take calculated risks, and mobilize resources to accomplish goals. In this environment, management of technological change is synonymous with management of the economy and economic development.

The context against which we develop technology policy should not be seen solely as "the U.S. against the world" or "South against North." Certainly, the competition among nations and regions for economic growth has consequences for our relative share of wealth and power. However, as a result of worldwide economic change, the future of the South is tied more closely to the future of other economic regions in the United States and elsewhere. Our policies and our plans must be rooted in that understanding.

Understanding the New Debate

Finally, policy development must respect the subtle and intricate relationship between science and technology. The two are not the same and it is often unclear which drives the other.

Science and technology are often used to cover the spectrum of innovation and change, from knowledge and ideas to products and processes. The two terms are related but have different meanings. Science, for example, is knowledge and technology is know-how; science is discovery, technology is application; science is explanations and predictions, technology is design and demonstration; science is intended to better understand the world, technology is intended to change the world—presumably for the better. Despite these differences, the two are truly interdependent.

"Technology," as stated so well in the *Project 2061* report, "provides the eyes and ears of science—and some of the muscle too." For example, it provides the instrumentation, data processing equipment, and communications. Science is not necessarily a linear route to technology. It *may* lead to technological applications and eventually to commercial outcomes. But the process can go in the other direction, and the independent development of a new technology is just as apt to lead to the search for new scientific knowledge and theories to explain the technological advance.

The differences between science and technology help explain the distinctions between research and development. The former is associated with science and the latter with technology. In fact, many European countries have begun using the phrase "research and technology development" (R&TD) to emphasize the utilitarian nature of development. In the U.S., however, the term "research" includes not only basic research, but also applied research.

The economic value of basic research is often more difficult to sell. By definition, basic research is undertaken without concern for utilitarian value. Hence, debates ensue over quality versus utility, and tradeoffs must be made to secure support. Basic research is more likely to yield a public good than a private good, and thus most support comes from the public sector. But since results are less likely to benefit a specific region, states are also reluctant to provide support. Both states and corporations are much more likely to invest in applied research or technology development in hopes of producing a product or process with local commercial value. The private sector, in fact, spends more than federal and state governments combined, seeking commercial innovations before competitors find them. Most commercial R&D, however, is concentrated in a relatively small number of goods-producing industrial sectors.

Although the terms "science and technology" and "research and development" often appear together, for policy purposes they are different. It is hard to imagine one without the other, however. Each is a necessary ingredient in economic development and growth. Competently developed, the two together offer new knowledge, new products, new skills and employment, and a better quality of life for all our people.

THE SOUTH AND THE STATE OF TECHNOLOGY

The idea of technology as an instrument of economic development in the South is still in its infancy. Even as science and technology crept into the economic development vocabulary, they were still considered distant cousins of conventional economic development policy, not immediate family.

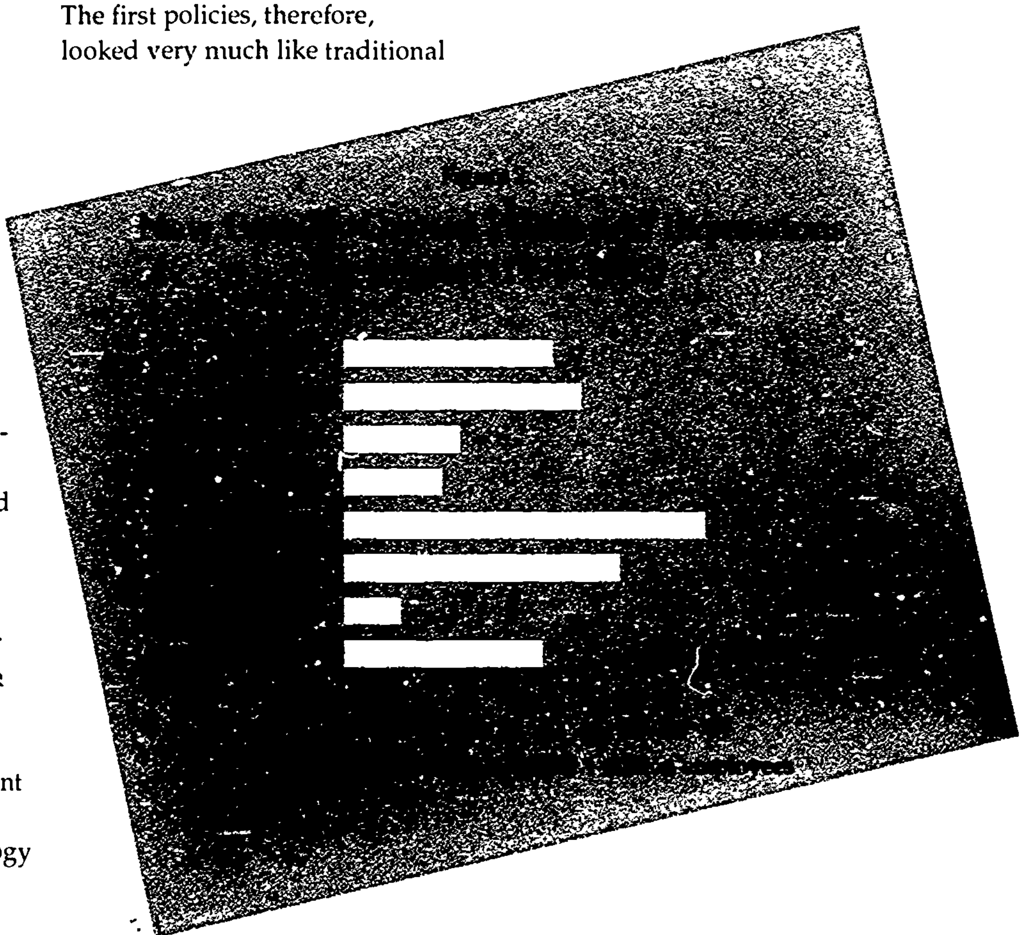
In the early 1970s, economic development in the South revolved around the three traditional factors of production: labor, capital, and land. Science and technology were acknowledged as important elements of economic growth. But for the most part they were subjects of university programs or federal policy, not state development strategies. The first two SGPB Commissions on the Future of the South barely noted technology, except as it related to energy needs.

The South in Transition

By the early 1980s, the South's economy had changed. Technological advances of the region's competitors at home and abroad were cutting into its share of growth. A number of southern governors realized that science and technology could no longer be ignored. States began to arm themselves with new policies designed to attract the growing number of technology-dependent firms searching for places to do business. Advances in technology remained market-driven, but states discovered that carefully structured policies can nudge the process along. Yet these first programs and the organizations created to carry them out were frequently too small, too short of resources, and too low in the organizational hierarchy to achieve the results that legislatures wanted. There were few comprehensive plans for integrating science and technology into economic development policy and little communication among those trying to bring about change. Further, there was a sense that the South lacked much of the infrastructure necessary for technology development.

The first policies, therefore, looked very much like traditional recruitment, except that they were seeking high-tech rather than traditional industries. Still, the region was relatively successful in attracting a large share of new high-tech businesses, even in the rural South. In 1972, the rural South had 37 percent of all high-tech businesses; by 1982 the proportion had risen to 43 percent.

Despite these successes, by the early 1980s the total number of high-tech branch plants in the U.S. was shrinking. Therefore, southern states began looking *within*, as well as *without*, for new jobs. Programs were aimed at new business formation or



business expansion: targeted research and development, technology-based business incubators, telecommunications, science parks, technology transfer, and seed capital funds. Every state addressed science and technology through new legislation or executive orders. At the same time, the South began looking beyond national borders to Europe and Asia, both to recruit technology-based businesses in the traditional economic development sense and to expand markets for southern businesses and find new technologies that could be used or produced in the region.

The South's Capacity for Technology-Based Development

The latest measures of economic capacity and progress show the South in a somewhat precarious position. Our work force does not compare favorably with those of the North or other industrialized nations in levels of education, math and science achievement, concentration of engineers, scientists, R&D expenditures, number of patents, or concentration of high-tech jobs. In the *1989 Development Report Card of the States*, published by the Corporation for Enterprise Development, our member states ranked on average 39th among the 50 states in technological resources. None received higher than a "C" on the composite measure.

These low grades are the repercussion of years of industrial development that paid scant attention to science and technology. Industry had been willing to operate with the "brawn" of its workers in the South, and the "brains" of its corporate headquarters located elsewhere. Consequently, the region did not develop a solid scientific foundation and did not win the recognition others received for scientific accomplishment. There were exceptions. Georgia Tech, Duke, and Vanderbilt Universities continued to excel in selected scientific disciplines, a few new technology-based development plans (such as the Research Triangle Park in North Carolina) emerged, and some research enclaves developed around federal space centers. But overall the South lagged behind other regions in research expenditures, scientific graduate programs, and scientists.

Science has become a team effort. Noted scientists tend to attract other noted scientists. As a region the South has not reached the critical mass of scientific expertise necessary to attract new scientists and engineers.

The economic recession of the late seventies sparked the first major changes in attitudes toward economic development. New political leadership looked long and hard at where the South's development policies had taken it, and concluded that the South had to pick up the pace.

Two deficiencies, in particular, stood out: the quality of the work force's skills and knowledge, and the slow rate of technological innovation—from the creation of new ideas to the deployment of technologies on the shop floor. The strategy of business recruitment and reliance on existing surplus labor had brought many new jobs to the South. But underinvestment in human resources and new technology had left the region in an untenable position as the face of global production and distribution changed.

Quality of the Work Force

Of all the conditions for technology-based development, the skills and knowledge base of the work force is widely considered the most important—and the most problematic. As such, it has posed a major barrier to technological progress in our region. Whereas a decade ago relatively poor academic performance scores and low levels of educational attainment were viewed as social concerns that prevented individuals from moving into the middle class, they now have also become economic concerns seen as holding states back from more rapid economic growth. The South's educational shortcomings have been taken to heart, and southern states today are doing more than any other region to redress these problems.

But parity in education is a long-term goal, and despite infusion of new funds and the introduction of new and innovative initiatives, state rankings of many educational indicators still remain low. In math and science education, for example, both southern and western states rank well below the northeastern and midwestern states on average number of courses taken and proficiencies attained.

Technological Innovation

Technological innovation is a process that requires inputs from a variety of actors—universities and research labs, two-year colleges, the private sector, and government—in addition to a quality work force. This plan builds upon and expands the strengths of these institutions, already in place in the South, in a way that will build the region's capacity for and develop the states' ability to plan for technology-based development.

Universities

While basic education is the fuel that advances technology, the engine of a state's science and technology policy is its university system, where most of the state's research is conducted. This is where scientific skills and knowledge are honed and new ideas can be pursued. Further, the universities employ and turn out scientific talent, impart skills and knowledge, generate new knowledge, and provide technical assistance. It is virtually impossible for a state to build and support a technology-based economy without a strong university system.

Academic effectiveness in supporting technology development is conventionally measured in terms of quantity, not quality—how many federal R&D dollars are received and how many graduate students in science and engineering are enrolled. On this basis, our member states do not fare well. None is among the top 25 in terms of R&D expenditures and most rank well below national averages on headcounts of graduate students. Obviously, we want to improve on both measures. One path is to concentrate resources on a technology or industry vital to the state's economy and build R&D centers that will draw resources and talent. Centers of Excellence have become one of the region's major technology development policies. It is safe to say, however, that most are still budding centers and have not yet reached the critical mass of scientists and equipment needed to achieve world-class status.

Two-year Colleges

The community and technical colleges are perhaps the South's premier strength. The region has a number of excellent two-year colleges that train for and support technology-based enterprises. These colleges offer a variety of associate degree programs for technicians, continuing education programs for managers and professionals, retraining for specific skills, and technical assistance with technology transfer. The goal for the region is to make the *best* of these colleges the *norm*. The STC's Consortium for Manufacturing Competitiveness was created to demonstrate the extent to which the best of these schools *can* support technology-based development, and to extend their innovative programs to other schools.

Private Sector

Corporate R&D is also an important part of the southern states' technology base. There are fewer corporate research centers located in the South than in other regions, which accounts for the lower concentration of technically trained people in industry. The most important factors in selecting a site for R&D, according to the Conference Board, are 1) to be near corporate headquarters, 2) to have a steady supply of scientific personnel, and 3) to have a good quality of life, which is largely characterized by good schools.

Research and development, while vitally important, describe only the early stages of the process of technology transfer. The ideas have to make their way out of our labs and into the factories and offices as quickly as possible. Our businesses must be able to make use of the new knowledge and developments.

One way governments can accelerate this process is by making information more easily available and encouraging greater collaboration between researchers and the private sector. All southern states have adopted this strategy in the last five years by aggressively forging new partnerships between universities and businesses, and by providing incubator facilities, seed capital, technical assistance, or information dissemination systems. Various states have also pinpointed specific technologies on which to build their high-tech economies and have begun to work toward —and in some instances achieve —centers of excellence. The Microelectronics Center of North Carolina, in Research Triangle Park, and the Center for Advanced Space Propulsion in Tullahoma, Tennessee are but two examples.

Breakthrough vs. Diffusion

If there is a weakness in the region's programs, it is an overemphasis on new breakthroughs and commercialization of new ideas into new products and enterprises, with scant attention to the widespread diffusion of technology and innovations to the existing businesses that comprise the foundation of the South's economy. The glamor of high-tech products attracts more public and private money and attention than the needs of traditional production, and as a result the South's manufacturing sector has been gradually eroding.

A STRATEGIC PLAN FOR THE NINETIES

Today there are programs in nearly every southern state that fall under the rubric of technology policy. Many are quite effective, others show great potential, and still others are falling short of expectations. The biggest flaws in the design and assessment of economic development programs around science and technology are time horizons that are too short; too much emphasis on high-tech industrial recruitment; and too few resources to accomplish their intended goals. Further, there is too little coordination. The most effective and productive economic development based on science and technology requires collaborative, concentrated effort. It depends on the cooperation of government, educators, business, and labor throughout the region. It requires, in short, a plan.

The process of developing a strategic plan should take into account all of the factors that affect the flow of ideas and innovations. The plan should allow enough time for ideas to percolate and develop while still keeping an eye on the competition. But it must also be somewhat selective. It cannot cover all of the things that technology might achieve nor can it suggest all of the activities that states can undertake. Further, there are many ways one might organize the available information and ideas into a regional plan for science and technology.

Economic development policy based on technology and innovation requires more than an adjustment of existing programs. States must redefine infrastructure needs and reorder priorities. For instance, an economy built on technology requires higher rates of literacy, greater worker flexibility and adaptability, technical expertise, research facilities, venture capital, and telecommunications networks.

It is with these factors in mind—the external forces and the internal conditions with which the region must contend—that the Southern Technology Council set out a plan to spur growth by advancing technology.

The framework presented on the following pages is only one approach, but one that we believe makes sense for the South under current conditions and needs. It includes six broad goals: 1) educating technically competent new entrants into the labor force; 2) re-training of the existing work force to adapt to technological change; 3) strengthening the research and development base; 4) widespread diffusion of existing technologies; 5) successful commercialization of new ideas and new technologies; and 6) planning for governance of science and technology at the state level. Each goal has objectives essential to attaining that goal, and under each objective, the plan enumerates specific actions that might be taken and by whom to help attain the objective.

Many of the goals, objectives, and actions are not particularly startling or even new. But most state development programs were set in place before technology was recognized as a policy instrument, and the plan may stimulate new thinking to help make existing programs more effective in developing technological innovation. Further, if this message is compelling and fortified with data, it will set in motion plans to integrate science and technology more closely into state economic plans. Should that happen, we are confident that this Strategic Plan for the Nineties will help position the South securely in a new technological age and a different economic world.

A PLAN FOR SCIENCE & TECHNOLOGY

Technically Proficient New Entrants in the Labor Market

Alan Dehmer

Magnet schools for math and science, such as those in North Carolina, Louisiana, and Virginia can be used as teaching laboratories for teachers from other schools across the region. Here, students at the North Carolina School of Science and Mathematics work in their biology lab.

Technology is created and capitalized, diffused and used by people throughout the work force—from machine operators and clerks to researchers and managers. Their combined skills, knowledge, and attitudes determine when, where, and how technology is introduced and utilized. Therefore, the acquisition of skills and knowledge by *new* entrants into the work force must undoubtedly be a vital part of any plan to produce and effectively use technology.

In this regard, the United States faces a tremendous challenge. Despite a great number of new programs and policies, too many teenagers still leave school *without* the basic skills to enter a technologically sophisticated workplace, let alone to become the future designers, developers, and managers of technology. Math and science illiteracy are rampant, far more prevalent, for example, than the inability to comprehend the written word. Fully half of our 17-year-olds do not possess the basic math skills needed to manipulate whole numbers in everyday tasks.

Substandard performances by our young people in math and science led the National Assessment of Educational Progress for 1986 to conclude that "school science is not helping them learn to use what they are being taught, to evaluate the appropriateness of procedures, or to interpret results." And in its recent report, *Project 2061*, the American Association for the Advancement of Science declared: "General science (math, science and technology) literacy eludes us in the United States...By all accounts, America has no more urgent priority than the reform of education in science, mathematics, and technology."

The problem is *so* urgent—especially when one considers international comparisons of performance in math and science—that the prestigious board of the National Center on Education and the Economy (writing in *To Secure Our Future*, one of the latest national educational reports) has advised the President to "declare a goal of matching the mathematics and science performance of students in all other countries by a certain date and create a cabinet council to devise a national strategy for doing that, in concert with the science community." We, the members of the Southern Technology Council, wholeheartedly concur.

Although math and science illiteracy are widespread throughout the U.S., these problems are more acute in the South. Even as national measures of academic achievement are rising, most southern states still rank low on such indices—particularly with respect to math and science. Shortages of scientific knowledge and technical know-how in the South are often cited as a barrier to the introduction of new technologies into the southern workplace and even as a primary reason for the declining fortunes of the rural South.

The entire region bears the burden of decades of insufficient attention to basic education by state and local governments and insufficient demand for high levels of literacy from our businesses. These attitudes have resulted in too many workers with inadequate reading and math skills. Southern states are determined not to let this happen again. They are enacting new policies and investing more money to improve basic education, to ensure that the next generation of new workers and managers—our future work force—will be better prepared.

The challenge of preparing the new work force must begin with—yet go well beyond—elementary and secondary education. Over the next two decades, the proportion of jobs requiring post-secondary technical education will rise substantially. In fact, most economic projections forecast that growth rates for scientists, engineers, and technicians will increase much more rapidly than for the work force as a whole. Thus, the region needs to expand and improve its professional-level science, engineering, and technical education.

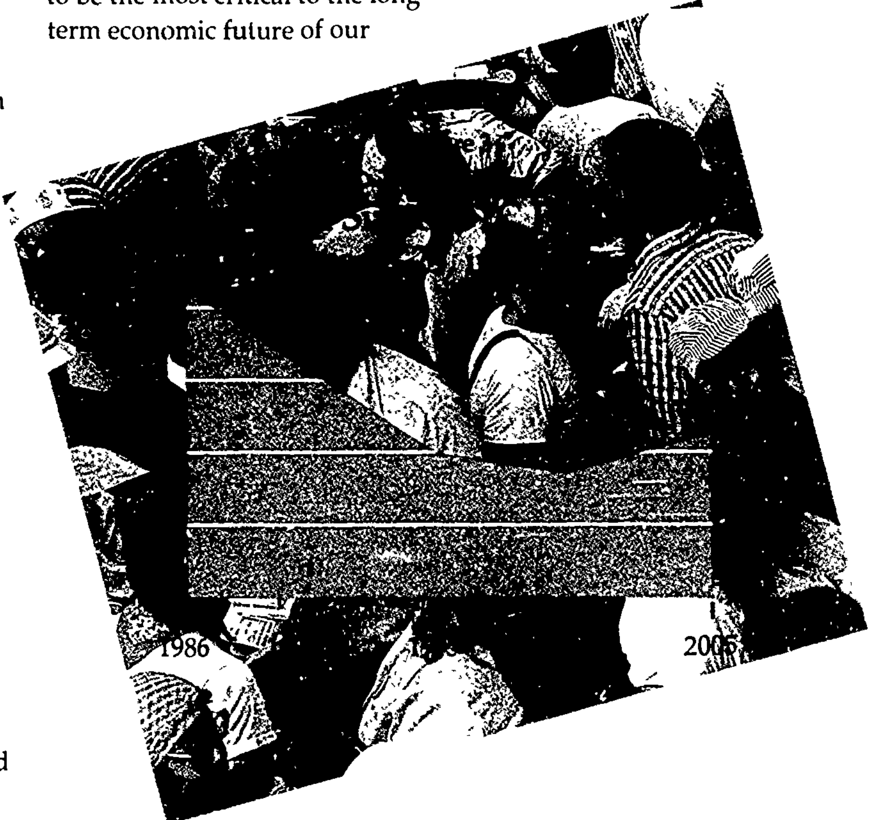
Changing demographics, however, are going to put added pressures upon the South's efforts to produce a large, technically educated work force. First, the total number of new entrants into the labor force will shrink over the next decade, and second, this new work force will be composed of larger proportions of minorities and women. Since the number of women and minorities who currently choose scientific and technical career paths is quite small, more effective efforts to increase their numbers in these fields will be needed to ease any shortfalls.

The Southern Technology Council considers the following objectives to be the most critical to the long-term economic future of our region: raising the basic abilities of new workers to work in more technically demanding workplaces; improving paraprofessional technical skills so that the technical work force can make greater contributions to innovation; attracting more women and minorities into technical fields, both to meet the projected demand and to expand their employment opportunities; and increasing the numbers and quality of scientists and engineers.

Objective 1

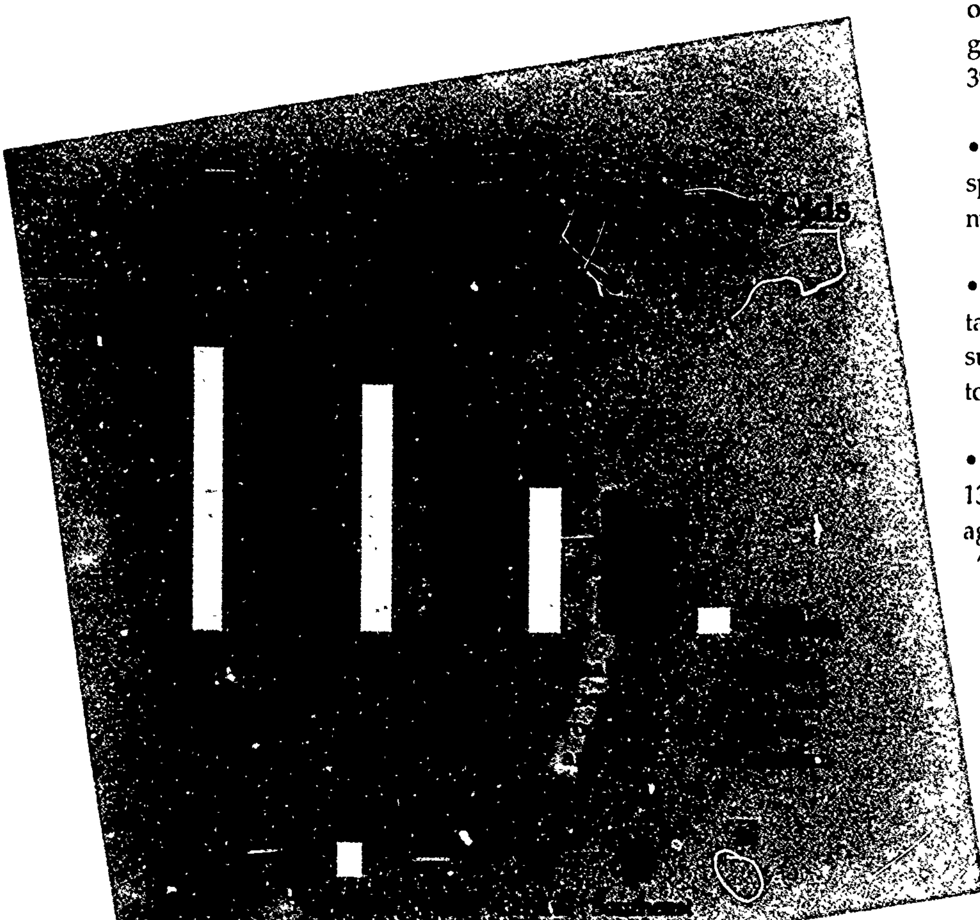
To Raise Levels of Math and Science Competencies by High School Graduation

It often takes an external threat to raise awareness of societal problems and spark educational



change. In the 1950s, the launching of the Soviet Sputnik brought new life to science education. Today, the low rankings of U.S. youth in international comparisons of math and science skills worry corporate leaders whose companies are plunging into high-tech fields. Even those young people who *can* meet minimal standards for reading and writing often lack the mathematical and problem-solving skills to work productively in a technologically advanced workplace. And without skilled new workers, American businesses are in danger of losing their competitiveness in world markets.

Internationally, U.S. students rank far behind students of the same age from other industrialized countries in both math and science—12th among 16 countries, for example, in geometry and 15th in measurements. These low rankings cannot be blamed upon a disproportionately large, low-achieving population in American public schools. In a 17-nation study of science achievement among *advanced* science students, high school seniors in the U.S. ranked *last* in biology, physics, and chemistry. Southern students rank particularly low on science and math examinations, but there is some cause for optimism. Although math and science proficiencies have not increased nationally over the past 20 years, the South has gained relative to the U.S. average.



There are many reasons for these low international and inter-regional rankings. Many math and science teachers are forced to teach outside their fields of expertise; many textbooks and teaching methods are outdated and of poor quality; too little time is devoted to math and science in the schools; and too little homework is expected of students. For example:

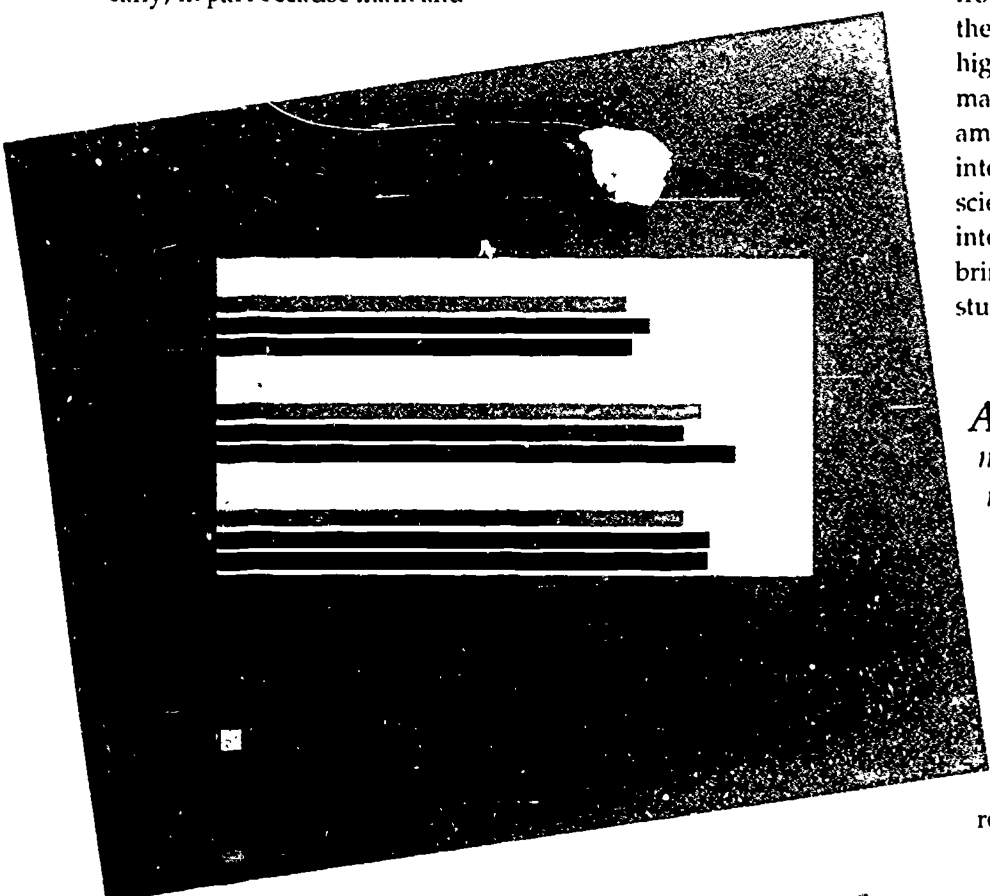
- In the South, only 20 percent of physics teachers have degrees in physics, compared to 39 percent outside of the South;
- U.S. students in grades 4-6 spend on average only 29 minutes per day on science;
- Only 15 percent of elementary school teachers in the U.S. surveyed last year felt qualified to teach natural science; and
- Only 50 percent of American 13-year-olds in a recent survey agreed with the statement, "Much of what you learn in science classes is useful in everyday life." This percentage was the second lowest among 12 nations.

The situation is likely to get worse before it gets significantly better. By 1983, the number of science education degrees awarded in the member states of the Southern Regional Education Board had dropped to two-thirds of the number in 1978.

The number of math education degrees for the same period dropped 40 percent. So, it's not surprising that math and science teacher shortages are growing larger. A 1988 survey of school officials concerning the supply and demand for teachers in 1989 reveals that the imbalances are worse in math and the sciences than in any other field except special education.

The quality of math and science education in the South's elementary and secondary schools affects not only the abilities of entry-level workers but also the supply of technical professionals. Attitudes toward math and science are formed in the first years of school; thus, many of the strategies aimed at increasing interest and proficiency in these subjects must begin there. The pipeline to technical careers empties out very early, in part because math and science are not made understandable and relevant in elementary school. For every 100 youths who entered high school in 1977, only 15 were interested in pursuing careers in science or engineering upon graduation; only 1.5 received a bachelor's degree in a science or engineering; and only one went on to graduate school in those fields.

In the South, students are slightly less likely to take higher level science courses. Less than eight percent of southern high school graduates in 1982 took physics, compared to more than 18 percent in the Northeast and more than 10 percent in the Midwest. Less than four percent took calculus in the South, compared to about 13 percent in the Northeast. According to many experts, the problem—simply stated—is that general math and science courses tend to depend too much on books at the expense of application, while applied and vocational courses depend too little on books at the expense of basic skills.



Fortunately, these problems are not going unnoticed. Not since the 1950s have math and science education received so much attention. Reports from the National Academy of Sciences, the National Science Foundation, the American Association for the Advancement of Science, and the National Assessment of Educational Progress have all made headlines in recent months. In addition, the Triangle Coalition for Science and Technology Education serves as the central clearinghouse and national catalyst for improvements. The Southern Technology Council has drawn on these various national efforts and other information from the region in order to select the following strategies as its highest priorities for improving math and science competencies among southern youth. They are intended to enrich math and science education, make it more interesting and relevant, and bring enriched programs to more students.

A. Use magnet schools and master teachers to enrich math and science education throughout the state and region.

Special magnet schools for math and science, such as those in North Carolina, Louisiana, and Virginia, have successfuly attracted some of the regions' best talent in math and

science. However, without special efforts, these "lighthouse" schools will reach only a few of the most talented youth. That is a valuable accomplishment—but an insufficient reason for disproportionately high expenditures at a single school.

Special schools ought to be used as teaching laboratories in which teachers are given the leeway and resources to develop, demonstrate, and disseminate improved math and science teaching methods throughout the state and region. For example, the staff could offer seminars and workshops for teachers from other schools, invite students from other schools for weekend or summer enrichment programs, and provide instruction over telecommunications or interactive video systems to teachers or classes. We recommend that **state legislatures** in southern states without magnet schools study the history and accomplishments of existing models and consider establishing statewide—or possibly regionwide—magnet schools that can enrich the curricula across the state and region.

B. *Make math and science education less abstract and more concrete.*

Interest and proficiency in science are increased more by doing than by reading about it. Yet, although experiential education has been supported by educators since the turn of the century, it still remains more theory than practice. John Dewey understood the importance of experiential science perhaps better than anyone. In 1916 he warned the nation's educators that science education does not mean memorizing laws and facts but should comprise "knowledge which is the outcome of methods of observation, reflection, and testing...Those who do become successful men of science are those who by their own power manage to avoid the pitfalls of a traditional scholastic introduction to it." We recommend that **university research** funds be made available to develop and test more experiential teaching methods and materials and that **state education agencies** approve and implement such science curricula.

A Science Teacher Corps for Appalachia

The Kentucky Council on Science and Technology has identified 31 science teachers across the state from among dozens of applicants to participate in an eight-month leadership development program to improve science education. These teachers will form a core of outstanding science teachers who will return to their home areas and pursue science education projects according to their own interests and experience in the program.

C. Integrate applied math and science into vocational-technical and other applied programs.

Vocational education provides an excellent opportunity to teach math and science in applied settings, but it is too rarely exploited. The Southern Regional Education Board includes among its recommendations for vocational education requiring students to demonstrate proficiency in math and science Successfully integrating basic math and science with vocational skills will require special pedagogical expertise that many vocational teachers currently lack Teachers will need additional in-service training, curricula for teaching programs will have to be redesigned, and students will have to complete more homework.

Agricultural education has provided the nation's premier examples of applied science in action in the schools. Good vocational agricultural programs have taught scientific methods, experimentation, and technology transfer to youth in ways that have been relevant to rural life, and that have led to America's global predominance in agricultural productivity. We recommend that **state vocational education departments** establish standards for integrating math and science competencies in their programs, monitoring outcomes, and reporting progress

D. Expand the use of computer-assisted and distance learning techniques, particularly in small, poor, and isolated school districts.

Videodiscs, computer-assisted instruction, and interactive video are all means to bring education to isolated and small communities. In addition, long-distance learning methods such as satellite teleconferencing can bring expertise to isolated high schools, particularly in the more sparsely populated parts of the South. Oklahoma State University's Learning by Satellite Project, for example, has been identified as a model program by the national Triangle Coalition for Science and Technology Education. We encourage the **southern states** to establish a regional center devoted to the development of distance learning methods for math and science and to the dissemination of information about such methods to all small and rural schools.

"Stand and Deliver" in the South

Under a grant from the federal Star Schools program, the South Carolina Educational Television Network and the State Department of Education will pilot test expanded curriculum in four rural schools. One of their first efforts will be to produce "The Teaching of Advanced Placement Calculus" for teachers in the four schools as well as other sites within an 18-state consortium.

E. Establish mentorships and practical experiences for math and science teachers.

The poor performance of American students in math and science is attributable at least in part to poor teaching. Teacher shortages—particularly in physics, math, and chemistry—have drawn some teachers into fields for which they are not qualified. But even some teachers who meet certification standards actually know too little math and science to understand and stay abreast of new developments. Some analysts argue that scientists ought to become teachers rather than trying to turn teachers into scientists. This would require undergraduates to specialize in a field of math or science *before* taking education courses. We realize this is a long-term goal. Thus, in the meantime, we recommend that **state education departments** and **business organizations** provide teachers with more experience in the fields of math and science by arranging exchange programs with industries either over summer breaks or for the duration of a semester. Such exchanges would give teachers a taste of "real world" applications of math and science and bring into the classroom career scientists who might like a chance to impart their interests and knowledge to youth.

Learning with Experts:

The Houston Mathematics and Science Improvement Consortium, sponsored by the National Science Foundation, pairs 120 high school teachers with mathematicians and scientists at five research institutions in order to improve their skills and increase their self-respect. Supported by stipends, the teachers spend six weeks during the summer in the research lab developing ideas that can be taken back into the classroom. Their new knowledge and materials are shared with other teachers in the program at Saturday seminars. Contacts between researchers and teachers often extend beyond the formal program, and have resulted in on-going relationships that keep teachers in touch with advances in their fields.

F. *Promote informal science education.*

Activities outside the school can be as effective as classroom teaching in science education. A century ago, the forerunners of 4-H and Future Farmers of America—boys' and girls' clubs sponsored by businesses—successfully promoted agricultural science. Youth conducted experiments, displayed the results, and shared technical knowledge. Today, science museums, science-technology centers, botanical gardens, science contests such as the worldwide Physics Olympiad, and scout organizations can effectively transmit science education and generate greater interest in school-based science. Less conventional means, such as placing simple science experiments as prizes in cereal boxes, may also be effective.

Television, though an intrinsically passive medium, can also enhance learning. Years ago, Mr. Wizard brought science into our homes; today, programs such as *Nova*, *Cosmos*, and *Newton's Apple* transmit popular science across the airwaves. But much more and innovative informal science education is needed. The National Science Foundation recognizes the possibilities of and provides support for informal science education. Still, because most of the potential informal sources lie outside the government, aggressive support from **community organizations** and the **private sector** is needed to further expand community and media-based science education. The **public schools**, however, ought to promote, encourage, and even reward participation in such programs.

Common Sense

A chemistry professor at Ouachita Baptist University in Arkadelphia, Arkansas writes a newspaper column to explain science in terms of real world experiences with the aid of a grant from the National Science Foundation's Informal Science Education Program. The column—which is aimed at middle school students, their parents, and teachers—is carried by more than 4,000 small town newspapers across the nation.

G. *Create Centers of Excellence for research and development of math and science educational materials and instructional methods.*

Surprisingly little is known about how students best learn math and science, and thus equally little is known about how to design instructional materials. There are still vigorous debates among science educators, for instance, over the proper balance between teaching the scientific process and imparting factual knowledge—as well as over the value of "new math," which actually is no longer so new. Finding better ways to integrate math and science into applied and vocational courses is another area that deserves additional research. We recommend that **universities** in the South identify and establish regional centers with specific expertise in various areas of math, science, and technical education. As *Project 2061* states, collaboration is essential to the improvement of science education. States that are willing to pool their resources and share information freely will achieve quicker results. Such a strategy would also highlight the top priority that the region assigns to science education. Moreover, since this research is of national importance, the **U.S. Department of Education** ought to share the research costs.

A Southern Center of Excellence

The National Science Center for Communications and Electronics in Augusta, Georgia is an example of a center devoted to the enhancement of math and science education. Formed in 1982 by an act of Congress, the center develops, evaluates, and distributes science and math curriculum materials, conducts research in instructional technologies, and offers continuing education to teachers. In addition, it has an interactive display open to the public, which draws more than 200,000 visitors per year.

Objective 2

To Increase the Participation of Women and Minorities in Scientific and Technical Occupations

The key to avoiding the projected imminent shortage of scientists and engineers is to increase participation among those who will make up so much of the future labor force—women and minorities. For many years, creating greater opportunities in scientific and professional fields for women and minorities was viewed as a worthy social goal that could provide them with higher paying careers. Today that desirable social outcome has taken on economic dimensions. During the 1990s, two-thirds of the new labor force entrants will be women and minorities. It simply will not be possible to support future technological advances without their skills and knowledge.

The decision to pursue a technical career depends on the foundation one receives in elementary and high school. The fact that fewer girls than boys and fewer blacks than whites take advantage of advanced courses in math and science inevitably constrains later career choices. Thus, policies to increase broader participation must begin in elementary school, or even earlier. But even among those prepared for technical careers, too few continue on to graduation and post-graduate work. Last year, only 28 blacks were awarded PhDs in engineering or natural sciences in the U.S. And the number of women entering engineering careers—on the upswing for some years but still small—is now declining. Since these are the talent pools for future professors, it will be increasingly difficult for universities to hire more minority and female faculty in technical fields.

The National Science Foundation (NSF) strongly supports broader access and participation by women and minorities and has initiated a number of programs to alleviate imbalances. In 1988, for example, the NSF supported a Regional Center for Minorities—headquartered at Clark College but organized as a cooperative venture that includes four other black colleges—to boost minority participation in science and engineering.

The following strategies are intended to attract more women and minorities into technical careers and to increase their chances for success by enriching their education.

A. *Establish special summer and weekend math and science enrichment programs for women and minorities.*

Although a high-quality, standard curriculum ought to be sufficient to attract women and minorities, the barriers against their participation are so engrained that they are not likely to break down in the next few years. Therefore, a special effort is needed to attract the interest of women and minorities while they are still in high school and to instill a sense of confidence that these challenging subjects can be mastered. Professors from Tuskegee University, for example, hold a weekly Saturday academy in math and science, supported by the General Electric Foundation. And in Philadelphia, more than 70 percent of the minority high school students who complete a special engineering introductory program (PRIME) go on to get their engineering degrees. We recommend that each **state department of education—**

working with **schools**, local **business** and **labor** leaders—support extracurricular math and science education activities aimed at women and minorities.

Getting an Early Start

In 1987, the University of North Carolina established a special Pre-College Program in Mathematics and Science aimed at increasing minority and female enrollment in math, science, and engineering. It identifies promising students in grades six through 12 and offers counseling, independent study groups, field trips to research and manufacturing facilities, enrichment tutoring, and Saturday academies. Almost 1,000 students from 34 schools currently participate in the program.

B. Seek balanced enrollments in special enrichment programs.

Because the South's high schools have limited spaces available in their math and science special enrichment programs—and because levels of exposure to math and science prior to high school are not uniform—unrestricted enrollments would probably lead to a predominance of white males. Therefore, efforts must be made to ensure a balanced enrollment without compromising standards. Enrollments at the North Carolina School for Science and Math are about half female and one-fourth black, resulting from a deliberate policy to achieve parity. We suggest that **state legislatures** establish targets for representative participation in special math or science education programs.

C. Recruit female and minority scientists and engineers to visit schools and talk to students about careers.

Through observing and talking with role models, youngsters can be exposed to the wide range of technical career opportunities available to them. Most black children do not have friends or relatives who are scientists and engineers, and it is unlikely that many have ever met a professional in a highly technical field. The same holds true for many girls. Opportunities to meet and talk with engineers of their own race or gender can open doors that mere words and pictures cannot.

We recommend that **state education departments** and **business organizations** strongly encourage the participation of professional women and minorities in career education programs, providing special incentives to **schools** and to **local businesses** who do so. Special interest organizations like the Southeastern Consortium for Minorities in Engineering can be helpful in identifying and preparing students who might become scientists and engineers.

D. Increase support for historically black colleges and universities to upgrade technical education.

Historically black colleges and universities (HBCUs) can play a major role in technical education for black youth. For many students, these schools offer a more psychologically and socially congenial setting than a predominantly white university. The black colleges created by the Land Grant Act of 1890, in particular, have technical education as part of their mission. It is important that pursuing a technical education at one of these institutions remain a viable option.

Even the land grant schools, however, lack well-equipped research facilities, good libraries, and research funds. We recommend that the **states higher education agencies** and **state legislatures** take steps to assure that HBCUs have the resources they need to provide good technical degree programs and to support the research associated with them. They also need sufficient funds to employ graduate students as research assistants. One step might be to initiate exchange programs between state research universities and the black research universities. We further suggest that in the coming year the **Southern Growth Policies Board** bring together leading policymakers with representatives of black colleges to address the technical education needs and potential of our HBCUs.

E. Provide transitional programs for women and minorities entering science and engineering programs.

The experiences of women and minority students entering science and engineering programs—where they comprise a very small proportion of the class—have not always been positive. They are likely to have had less high school math and science than their classmates, and they are more likely to feel isolated and excluded from informal study groups. Therefore, to increase their chances of succeeding in their studies and becoming role models for future students, women and minorities deserve special attention. This means offering more than financial aid, which is an important source of support but insufficient to smooth the transition from high school to university.

South Carolina has implemented a transitional program at a technical college for minorities which is intended to lead to a university engineering program in the second year. In other states, the universities themselves provide the support systems.

We recommend that the region's **colleges** and **universities** identify, create, and implement support systems—particularly through the first two years—that will maximize the chances for women and minorities to succeed.

Objective 3
To Produce More Flexible, Adaptable, and Innovative Technicians

As industry is forced to become more flexible and responsive to changes in both market demand and new technologies, the work force must adapt as well. An employee who expects to operate one machine day after day and simply follow directives from above is no longer highly valued as a worker. A modern manufacturing plant is not just an odd-lot collection of machines; it is a unified system. Modern production workers must understand that system in *all* its aspects.

Computer-integrated manufacturing (CIM)—which is believed to represent the factory of the future—epitomizes this systems approach to production. Each employee must understand not only his or her own work station, but also where parts flow and how all the parts are related to one another. The days of the specialist are fading, and many new plants already have reduced their dozens of former job classifications to two, three, or four. A technician in an advanced manufacturing plant is likely to be an operator, quality control inspector, maintenance person, and first-line supervisor all in one.

Similarly, wider use of computers and telecommunications devices is rapidly changing the distribution of office work between professionals and clerical staff. Professionals, for example, are more apt to type their own letters, but they are still likely to request a secretary to proof their copy and transmit it by any one of various electronic means.

It is time to take stock and rethink the technical content and breadth of technical education as well as the quality of the instructors. The new jobs of the 1990s will demand what the Southern Growth Policies Board has described as the "Renaissance Technician." The experience, inventiveness, and adaptability of the work force are today more and more accepted as keys to innovation. Can our schools provide the level of expertise needed in the technological workplace and at the same time prepare students for continual change?

A Helping Hand

Auburn University in Alabama has made great strides not only in attracting black students into its science and engineering programs but in helping them succeed. The program begins by actively recruiting qualified minority students, helping them secure enough financial aid, and then providing continuing support. The latter includes a year-long agenda of social and cultural activities to make them feel comfortable, professional staff mentors, and a "big brother or sister" program that matches returning students with entering freshman. In 1988-89, about two-thirds of all entering black students went into engineering. More than 60 mentors and 80 returning students help guide them to successful completion of their degree requirements.

To improve its technical work force, the region must better understand what is needed to adapt technologically, how to impart the necessary knowledge, skills, and behavior, and what the role of its various institutions ought to be. The following recommendations address information needs, the improvement of instruction, and coordination of effort among institutions.

A. Identify and impart the technical, economic, and international skills needed in the workplace of the future.

Employers using state-of-the-art methods and equipment—and possibly working in foreign markets—need workers who are flexible and adaptable to change. These employers are increasingly willing to assume more responsibility for training in job-specific skills in return for employees who are able to learn quickly and have a good grasp of the fundamentals. Further, new workers who are willing to expand their knowledge and skills for the technically advanced and internationalized workplace will make the modernization of manufacturers and service providers more rapid and efficient.

Students ought to be exposed to knowledge that—while not absolutely essential to the technical performance of a job—is critically needed to become an innovative and contributing member of a work team. For instance, understanding organizational behavior may not be needed to perform a particular job, but would be needed to move into a supervisory position or to take part in discussions of proposed production reorganizations. Similarly, learning statistics allows an employee to understand quality control, reliability, and survey methods.

We recommend that **technical and community colleges** in each state review their technical curricula, consider information about anticipated skills needs, and make necessary revisions to broaden technical degree programs. The STC staff is presently conducting research on the skills used in small manufacturing firms, but broader efforts to document skills needs in other technologically advanced industries ought to be started.

Seeking a New Pedagogy

Under a grant from the U.S. Department of Education for 1989-90, the Consortium for Manufacturing Competitiveness will set in motion a system to identify common sets of skills needed by small and rural manufacturers. A group of small manufacturers who are on the cutting edge in the use of advanced technologies will be surveyed periodically in order to provide an on-going Nielsen Poll about skills needs. Their responses will be analyzed to identify common ground and changing skill requirements, which will in turn be used to inform curriculum development.

B. Require technical education instructors to have both business experience and teaching skills.

In the past, many technical or vocational education instructors who met general state qualifications had experience in either teaching or industry, but seldom in both. Each approach presents a different problem. On the one hand, lack of grounding in the workplace limits an instructor's ability to make courses relevant to modern work. On the other hand, relying too heavily on part-time instructors who lack training in basic teaching skills limits how effectively theory can be woven into applied courses. Yet, given the current shortage of instructors in many areas, particularly in rural schools, what can be done?

Retired engineers and industrial managers who want to share their knowledge and who are willing to acquire the requisite teaching skills represent an untapped pool of highly experienced potential instructors. We recommend that **state education agencies** establish standards for technical faculty that include both a minimum of three years experience in business and the equivalent of one full semester of teaching methods.

C. Teach metrics to all students.

The United States is currently one of only three countries that do not use the metric system. Yet, with the expansion of export markets and increased joint projects with other nations, knowledge of metrics has become essential. Under the Omnibus Trade and Competitiveness Act of 1988, .ie metric system is designated as the preferred system of measurements; all federal grants and procurements will now be expressed in metrics. A work force that is able to use the metric system would give the South a decided advantage in the international marketplace. It is time to take seriously the teaching and use of metrics in all math, science, and technical education curricula. We recommend that **state education agencies** require that **schools** require students to demonstrate proficiency in metrics in order to fulfill high school math requirements.

D. Match high school technical curricula to post secondary technical requirements.

With the growing demands on high schools for both increased basic skills and a variety of other skills, such as languages and geography, responsibility for teaching higher-order technical occupational skills has shifted to the two-year colleges. High schools must therefore offer the student a solid foundation in math, science, and technology in preparation for their post-secondary technical education. College and high school administrators should work together to ensure a smooth transition from high school to technical college programs.

A program growing in popularity is the "two plus two" model. This program combines the last two years of high school with two years of post-secondary education and results in a technical associate degree. A common version of this model, called "Tech Prep," requires collaboration between high schools and colleges in technical curricula. An amendment to the Carl Perkins Vocational Education Act that would provide federal support to encourage such programs was introduced in Congress in 1989. It is called the Tech Prep Education Act. Whether or not the federal government adopts this or similar legislation, we suggest that the South's **state elementary and secondary** and **higher education agencies** jointly assess existing technology preparatory programs and introduce such programs statewide.

Tech Prep

A four-year technology program in operation at Richmond, North Carolina, Tech Prep involves both the county schools and Richmond Community College. It combines two years of high school with two years in a community college setting and culminates with an associate degree in a technical discipline. The high school segment blends math, physical science, economics, and English with vocational courses on selected fundamental concepts of technology, such as electronics, drafting, and industrial mechanics.

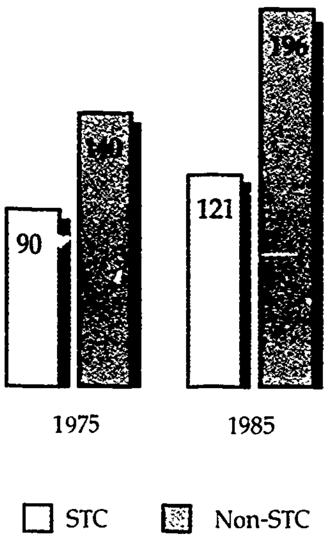
Objective 4
To Increase the Number and Quality of Scientists, Engineers, and Technicians

It is highly likely that over the next ten years there will not be enough scientists, engineers, and technicians in many fields to meet the demands of emerging industries. A dwindling college freshman cohort displaying a diminishing predilection for science and engineering points to future shortages. These shortages may be most severe among PhD candidates, the main talent pool for new professors and researchers. For example, the number of Americans earning engineering PhDs fell by more than 50 percent between 1970 and 1984. Japan now graduates about four times as many engineers per capita as the U.S.

Furthermore, most measures of the relative concentrations of scientists and engineers, either working for a living or toward an advanced degree, place southern states well below the national average. Southern manufacturing industries, which often are the branch plants of companies headquartered elsewhere, employ fewer technically trained people per capita than other regions of the country. Research-intensive firms are unlikely to locate in areas experiencing technical skill shortages. More than 96 percent of high-tech companies recently surveyed rated availability of technical personnel as important to their location decision. And those who do locate or expand in the South often are forced to look

Figure 7

Scientists and Engineers with PhD's Residing in the Region (per 100,000 population)



outside the region for their most technically trained employees.

Increasing the *quantity* of scientists and engineers is important for two reasons. First, and perhaps most obvious, an increase in the proportion and number of technically trained workers in the work force is projected. At the same time, labor market projections by Data Resources based on Bureau of Labor Statistics staffing patterns project a national shortfall of about 360,000 engineers and natural scientists under an optimistic economic forecast and about 115,000 under a pessimistic economic forecast. And, with 13 percent fewer potential workers in the 20-29 age bracket projected for the year 2000 in the South, even a 50 percent per year increase in rate of entry by women and minorities into technical career paths would not alleviate the shortage.

Second, the aging of current faculty and the shortfall of scientific graduates in recent years suggest that colleges and universities face a potential shortage of scientific faculty in the not-too-distant future. The problem would become more severe if the large numbers of foreign nationals enrolled in American graduate schools choose to return to their home countries.

The *quality* of the South's scientific and technical work force is equally important, even if less quantifiable. Much of the innovation that drives our economy is a result of technological advances—many of which originate in other parts of the world. The South needs ingenious and inventive scientists and innovative and resourceful engineers who have access to worldwide information networks. In addition, both scientists and engineers would benefit from closer contact with industry so that they could be continually aware of commercial needs and problems. Furthermore, the quality of the scientific and engineering faculty is often what attracts the best graduate students from all over the world, exposing them to the advantages of the region and opening doors to opportunities for work in the South.

Some of the barriers to improving the quality of the region's scientists and engineers include unfamiliarity with or, worse yet, antipathy toward career opportunities in science and engineering among high school teachers and counselors. Other obstacles include college faculty and students who are too isolated from the real challenges and problems of businesses and industries, and those who lack familiarity with other languages and cultures.

Many of the actions needed to improve the supply and quality of the professional work force must begin long before college entry and have previously been cited in this report both as improvements to science education and as a means to broaden participation by women and minorities. The following steps can be implemented directly at the post-secondary level to recruit students into technical education and to ease those students' financial burdens. For those who do enter programs for technical careers, there are suggested actions that might steer more students toward critically important but often neglected fields, such as manufacturing engineering.

A. Establish loan forgiveness or repayment subsidy programs for selected education programs for critical technical fields.

The National Defense Education Act of 1958 provided subsidies for loan repayments for youth who were willing to work or teach in critical technical fields. Similarly, some isolated communities pay the college loans of doctors who are willing to practice there for a specified period of time. We think it is reasonable to forgive student loans to alleviate critical shortages in technical careers. Therefore, we recommend that **state legislatures** and the **U.S. Department of Education** create financial incentive programs to draw more young people into careers considered critical to the region and to the nation.

B. Establish counseling institutes to focus exclusively on technical career paths.

Although family, friends, the media, and indeed the full range of one's life experiences can influence the career paths of our youth, schools exert perhaps the greatest influence. The schools, after all, present the various options to students and, ultimately, force choices. Within the schools, teachers play an important role, but the students' counselors and advisers are the critical actors. In order for high school counselors to advise students effectively, however, they must be knowledgeable about technical career paths themselves. Unfortunately, most school counselors have had little exposure to or background in math or science and little, if any, first-hand knowledge of scientific or technical careers.

Still, career counseling is a critical intervention point—especially when so many students hold negative perceptions of technical careers, believing science and technology to be the logical domain of bookworms and nerds. Counselors particularly need to be aware of other, sometimes more subtle stereotyping, which can result in minorities and women being directed away from technical careers. We recommend that **state education departments** create special counseling institutes that would both help counselors stay informed about the rising potential of technical careers and also look for ways to improve attitudes toward careers in science and technology. Further, we recommend that state agencies monitor school records of student career choices, and, where needed, intervene to see that equal opportunities exist.

C. Establish domestic and international exchange programs of personnel between and among industry and universities.

With both technology and the nature of work constantly changing, it is virtually impossible for university personnel and professionals alike to keep up with the latest applications and problems in their fields. We recommend that **colleges and universities** work with **businesses** to establish programs so that professors or researchers might work in industry for short periods of time and industry personnel might be assigned to work in colleges. Such programs could and should be designed to allow international exchanges as well. Both employers and faculty would benefit from reciprocal exchanges. Colleges would receive the benefit of instruction about the latest technological advances, and businesses would reap the benefit of better prepared and possibly more innovative new job applicants—as well as new ideas from university research programs.

D. *Upgrade manufacturing engineering within schools of engineering.*

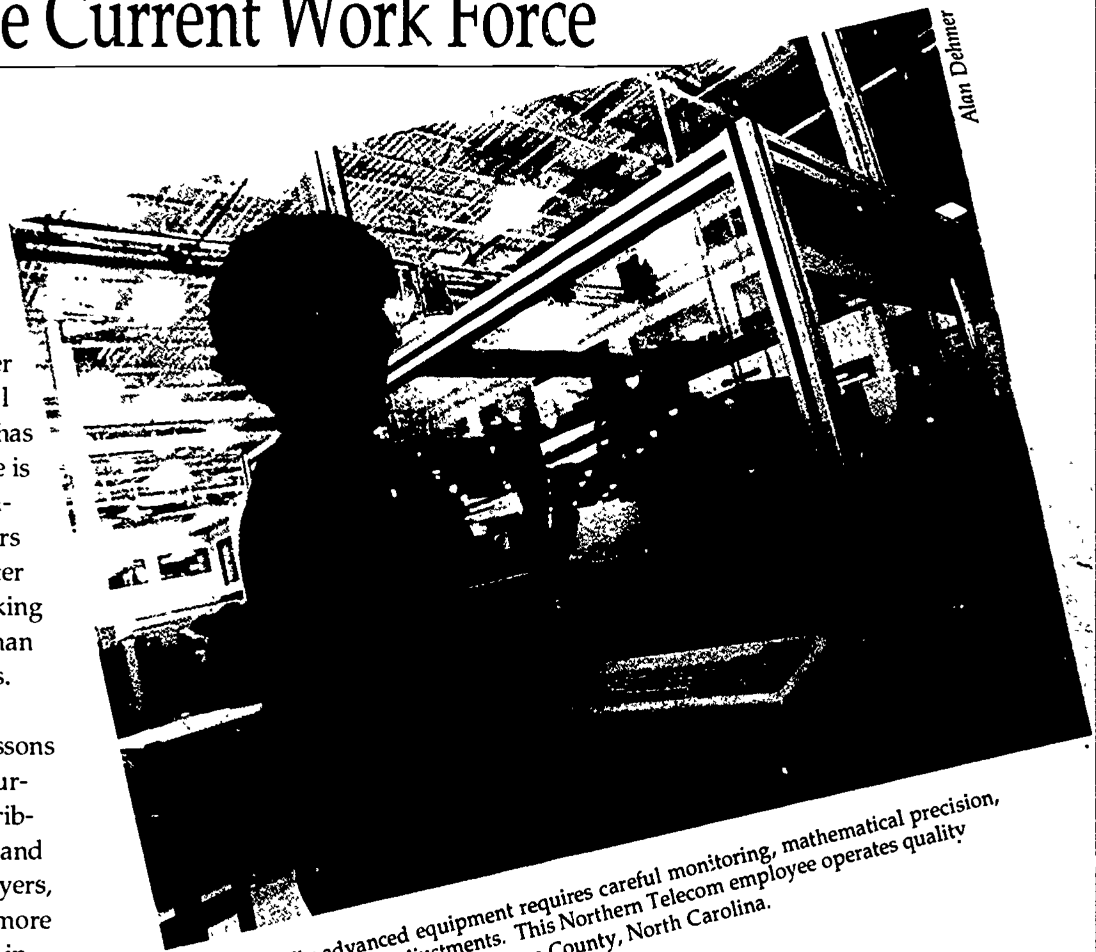
Among university engineering programs, manufacturing or industrial engineering generally rests at the bottom in both status and anticipated earnings. This has happened in part because defense and high-tech industries offer more glamorous work environments, higher salaries, and more contracts to engineering faculty. Engineers have often elected therefore to concentrate on the fields of electrical, aerospace, chemical, and nuclear engineering. Industrial engineering is still associated with dreary and dirty traditional manufacturing shops—as well as with timeworn techniques such as motion and time studies, work sampling, learning curves, and conventional inventory control models. Automation is changing the nature of industrial engineering, but curricula and attitudes respond very slowly. We recommend that states' **commissions of higher education** seek ways to market manufacturing engineering programs more aggressively by upgrading equipment and facilities, rewarding consulting work with industry, and finding new high-tech names for industrial engineering programs, such as "Automation Engineering."

E. *Expand cooperative programs in colleges of engineering.*

Engineering programs in the U.S. are widely criticized for having become too entrenched in their ivory towers. With the low status accorded to manufacturing, too much attention is paid to exotic product development and to stretching the frontiers of technical knowledge. In fact, American engineers have been described as displaying what one journalist terms "Nobel Fever." As a consequence, too little attention is paid to applying what is already known to industrial processes and problems.

In many European technical colleges, students spend their last year in industry working on real problems. Some southern universities do have cooperative programs (co-ops) in which students alternate work experiences with school, but these are optional, not required. Only a handful of American universities, such as the University of Cincinnati and Northeastern University, require students to work in a co-op setting within industry. As one way to make the engineering curriculum more relevant to the challenges one actually finds in the business world, we recommend that **universities** require some form of co-op experience which gives students the opportunity to apply classroom theories to practical problems.

Upgraded Skills in the Current Work Force



Alan Dehmer

Technologically advanced equipment requires careful monitoring, mathematical precision, and frequent corrective adjustments. This Northern Telecom employee operates quality control computers at a plant in Durham County, North Carolina.

The debate in the late 1970s and early 1980s over whether technology demands fewer or more skills and lower or higher levels of educational attainment and achievement has finally been put to rest. There is general agreement among employers that they want workers with more education and better critical thinking skills. "Working smarter" has become the human resource theme of the eighties.

One of the most important lessons of the Japanese industrial resurgence is that *all* workers contribute to increased productivity and innovation. American employers, too, are now giving workers more autonomy and independence in order to take advantage of their skills and experience. Moreover, the introduction of new technologically advanced equipment does not, as formerly believed, reduce the need for skills but in fact requires careful monitoring, mathematical precision, and frequent corrective adjustments. A recent national survey found that in 75 percent of all plants which had adopted new computer-controlled equipment in the last five years, machine operators have some responsibility for programming the machines they control. And in nearly half of those plants, there are no programming specialists; the operators have *sole* programming responsibility. Yet, American firms invest far less in training their workers than do, for example, Japanese or Swedish firms. Japanese firms spend three times as long training workers for flexible manufacturing as do American firms.

The demand for a more skilled work force has put the South at some disadvantage. A passive, cooperative, but unskilled labor force which was once the South's ace-in-the-hole in the jobs competition is now its Achilles heel. Although the skills of the region's new entrants into the labor market are quickly improving, the educational needs of the South's older labor force are higher than anywhere else in the nation. Rates of functional illiteracy are high, many workers have held only low-skilled jobs in nondurable manufacturing plants, and many more simply lack the confidence to enroll in retraining programs which would prepare them to work with sophisticated technologies. An estimated one out of every six southern adults between the ages of 22 and 59 has completed no more than eight years of formal education. Thus, training for many workers must begin at the basic skills level.

Training needs in the region are greatest in rural counties and in counties with high concentrations of blacks. The anticipated shortage of new workers will place greater demands on current workers to staff the next decade's new jobs. Thus, improving the technical skills of the existing southern work force is one of the keys to technology-based development. Community colleges, community-based training organizations (CBOs), employers, unions, and employees must share the responsibilities for retraining, but new technologies will shift the balances among areas of responsibility.

Community colleges are finding, for example, they must take on increasing obligations for literacy, basic education, management education, and broad-based critical thinking skills. CBOs and proprietary schools must take on more training of disadvantaged and displaced workers, while employers, equipment vendors, and private trainers must provide more job-specific skills. Further, to be willing to invest his or her own time and other resources in preparing for the future, the individual worker must perceive a value from retraining that is above and beyond maintaining the status quo.

Objective 1

To expand and improve continuing education for more technically demanding work.

For many years, educators have talked about the need for life-long learning. People change careers, interests, and lifestyles. But life-long learning has largely remained an unrealized goal. Today, technological and economic pressures are turning that social goal into an economic imperative. Improving the technical skills and knowledge of the southern work force is essential to competitiveness. People change jobs, careers, and homes not only when they *want* to but when they *have* to in order to keep pace with changes in the workplace.

Two and four-year colleges and universities will continue to carry the major load for continuing education, but those institutions will have to find more effective ways to reach the public. In addition, adult basic education programs must support literacy education, and business assistance centers must upgrade management skills. Although education at all levels is important, the Council has targeted two sets of actions. The first, basic skills, was selected because the number of functionally illiterate workers is still very high. Management training was also selected, because management of and for technology receives too little attention.

A. *Teach reading, writing, and basic math skills to employees who need to adapt to a more technologically demanding workplace.*

Businesses that once assumed they could retrain their existing work force as the nature of work changed are now finding that many employees lack the fundamental knowledge not only to understand but even to use new technologies. In a 1988 Congressional hearing, the president of Motorola testified that 60 percent of the company's employee training budget must go to support remedial math and reading skills. Case studies conducted for *Reviving the Rural Factory* (Southern Growth Policies Board, 1988) also found a heavy emphasis on math remediation at plants that were introducing new process technologies. We believe that it is up to the **state education agencies** and **job training councils**—which have the requisite resources and expertise—to support and provide remedial education. It is up to businesses to identify the students and encourage them to enroll.

B. *Develop "management of technology" programs.*

There is a growing awareness that the successful application of new technologies is inextricably linked to the organization of the workplace and to the management of technology. Management of technology, in fact, can be as important as the technology itself. Further, such management intersects the expertise of both engineering and business schools. Articles about the subject appear with equal frequency in engineering and management journals. Thus a re-education of management must take place in concert with the retraining of the work force. We recommend that **states** support programs in the management of technology in their community colleges, in the continuing education departments of their colleges and universities, and in their industrial extension services. We further recommend that **business** and **engineering colleges** collaborate with each other and with **business associations** to design and provide the highest quality programs.

C. *Create "link trainer" units to provide simulated business settings.*

Just as pilots prepare for flight training in link trainers under simulated real-life circumstances, management and employees could benefit from analogous methods. Most of the training modules currently available are provided by vendors and are usually confined to particular sets of tasks based on the use of specific equipment. Their main drawback is that they fail to prepare workers to use computer-integrated manufacturing (CIM) systems.

Many members of the Consortium for Manufacturing Competitiveness, as well as other schools in the region, are beginning to develop small-scale factories and offices. Some representative examples include the Regional High-Technology Center at Haywood Community College, the CIM cells at Oklahoma Technical Branch at Okmulgee, and Valencia Community College in Florida. The high costs and rapid obsolescence of equipment, however, make such programs prohibitive for most schools. We suggest that the states identify a set of schools, as South Carolina has done, to build link trainers for high-tech, high-growth industries. **State education agencies** and **departments of economic development** should work with the **equipment producers** and **private sector advisors** to design and support an appropriate work environment.

Southern Arkansas University Tech's Mobile Link Trainers

Three mobile labs have been equipped with state-of-the-art, automated manufacturing tools for on-site training at schools and businesses throughout the state of Arkansas. Southern Arkansas University Tech, which is a member of the STC's Consortium for Manufacturing Competitiveness, also operates a CIM center on-site to provide a more life-like factory setting for training.

D. *Upgrade technical and managerial skills through telecommunications systems and distance learning technologies.*

Distance learning and computer-assisted learning can be used to bring education and training to small communities and small businesses that lack the resources to provide their own training. The National Technological University (NTU), for instance, now provides both graduate credit and continuing education courses over the GSTAR I satellite at 240 sites, including six universities and 28 business sites in the South. We suggest that **southern universities** continue to develop new teaching technologies for use in adult basic education and to take advantage of existing programs such as those at NTU.

E. *Use unemployment insurance funds to help finance retraining.*

The most pressing job issue of the 1990s is likely to be the large percentage of unemployment which results from the dislocation of workers who lack the technical skills needed in the contemporary workplace. Unemployment as a consequence of cyclical downturns in the economy is still a crucial problem in the South and demands the safety net approach of the insurance fund. But a temporary safety net of insurance payments is not going to make even a dent in the skills problem. Therefore, some states have begun to experiment with using a small share of unemployment insurance funds to finance the retraining of workers who need to acquire a higher level of technical skills. We recommend that **state legislatures** put the use of unemployment insurance funds for such retraining on their agendas for discussion as soon as possible.

Objective 2

To Improve the Private Sector's Technical Education and Training

Estimates of private-sector investment in training range as high as $60 billion per year. States, too, have allocated substantial sums to provide training. But the faster technology changes, the greater the chance that an employer rather than educational institutions will provide training. In addition to employers, private sector training providers include private training companies, proprietary institutions, and equipment manufacturers. In fact, in a survey conducted for the STC, 98 percent of manufacturers relied on vendors or their own training for new equipment, 14 percent used private training companies, 40 percent used community colleges, and 10 percent used universities.

There is evidence, however, that private-sector training is not as effective as it could be. Vendors of automated equipment, for example, play an important but limited role in training workers to use and understand their latest technologies. Most of their training, however, is directed at programmers, not managers or operators, and it is usually of short duration.

Much of the private sector investment in training is spent on middle and upper-level management and on entering workers. Still, a considerable sum goes for training and retraining in response to changing technologies and organizations. This often includes upgrading basic skills. Whereas once the emphasis in training was on the *use* of equipment, it is now increasingly on *understanding* the tools. Some businesses contend that understanding the system is so important that they invest in sending teams to home bases—even those located overseas—where equipment is in production. There is a growing awareness of the role of workers in innovation, a process Robert Reich calls "collective entrepreneurialism," in which the enterprise advances through a series of small innovations resulting from cooperation among members of the work force, not from the big engineering breakthrough.

Even though the private sector is already heavily invested in education and training, the following actions ought to help it to expand its commitment to training and retraining for new technologies.

A. *Establish college credits for certifiable work-based technical education.*

Certification of skills acquired through work and training is important to workers and employers; therefore credentials are important to legitimize continuing education. Institutions that give out credentials ought to accept skills acquired in non-institutional settings, provided that they can verify the competencies. General Motors, for instance, provides college credit for many of its internal programs.

We recommend that **universities, commissions of higher education,** and businesses join together to devise and establish procedures to insure the quality of employer-based training and to give appropriate recognition to and credit for non-traditional technical training and the education of adults.

B. *Assess the basic competencies of employees and provide support for compensatory programs.*

Since raising the levels of basic math skills is the responsibility of the states, state governments ought to help businesses assess new skills needs and contribute to the remediation of deficiencies. National attention to low reading skills and cultural illiteracy has, until quite recently, caused math illiteracy to be overlooked, although it is actually much more prevalent. A recent series of reports, including those from the National Academy of Sciences and the American Association for the Advancement of Science have now brought the issue into the national spotlight. We recommend that **state education agencies** develop methods and make resources available to assess math literacy needs and that they provide adult basic education through the community college systems, high schools, employers, unions, and trade associations. **Businesses** should conduct the assessments and, together with the state, make arrangements for the education.

C. *Encourage businesses to provide release time and rewards for technical skill upgrading.*

Upgrading technical skills before they become obsolete is a way to increase employer productivity and employee flexibility. The work force needs both encouragement and some sharing of the burden, however, to upgrade its technical skills. Much of the education of managers and other professionals is offered during work hours, but salaried and hourly workers usually are expected to participate in training programs on their own time. This is especially difficult for the parents of small children. We ask **businesses** in our region to encourage higher rates of enrollment, attendance, and completion rates in training by providing at least partial release time and by rewarding employees for skill upgrading.

D. *Establish formulas and partnerships for sharing the costs of training for technological change.*

Training is costly, and both the private and public sectors have invested heavily in it during recent years. Generally speaking, the more advanced the technology, the more costly the training, particularly if equipment is involved. Schools are seldom able to replace outdated equipment as quickly as it becomes obsolete, and businesses are not often able to take on the entire training burden, especially if they are relatively small. Partnerships are needed so that businesses can either provide the setting or lend equipment to schools, and so that schools can provide instructional materials and personnel to companies. In Pennsylvania, for example, the training costs are shared equally by the state, the company, and the individual. We recommend that **state employment and training agencies** and **businesses** find new arrangements for sharing training costs and responsibilities to deal with rapid technological change.

Objective 3
To Encourage Workers to Invest Time and Resources into Upgrading and Expanding Their Skills

The key to the success of any retraining initiative is the workers' willing and enthusiastic participation. To obtain the desired degree of commitment, there must be incentives. Too often, the introduction of new technologies has been accompanied by skills downgrading. For example, when General Electric introduced new numerically controlled equipment in its Lynn, Massachusetts plant, it initially reduced the operators' grade level from 19 to 17. More recently, when a southern plant added robotic welders, it expected welders to learn new skills but reduced the pay level, ostensibly because the work was "cleaner." There ought to be potential rewards and appropriate incentives for the individual worker to engage in retraining programs. There is a major need, we believe, for incentives that will encourage workers to invest their time and money in further education and training. One of the most frequently advanced training policies is modeled on the Individual Retirement Account. In an Individual Training Account (ITA), an individual employee accumulates credits for education or training for career enhancement or advancement.

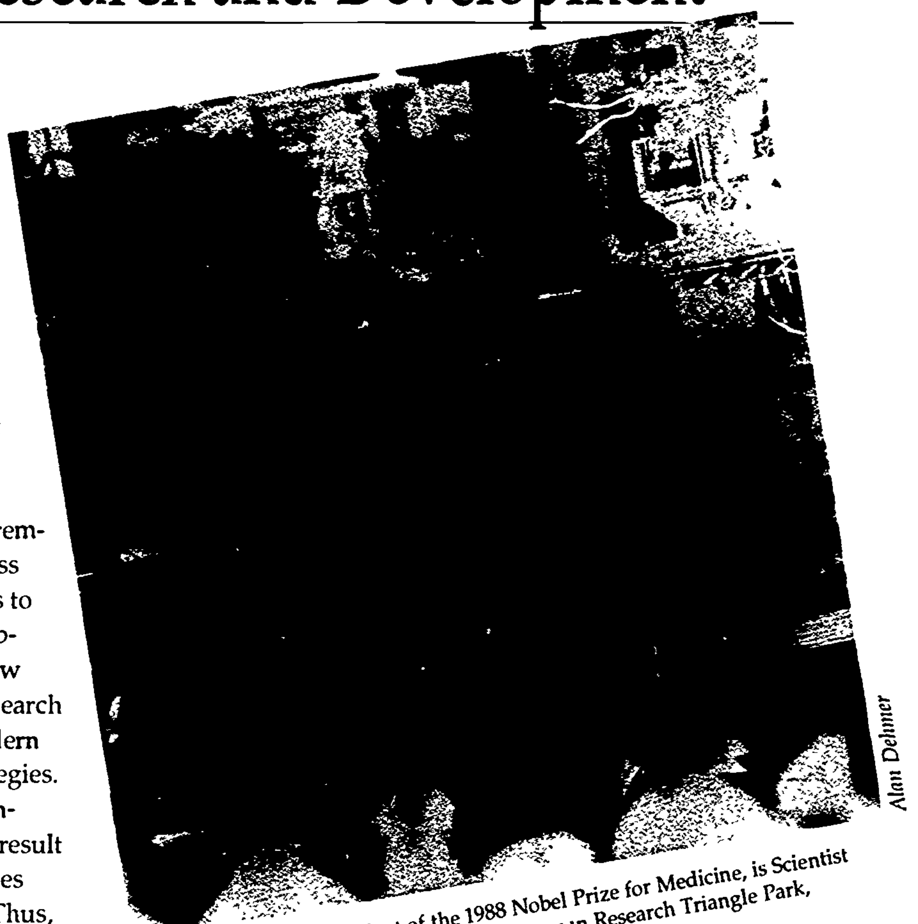
A. *Offer tax incentives to both businesses and individuals for investing in retraining.*

Human capital is a long-term investment and ought to be treated as such by state and federal tax policies. For example, firms ought to be able to depreciate investments in training their work force, and individuals ought to be able to claim deductions for expenses they incur. Some deductions for education and training are allowed, but under federal law they are limited to educational expenses necessary to retain a job. Deductions for cross-training (to become more flexible) or for new occupations are not allowed. Even tax credits, however, will not benefit the poorest segment of the work force. Since some of the gr atest investments will be required by the least educated—who probably are not in higher tax brackets—negative income taxes could be used. If the southern states truly believe that education and training are investments that will lead to higher productivity and long-term growth, then tax incentives must also be considered as part of that investment. Thus, we recommend that **state legislatures** and the **U.S. Congress** consider various forms of tax incentives to encourage retraining among the work force.

B. *Labor and management should cooperate to encourage greater participation in cross-training and retraining.*

Labor is taking an increasingly greater interest in education and training. Organized labor was originally a strong supporter of federal vocational education legislation because it was intended to provide mobility paths for workers. Today, labor has a major role to play in training policy, but it also means redefining jobs to allow for the flexibility that new workplace technologies demand. Labor unions can work with management to organize cross-training and retraining programs and encourage participation in ways that protect jobs. We recommend that **labor** and **industry** together develop incentives for retraining that will benefit both parties.

Improvement and Expansion of Research and Development



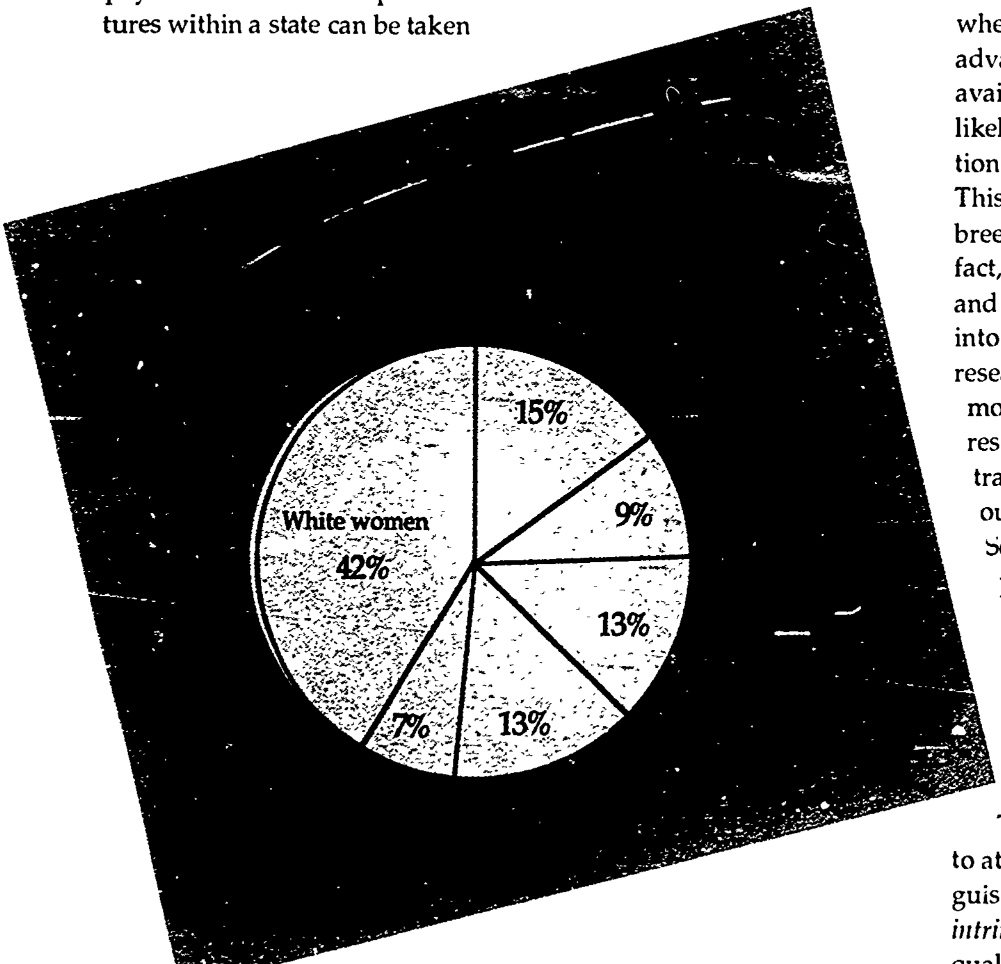
Gertrude B. Elion, a recipient of the 1988 Nobel Prize for Medicine, is Scientist Emeritus with Burroughs Wellcome Company in Research Triangle Park, North Carolina.

In the 1980s, research and development (R&D) finally emerged from the obscurity of university laboratories to assert their place in the bright spotlight at center stage in the Sunbelt economy. However, it had taken a precipitous drop in American technological supremacy and an accompanying loss of industrial competitiveness to make state economic development agencies realize just how important investments in research and development are to modern economic development strategies. R&D expenditures by government and industry alike can result in new products and processes that can translate into jobs. Thus, states have become the newest stakeholders in research and development, complementing and leveraging the R&D investments of the federal government and industry. Now it is up to the states—separately and as a region—to carve out their own research agendas based on their economic priorities.

This new courtship of research by state and local economic development agencies is by no means a clear or simple relationship, especially when other suitors still knock at the door. The new jobs arising from research performed by a local university or corporate R&D lab are just as likely to take root all the way across the country or on the other side of the globe. But those closest to the source of R&D expertise have the advantage of opportunities to join in the research, to contract with researchers, faculty, and students as consultants and interns, and to appeal to faculty entrepreneurs who may want to remain close to their home base. Furthermore, both firms that depend heavily on innovation and the R&D facilities of corporations have a tendency to cluster near established research centers. These are often high growth enterprises, suggesting that R&D involvement is an indicator of the growth potential of a state's industries. Therefore, despite the possibility that the results of local R&D will be widely dispersed, localities, home states, and even neighboring states have a decided edge over their more distant competitors. Thus provisions must be made to ensure that all states in the region have the opportunity to contribute to and benefit from research and development.

An expanded R&D program, however, requires a special support system. Research has come a long way since the lone inventor tinkering in a basement or backyard shed. Today it requires a team effort, sophisticated facilities, expensive equipment, high speed data processing, and information sharing networks. Although the economic impact of research and development cannot always be directly related to the level of investments on a project-by-project basis, it is generally accepted that a stronger scientific and technological base is more likely to yield greater economic payoffs. The scale of expenditures within a state can be taken as one indicator of their impact. Unfortunately, the distribution of R&D investments across the United States is quite skewed. For example, four states—California, Maryland, Massachusetts, and New York—accounted for 47 percent of all federal R&D funds in 1986. The STC states' combined share of federal R&D funds increased in constant dollars from 1970 to 1985 but remained at about 14 percent of the U.S. total.

The key elements of a plan to achieve these goals include a plentiful supply of topnotch researchers, accessible high quality facilities, and a good environment in which to carry out research.



Objective 1

To Attract and Retain Distinguished Researchers in the Region

The quality of any research can largely be predicted by the stature of the research scientists who conduct it. Distinguished scientists and faculty bring with them not only ideas and prestige, but also funding and contacts with others in their field. They attract and inspire other, usually younger, scientists. Thus, universities, research laboratories, and corporations vigorously compete for good scientists. But distinguished scholars also tend to go where their colleagues already are, and where well-equipped facilities for advanced research are already available. Such a setting is more likely to help them attract additional support for their research. This trend implies that success breeds success—so much so, in fact, that it takes an extreme effort and major investments to break into the circle of highly successful research centers. Consequently, most of the nation's scientific resources have become concentrated in just a few states. Obviously, those states are not in the South. In 1985, only about 17 percent of the nation's PhD scientists and engineers resided in the STC states. We believe the region must commit its resources to increasing that number.

The factors that are important to attracting and retaining distinguished scientists extend beyond *intrinsic* rewards—such as the quality of their colleagues—to include *extrinsic* rewards as well, such as the quality of the local environment. Scientists consider freedom, respect, and recognition as the intrinsic values of their profession. They like to work in an intellectually rewarding environment. But they also have a preference for areas with cultural and intellectual attractions, including good public schools, museums, theatre groups, and symphonies. Thus, quality of life considerations can have a significant impact upon the quality of research. And, of course, financial considerations are also important.

The South should make a concerted effort to make the most of the natural resources and advantages it already possesses through allocating additional funds and facilities for research and development, providing higher salaries for qualified research scientists, and assuring a better quality of life all across the board.

A. Provide stipends for talented graduate school candidates in science and engineering.

Young people looking for challenging opportunities are generally quite mobile. Therefore, R&D organizations and universities in the South must cast a wide net to recruit professional scientists and enroll first-rate graduate students in science and engineering programs. Higher salaries, better working conditions and more attractive social and cultural environments for professionals—along with more stipends, scholarships, and fellowships for graduate students—are an essential part of such a campaign. We recommend that **university** graduate schools use their own funds and seek support from technology-dependent **industries** to launch an intensive campaign to attract the top science and engineering students into southern universities.

B. Increase the number of endowed chairs and raise salaries for renowned professors in science and engineering.

The term "competitive salaries" is relative and somewhat ambiguous. Still, salaries offered by southern employers ought not to be consistently lower than current national norms. After all, the South's fabled lower cost-of-living usually does not apply to locations with research colleges or universities and should not be used to justify lower salaries. Employers should be able to recruit and retain highly qualified scientists and engineers by offering comparable or even relatively higher salaries than those available in well-known research universities, university administration, or athletics. One path to greater prestige and higher salaries is an endowed chair. More such chairs underwritten by **foundations or corporations** would enhance university departments, add to their salary budgets, and attract more qualified researchers. We suggest that the South's **universities** seek innovative ways to increase the compensation for our region's outstanding scientists and engineers.

C. Create an environment of challenging, directed research with individual and group autonomy and recognition.

Management studies have shown that while most scientists demand professional autonomy and recognition by their peers and superiors, they also need well-defined organizational goals. In fact, scientists' personal satisfaction and productivity appear to be enhanced whenever they are challenged by goals that are both well-defined and consistent with the overall objectives of the organization which employs them. All of these qualities—autonomy, recognition, goal definition and legitimacy—must be fostered by the leadership of research organizations. We recommend that this leadership—which must also understand and manage the complex social and political context in which their organization operates—take pains to mediate between professional expectations and organizational requirements in ways that will maximize the productivity and job satisfaction of scientists.

Objective 2

To Target State Resources on Research and Technology Development in Strategic Areas

To select and invest in research that will be economically fruitful is at best a risky proposition. New developments and commercial successes can emerge from the most unlikely of R&D projects, while allegedly safer investments may not pay off at all. Thus, while R&D investments are highly regarded as industrial policy in other nations, such a notion has been too controversial in America to be designated our national priority, except where national security or public health and safety are involved. States, however, have now embraced industrial policy and appear willing to make tough choices. Nearly every state has pinpointed technologies or industries on which it wants to stake its technological reputation and future. These choices are usually made on the basis of available information concerning ex ing techno logical strengths, industrial needs, environmental issues, and strategic plans.

The region's greatest need is for R&D concerning those technologies which are crucial to its key industries. Manufacturing, for example, is so important to the economic health of the rural South that the development of new process technologies, control systems, and materials to improve productivity must be considered vital. On the other hand, some states have chosen to modernize certain traditional fields, such as aquaculture, to replace those on the verge of decline, such as agriculture. Biological research, needless to say, would be an ideal candidate for special attention and funding.

The success of targeted R&D in the South will depend on the wisdom of selection, the terms of the commitment, and the adequacy of available resources.

A. Identify the strategic research needs in each state.

For every industrial sector, there are certain technologies which are critical to advancing the state of the art or which may be detrimental to the environment. Once the primary goals for social and economic development are set, the range of technological choices and alternatives may be more apparent. We recommend that each southern **governor** appoint a committee of economic development experts, scientists, and industry representatives to analyze the state's industrial growth plans, project its technological needs, identify environmental concerns, and develop a set of research priorities. It will be important to reassess these choices at specific intervals to see how conditions may have changed and what modifications might be needed.

B. Support R&D for strategically important technologies or exceptional environmental problems.

Once strategic research priorities are selected, a strong capability for supporting them must be built. Since states have limited resources for R&D, that capability must be enhanced with the help of federal and private R&D programs. The federal government is most likely to support basic research, while the private sector will likely target technology-based investments which are the most likely to realize short-term commercial payoffs. The state, whose investment share is generally the smallest, ought to provide core funding for the physical infrastructure and the scientific expertise required to attract incremental federal government and industrial R&D program investments. We recommend that state **legislatures** target R&D expenditures based on their states' industrial and economic development needs and the ability of those appropriations to leverage private and federal investments.

Florida's Key Technologies

The state of Florida has targeted six key areas in its research and development program: software and computer science; microelectronics; lightwave technology, computer-integrated manufacturing, simulation and training; biomedical devices; and biotechnology. These choices reflect decisions to build on the state's growth in the space and electronics industries as well as Florida's health care needs.

Objective 3
To Increase Total Public and Private Spending for R&D

The relationship between levels of R&D expenditures and technology-dependent economic development is becoming clearer. Today, nations big and small alike devote sizeable portions of their gross national products to R&D under the assumption that such investments will ultimately lead to economic development. The tiny nation of Denmark, for example, has recently earmarked about $70 million for collaborative research. Both the Corporation for Enterprise Development and SRI, International include R&D expenditures in their indices of economic vitality, lending further validity to the assumption of a linkage to economic development. States bid against each other to attract high-tech industrial R&D complexes for the same reason. Thus, the allegedly unproven relationship between R&D and economic development is universally accepted as fact.

Research and development, however, is becoming more costly. The competition for the best and brightest scientists and graduate students must inevitably raise pay scales, which in turn increases the costs of doing research. Further, the growing complexity of R&D enterprise requires sophisticated—and expensive—equipment. The South's R&D facilities and equipment are often too old and in many cases, obsolete. Many institutions lack well-equipped facilities in emerging fields such as biotechnology, microelectronics, lasers, and superconductivity. Instiuutions without modern equipment will not be able to attract and retain distinguished researchers—even if they can afford to pay high salaries.

Although more money does not necessarily produce a winning R&D hand, it does buy a seat at the table. The South needs a strong base of support for R&D if the region is to be on an equal footing with its competitors. We suggest the following steps as ways to increase federal, state, and private expenditures in the South for economically useful R&D.

A. *Recommend that the National Science Foundation extend and broaden the EPSCoR Program.*

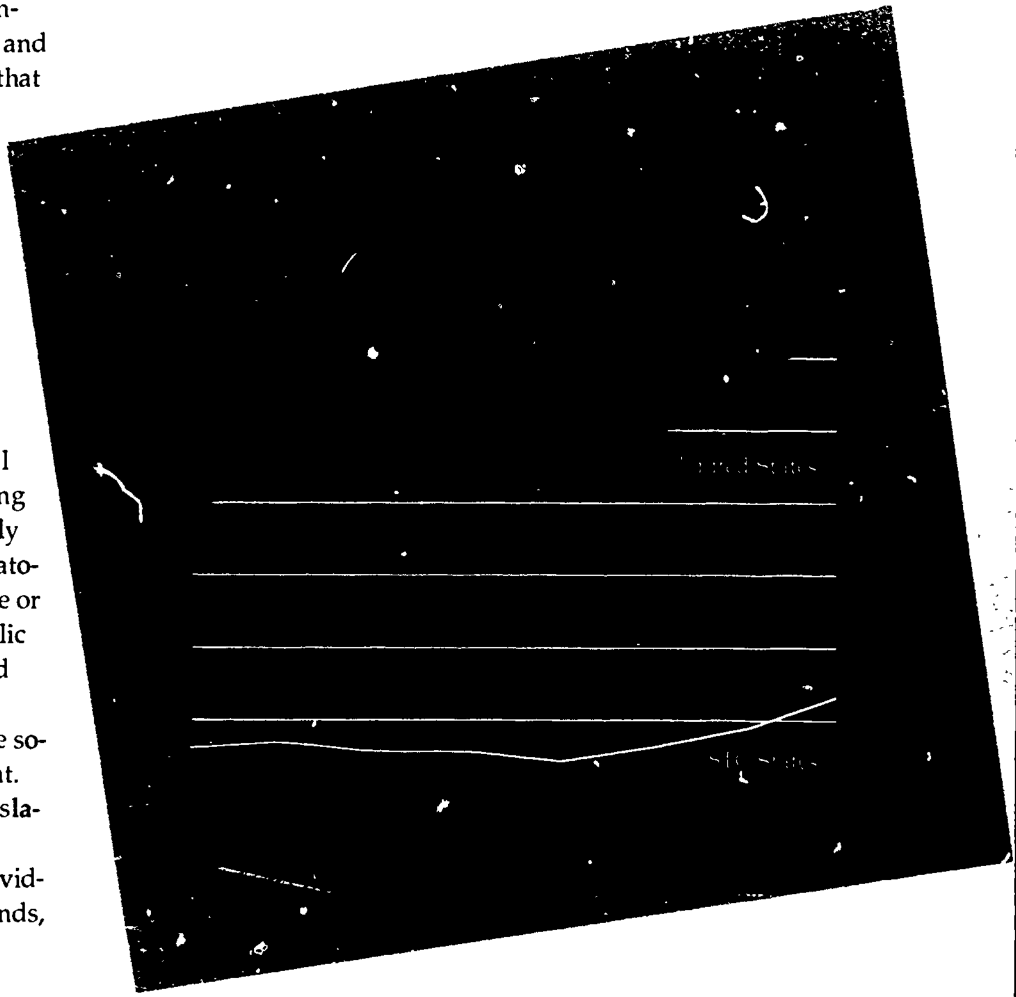
The National Science Foundation's (NSF) Experimental Program to Stimulate Competitive Research (EPSCoR) has been extremely important to the expansion of the South's research and development capacity. Research grants tend to go to those areas that already have a strong capacity, and it is difficult for other states to compete. The EPSCoR program can and does open the door. The funds that the seven participating STC states—Alabama, Arkansas, South Carolina, Kentucky, Oklahoma, Louisiana, and Mississippi—receive have been able to leverage up to six times more from state governments, universities, and the private sector. The program provides financial support for graduate students, research equipment, visiting scholar programs, and project seed funds. It is important, however, that the support continue beyond EPSCoR's mandated five-year term and that it be extended to other agencies. We recommend that the U.S. Congress take such actions.

Getting a Boost

Kentucky, whose universities rank 47th in the receipt of federally-allocated R&D funds, was a second round EPSCoR winner in 1986. In the state's first year of EPSCoR participation, 120 faculty, 63 graduate students, and 11 post-doctoral students actively engaged in research projects ranging from astrophysics to microeconomics—all funded by the program. The grant also made possible an innovative mentoring program which links faculty at regional state universities with faculty at the state's two institutions which award doctorates.

B. *Upgrade and extend the use of advanced research facilities.*

Federal and state funding agencies are well aware of the problem of aging and obsolete equipment in university and private laboratories and of the growing need to control precisely the conditions—temperature, humidity, stability and cleanliness—under which modern research is conducted. In addition, access to information is a basic requirement for effective research—implying the need for good libraries, high-speed computers, precision instruments, and telecommunication networks that carry data, video, and voice.



These resources all cost money, but federal funding for such facilities has decreased substantially over the last two decades. Smaller universities or labs, four-year colleges, and community colleges have a particularly difficult time competing for federal dollars and raising the matching funds to replace technologically obsolete equipment and laboratories. Greater sharing of unique or high-cost facilities among public and private laboratories would help to optimize their use and would justify the costs of more sophisticated research equipment. We recommend that state legislatures invest in R&D facilities, programs and equipment, providing incentives for matching funds, commercial applications, and sharing among users.

Bonds for Science

The University of Kentucky used revenues from the sale of state bonds to purchase scientific and engineering research equipment. Through this process, over $20 million was invested in the university's R&D infrastructure during 1987 and 1988. Some of the targeted areas were advanced electron microscopy, computer architecture, biomedical imaging technology, and materials preparation and characterization facilities.

C. *Increase incentives for faculty to seek R&D grants.*

The preparation of quality proposals takes considerable time and resources. Faculty members who must seek outside funding to support their research generally have to squeeze in proposal writing among their other regular duties, and they often run up against deadlines. Submitting proposals does not guarantee funding but it is certainly a prerequisite. NSF and other federal agency records indicate that southern scientists do not submit enough applications, which to some extent may account for the lower levels of funding. Preparing more high-quality proposals is one way for the region to increase its share of federal R&D dollars. We recommend that **public and private colleges and universities** encourage and support the preparation of quality proposals and consider the level of work required in their faculty evaluations.

D. *Use state tax polices to encourage investments in R&D.*

Federal tax credits on R&D are generally believed, if not proven, to have stimulated R&D investments by the private sector. Similar policies at the state level could be expected to increase investments and perhaps to encourage more corporate R&D in the South. Another area needing special attention, for example, is the replacement of obsolete research equipment State laws can remedy this problem by allowing accelerated depreciation on equipment and eliminating sales taxes on the purchase of state-of-the-art equipment. We recommend that **state legislatures** design R&D tax policies to encourage greater investments and activity by the private sector in research and technology development.

Stimulating Technology

A provision of Mississippi's Advanced Technology Initiative provides for tax exemptions and bonds to stimulate economic development through investments in advanced technology businesses. The state exempts these businesses from state sales and use taxes, as well as certain ad valorem taxes; allows a $1000 tax credit for each employee; and provides industrial revenue bonds. Though not exclusively an R&D initiative, the provisions apply to firms for the development of new advanced technology products or processes.

Objective 4
To Enlarge Multi-institutional Collaboration and International Exchange

Research is far too limited by institutional boundaries. Even though researchers maintain wide-ranging information networks within their disciplines, such networks tend to be restricted in scope to the U.S. Moreover, research projects are usually conducted by individuals within a single institution. The South can expect to improve its R&D by pooling its resources and combining its strengths. Benefits would also result from looking across the oceans to establish information exchanges and even to arrange collaborative research.

Cooperation as a means to improve the quality of research and development is growing increasingly popular—and necessary—as global competition heats up. Universities in various southern states already cooperate on some fronts. Universities have bid jointly on engineering centers, special projects, and science and technology centers. The Southeastern Universities Research Association (SURA) came into being as a regional effort to capture the Continuous Electron Beam Accelerator Facility (CEBAF). But cooperation is still an exception to the rule and is rarely pursued by universities unless special conditions seem to require it. It is not yet a standard mode of operation for improving the quality of research.

The Southern Technology Council, in its 1986 report *Regional Science and Technology Centers of Excellence*, strongly encouraged states to work more closely together in order to expand and improve their R&D bases. The Council recognizes that cooperation does not come easy; there are certainly institutional barriers and professional jealousies to be overcome. But the potential benefits of increased R&D resources and quicker payoffs warrant the effort. The following recommendations draw on that 1986 report to set some specific objectives and to suggest steps that might be taken to achieve them.

The benefits of international collaboration must also be seriously considered. International exchanges are much more common among other nations than with the U.S. The European Community, for example, has established a large array of multinational R&D programs, such as ESPRIT for telecommunications, BRITE for manufacturing technology, and EURAM for materials research. Foreign researchers frequently come to this country for graduate education or for R&D assignments in our laboratories. It is much rarer for our scientists to go abroad. Even trips to international conferences and workshops are often frowned upon. Universities fear being criticized for the expense of too many trips abroad or for sharing information with potential competitors. Yet, the potential cost of lost "trade secrets" must be balanced against the inevitable cost of knowledge lost and opportunities missed through remaining isolated. The latter grows larger as European and Asian R&D grows stronger. It is encouraging that some southern policymakers are beginning to appreciate the need for international exchanges. That attitude needs to become the rule rather than the exception.

The following actions are intended to help identify and encourage areas for collaboration.

A. *Select the areas of R&D that present the greatest opportunities for collaboration.*

The areas of R&D most likely to enhance the growth and development of the South are those in which the region already has some strength but where the potential exists to become truly world class—as well as those areas which meet critical needs of the region's economy. Of course, the greatest opportunities for the region lie in those areas where these two criteria intersect. In its report *Regional Centers of Excellence*, the STC has taken a step toward identifying these strengths and needs, but a more detailed and rigorous analysis is needed. We suggest that designated **state agencies** in the southern states begin collecting the information necessary to arrange R&D consortia within the region that will result in centers of internationally recognized excellence.

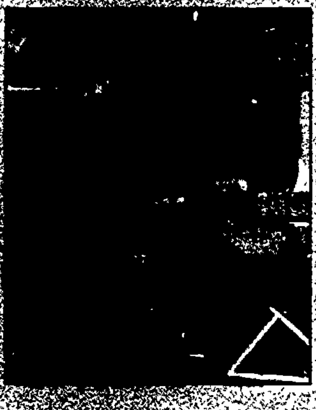
B. *Support regional efforts for large-scale research and development initiatives.*

Southern states can improve their chances for large-scale federally funded R&D projects by joining forces and working together as a region. Regional efforts will expand the R&D infrastructure and multiply the resources of regional institutions toward competing for funds. The process also establishes an environment for further consortia building. We, the **Southern Technology Council**, will work with organizations such as the **Southeastern Universities Research Association (SURA)** and **Oak Ridge Associated Universities (ORAU)** to bring together state representatives in the early stages of all major federal or private sector science initiatives to identify ways to stimulate consortial arrangements for multi-institutional proposals and to improve southern bidders' chances of success.

Pledging Mutual Support

When the request for proposals for the Superconducting Super Collider (SSC) was released, the Southern Technology Council (STC) and the Southeastern Universities Research Association (SURA) organized a meeting for state representatives to discuss strategies which—without compromising the competitive positions of individual states—might increase the chances that the SCC facility would end up somewhere in the South. As a result of this meeting, southern research universities made a commitment to create 100 new positions in high-energy physics, if any southern location were chosen. In addition, various groups of southern states formed their own consortial arrangements to expand their resources.

Centers of Excellence in Oklahoma



The Oklahoma Center for Advancement of Science and Technology (OCAST) initiated its first "Centers of Excellence" competition to spur collaboration among its universities and colleges and with the private sector. Building on the recommendation of the 1986 Commission on the Future of the South and the STC, OCAST will fund at least two multi-institutional, public-private R&D centers this year from among 14 proposals.

C. Give preference to collaborative R&D in state research grants competitions.

Collaboration among colleges, universities, and private sector is as important and as uncommon within the states as among the states. It is even less common with their counterparts in other countries. But turf battles over recognition and the administration of joint projects often prevent collaboration. Joint proposals may also require greater effort and higher costs to prepare. We therefore suggest that the **federal agencies** and **state research programs** encourage more cooperation by giving preferential treatment to multi-institutional and multi-national proposals.

D. Provide incentives for international information exchange and collaboration.

International contacts are essential to create the networks that lead to information exchange. Instead of setting up barriers, states ought to offer incentives for building such information networks. Further, although American researchers can often work successfully overseas because scientists and engineers in many parts of the world can communicate in English, they ought to be strongly encouraged to become proficient in at least one foreign language. First, **state legislatures** have to accept the fact that R&D is now global and the South cannot remain isolated. International exchanges must therefore be viewed as an important part of any R&D budget. Second, **universities** and **corporate R&D labs** ought to facilitate international cooperation in R&D by supporting travel and allowing research staff to work overseas periodically to develop ties to other nations, learn from them, and keep abreast of developments there.

Objective 5
To Expand R&D Opportunities for Small Firms

Small businesses are credited with having created the largest number of jobs in the American economy during the decade of the eighties. In fact, small and medium-sized businesses currently employ about 50 percent of the work force. Now, more than ever, they are facing stiff domestic and international competition. Yet, they are generally unable to invest in R&D to enhance their innovative capacity and competitiveness. The essential reasons for their reticence are scarce resources and a lack of information about new technological opportunities. The following actions are recommended to help correct this situation.

A. Set aside state research and development funds for small businesses.

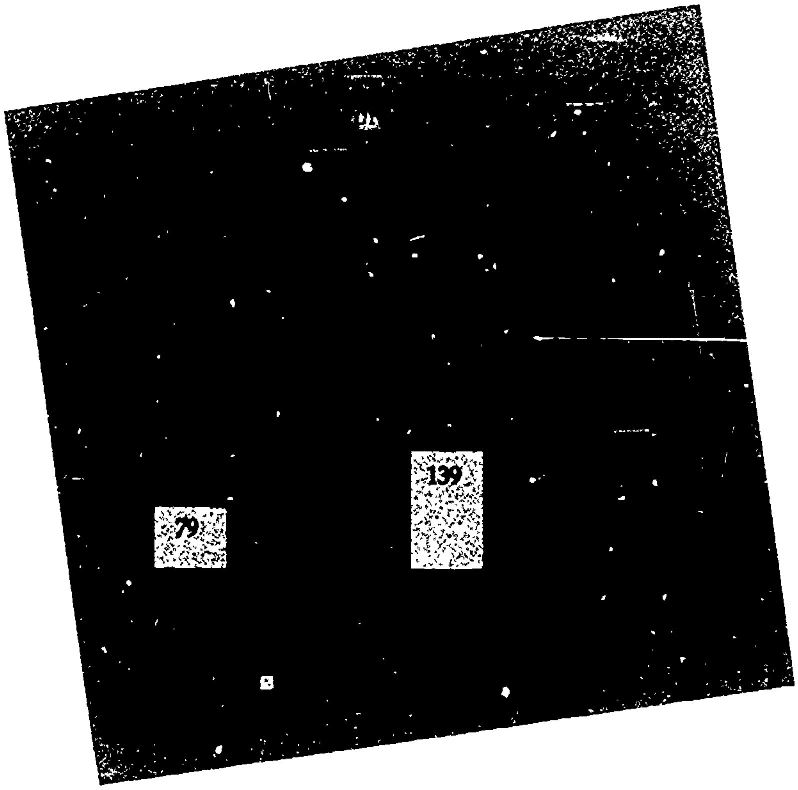
Small businesses, while highly innovative, are seldom able to carry out very much significant R&D. The federal SBIR program was created to encourage and support R&D by small businesses. We suggest that **state legislatures** which have not yet established such programs do so as soon as possible in order to provide the necessary information as well as start-up and matching funds. This commitment would send a message to small businesses that the state values and wants to strengthen their R&D and innovation capabilities.

B. *Expand small businesses' participation in the federal Small Business Innovation Research (SBIR) Program.*

Since its inception in 1982, the federal SBIR program has proven to be a very successful mechanism for stimulating research and development opportunities for small firms. Although some STC states have implemented programs or offices to assist firms in the SBIR application process, these assistance programs should be expanded—and established in states where they do not exist—in order to reach a greater number of potential applicants. In addition to promoting the SBIR program and providing technical assistance to small businesses who wish to apply, states can also provide matching grants to SBIR recipients and assist them in acquiring non-federal funds for commercialization. We suggest that the appropriate state agencies establish offices or programs to assist and expand small business participation in the federal SBIR program.

C. *Supplement SBIR award recipients to cover the time lag between support of feasibility study and development.*

A major shortcoming of the SBIR program is the time lapse between the receipt of funding for Phase I (the initial feasibility study) and Phase II (further development of the innovation). The gap in funding can last as much as a year, often leaving small business participants—who have invested heavily in the technical feasibility stage—extremely vulnerable as they await the research and development funds that will allow them to begin to implement the idea. We recommend that the state legislatures develop special SBIR support programs to be carried out by state economic development agencies in order to advance or supplement anticipated federal funds to promising projects confronted with this time lag.



Bridges to Success

New Jersey's Commission on Science and Technology introduced a special program to provide up to $10,000 per quarter for up to one year for "Phase I" Small Business Innovation Research (SBIR) recipients while they await funds for the next phase of their fledgling enterprises. The result has been greater participation in the program and a higher survival rate for firms that have received such bridge grants. In 1987, $300,000 in grants from the state leveraged more than $1 million in federal funds.

Rapid Commercialization of New Ideas and New Technologies

It is frequently noted that while the U.S. receives the Nobel Prizes, Japan receives the profits. The U.S. remains an undisputed leader in scientific research, but with the advent of the global economy, it has lost its leadership in translating research strengths into economic gain. In fact, the U.S. recorded its first high-technology trade deficit in 1986, and, despite the dollar's decline relative to other currencies, the country posted only a small surplus in 1987. Moreover, much of the high-tech trade deficit stems from losses in semiconductors, consumer electronics, and machine tools—industries in which the U.S. pioneered the basic knowledge and once held the advantage.

Allen Weiss

A Council on Competitiveness report, entitled *Picking Up the Pace: The Commercial Challenge to American Innovation*, states:

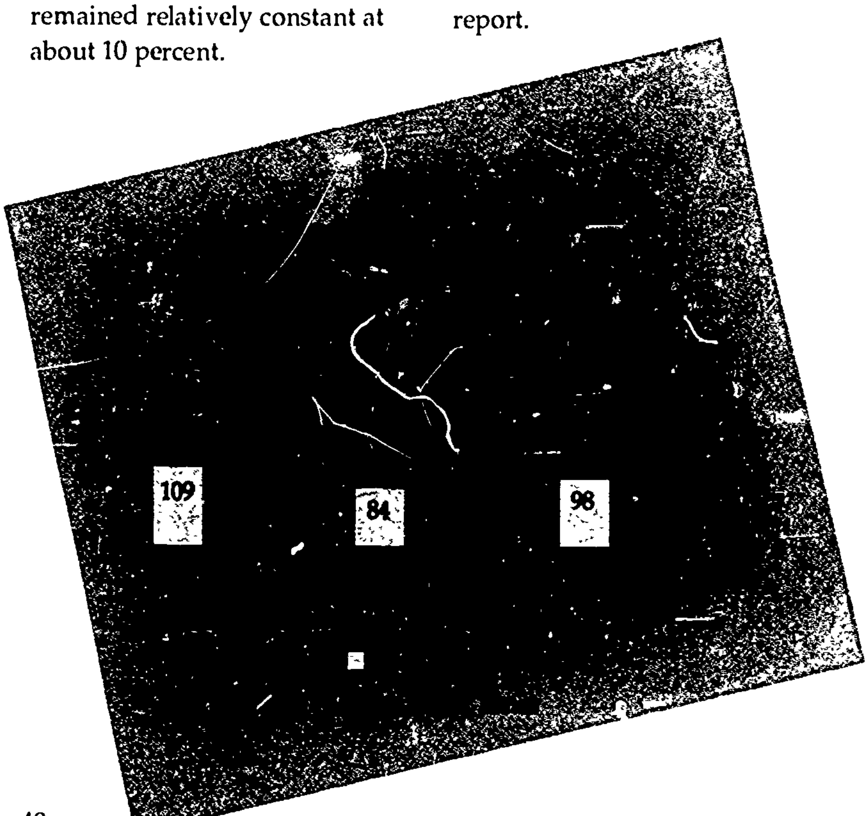
> America's primary problem in the science and technology field relates neither to entrepreneurship, research, nor the performance of its universities, but to the commercial application of technology. Considerable evidence suggests that America is failing to commercialize the kinds and quality of technology that the market demands.

The innovation process has changed, the report asserts, and the U.S. has been slow to adjust. Commercially successful innovation is no longer driven by research; it is driven by market demand. Thus, American firms can no longer be successful if they segregate their marketing, manufacturing and R&D functions. U.S. policymakers, too, must begin to develop market-sensitive science and technology policies. Japan has become extraordinarily successful in part because it has comprehensively integrated market demands with research and development priorities.

Driven by increasingly competitive pressures, the time lag between initial research and subsequent patent applications is growing shorter. The U.S. Patent Office provides perhaps the most vivid illustration of this trend. In the 1800s, patent applications generally cited research that was tens of years old. The research cited in today's patent applications is scarcely a few years old. The record of who actually submits patent applications is equally as revealing. Foreign residents increased their share of U.S. patents from 35 percent in 1975 to more than 46 percent in 1987—primarily because Japanese applications more than doubled.

In addition, the STC region still trails the rest of the U.S. in the number of patents issued per capita, although we have closed the gap somewhat over the past two decades. In 1987, the STC states received 98 patents per million residents, compared to 215 patents per million residents in the non-STC region. From 1980 to 1984, the region's share of high-tech patents issued in the U.S. remained relatively constant at about 10 percent.

Since the early 1980s, states have looked for ways to speed up the transfer of marketable ideas into commercial products and services without unduly disrupting the market system. Their most common interventions have involved exploiting the commercial potential of universities; supplying or encouraging higher risk, early stage financing; and providing special services to increase the rate of business formation for technology-based firms. The following objectives and strategies outline ways to improve the rate of commercialization of new ideas and new technologies by 1) building upon the scientific strengths in the region; 2) linking those strengths to market demands; and 3) providing the infrastructure and support necessary for effective commercialization. Other requisite support systems—specifically, a scientifically strong R&D and human capital base—are addressed elsewhere in this report.



Objective 1
To Encourage More Entrepreneurial Behavior on the Part of Universities and Their Faculties

Although many new ideas with commercial potential are generated within university settings, most academic environments are not as conducive as they could be to developing and exploiting commercial applications. And likewise, private industry and entrepreneurs are not taking full advantage of the research taking place at universities. Last year, just four universities in the U.S. accounted for 60 percent of all commercial licenses granted.

Institutions of higher education have been slow to adjust their policies and programs to take advantage of this potential, in part because of the friction that exists between entrepreneurial and academic cultures. Academic culture places the highest value on the freedom to pursue basic research that breaks new ground or expands knowledge, unencumbered by market needs or commercial constraints. Most research universities have nurtured the academic culture as the only haven for free inquiry.

Entrepreneurial behavior likewise requires certain elements of free inquiry—risk-taking and a willingness to fail—but it also requires pursuing research that will most likely lead to short-term, marketable results. We contend, however, that there is room at the university for both the potential entrepreneur and the pure scientist, and that universities ought not only to allow for both, but also to nurture both. Rewarding risk-taking behavior and the commercial activities of faculty members will encourage more entrepreneurial behavior within the universities.

The following strategies detail ways in which government, universities, and the private sector can work together to enhance and promote the technological and economic development role of the region's colleges and universities.

A. *Implement intellectual property management policies that reward the individual researcher as well as universities.*

Universities with patent and licensing policies that discourage the individual researcher by subordinating his or her income-generating opportunities relative to the institution stifle the patent potential of their faculties. Measures to balance this situation and reward both the institution and the researcher are necessary and overdue. Incentives to the researcher include not only financial rewards, such as licensing incentives and shared royalties, but also tenure and promotion rewards that recognize the value of commercialization activities. We recommend that **universities** assess their current intellectual property management policies and, where appropriate, adjust them to be true incentives. Additionally, we suggest that **state legislatures** consider rewarding universities that generate outside income through licensing and royalties.

Rewarding Innovation

Recent legislation in Louisiana specifically allows faculty and staff members of institutions of higher education to share in the "proceeds of patents, copyrights, licensing rights or royalties." At present, Louisana's higher education intellectual property policies generally allow a third of these proceeds to go to faculty or staff inventors.

B. *Allow non-academic researchers to use university resources.*

Industry could greatly benefit from access to university-based process and product development expertise. Yet, university faculty and facilities represent resources often left untapped by non-university researchers. Since university facilities are seldom in constant use, they could be made available at a fee to outside interests without sacrificing educational opportunities. In the bargain, graduate students would gain opportunities to work on actual industrial product and process development problems. Under a shared royalty agreement for private sector applications gleaned in a university setting with university support, both the university and private sector could benefit. We suggest that **universities** vigorously pursue such joint efforts with **industry**.

C. *Increase university equity participation in new companies stemming from university and joint university/industry ventures.*

Universities and the private sector are already involved in joint technology development, yet university participation is often limited to licensing and royalty agreements with private firms. However, universities can play a more active role in exploring the commercial applications of new ideas by actually participating in the formation of public/priva partnerships organized around new technologies. Such poten-

Sharing State-of-the-Art Equipment

In May, the Bowman Gray School of Medicine at Wake Forest University in North Carolina began operating MICROMED, a new intermediate voltage electron microscope center funded by the National Institutes of Health and the North Carolina Biotechnology Center. It is the only center of its kind in the country dedicated to medical research. The center has offered to open its resources to other research efforts and to train visiting investigators to use the equipment. During the program's first two months, twelve outside researchers took advantage of these opportunities.

tially lucrative—though risky—participation could lead to a higher rate of innovations, with more university research findings being incubated into useful products. We recommend that **universities** carefully consider the potential of equity participation in start-ups based on university and university/**private sector** research.

University Venture Capital

To date, only a few entities have been created to organize free-standing companies owned in part by universities. One is Commtech International, a limited partnership affiliated with SRI International of Menlo Park, California. Commtech has raised several million dollars to commercialize the technology generated at SRI, with equity to be shared among SRI, Commtech, and other investors. But returns take time; Commtech has been in business since 1983 and is just now marketing its first products. A more recent arrangement between Washington University and Alafi Capital Company has created a 50/50 partnership to incubate commercially viable ideas developed by the university.

D. *Expand university participation in high-tech trade shows and exhibitions.*

Trade shows and exhibitions for technology-related products and industries give university research centers an opportunity to display their capabilities, publicize research results, and learn about commercial applications and new markets. Although universities are not generally in the business of marketing their research capacities, they might find that with the right set of incentives—rewards to faculty, special state funding, potential university-faculty profits from joint ventures—trade show participation could lead to new and perhaps lucrative R&D projects. They might also increase their collaboraton with the private sector in R&D. We strongly recommend that **research universities** expand their participation in relevant trade shows and exhibitions.

Objective 2
To Accelerate the Dissemination of Research Results

Scientific and technological breakthroughs may take years before they can be applied commercially, if ever. Twenty years ago, delays simply meant that Westinghouse would be beaten to the marketplace by General Electric, or vice versa. An American company won either way. But today competition is global, and shortening the time it takes for a new idea to travel from laboratory to market has become a national priority. If the region's researchers were to apply as much energy into being the first to find new applications as they do in being the first to publish, faster innovation rates could be accomplished.

The competition for new commercial applications is often what drives research activity. Superconductivity is a good example; scientists all over the world are racing to achieve commercially applicable high temperature superconducters. But few fields of scientific endeavor enjoy the same level of media attention as does superconductivity. Most research simply lies buried in academic journals for much too long. Governments and universities could expedite the commercialization process by disseminating research findings more quickly and broadly. The following strategies outline ways to increase the flow of information on new research between those generating the research and those most able to apply it to new products and processes.

A. *Regularly conduct symposia and workshops with university, industrial, and financial sectors to present new research findings.*

Industry is often not fully aware of the vast array of research activities taking place at universities, and, in turn, university researchers are often unaware of the commercial possibilities of their work. This observation is especially relevant to our smaller universities, where resources often exist but are not tapped. Jointly-sponsored university/private sector workshops could highlight recent research activities, giving university researchers the opportunity to learn about industrial research and development needs. At the same time, such workshops would inform industrial participants about universi'y-based research and expertise.

The financial community in the South is even less aware of the commercial potential of the new ideas being generated at our universities, for it has yet .o come to terms with the changing financial requirements and accounting schemes needed to support technological innovation and commercialization. We recommend that **universities** and the **private sector**—including both the industial and financial communities—regularly schedule and participate in joint symposia to facilitate the transfer of new ideas into the marketplace.

B. *Establish a regional data base of expert technical resources and research activities.*

Timely, reliable, and accessible information is the cornerstone of a first-rate technology transfer system. Informational resources, such as computer data files of a state's current research expertise and activities, would serve a variety of industrial, research, and governmental needs, including quicker and wider dissemination of research findings. Such information could be accessed by businesses and the public sector looking for technical assistance, other researchers seeking colleagues for partners or information, and potential investors in search of marketable ideas. We recommend that **sta.e economic development agencies** develop similar data bases which would be reciprocally accessible to interested parties throughout the region.

Brokering New Ideas

Louisiana was the first state to implement a state-wide record of u i-versity innovations. In 1984, the state hired the Gulf South Research Institute to put into place Control Data Corporation's "Quest" system, which is designed to solicit, store, and evaluate ideas emanating from public and private research labs. In the first year of operation, 261 ideas or inventions were submitted and 87 were judged to have commercial potential. While some of these have gone to market, perhaps the most important result of the effort has been the establishment of Technology Transfer Offices at colleges and universities throughout the state. Similarly, the Oklahoma Center for the Advancement of Science and Technology (OCAST) has created the Oklahoma Technical Resources Network, a statewide data base delineating the research expertise of the faculties of Oklahoma's colleges and universities and of participating private companies.

Moving Technology Out of the Labs

Virginia's flagship technology initiative, the Center for Innovative Technology (CIT), began a three-year demonstration economic and technology development program in late 1987 in cooperation with the state's community colleges. In addition to providing assistance with product and service design, development, management, and marketing, the community colleges also provide the latest scientific and technical information through Virginia Tech's computer search capability. More than 200 projects were underway by the end of the first year of operation.

C. *Establish technology information brokers.*

New and small firms are often overwhelmed at the prospect of approaching universities for assistance with ideas with commercial potential. And, as pointed out earlier, universities generally are not accustomed to applied research and development. Yet there are a number of good information systems, including national systems, available at the South's universities, including NASA's Southern Technologies Applications Center (STAC) data base. Despite attempts to publicize these information systems, they remain underutilized because they are not easily accessible, because potential users are not aware of them, or because the users do not realize their potential value. Accordingly, more aggressive marketing of this capacity of universities to assist technologically-based businesses is necessary. We suggest that **state higher education agencies** establish selected, technologically sophisticated community college or university offices to serve as information and technology brokers among research labs, entrepreneurs, and small technology-based businesses.

Objective 3

To Increase Access to Equity Capital for Early Stage Financing

Lack of capital in the very early stages of product development and new business start-ups is a well-recognized barrier to commercialization. Traditional lenders—i.e., banks—are naturally averse to the risks involved in financing the early innovation stage. As a result, most innovators in search of financing beyond their families and friends rely on limited venture capital sources.

This tactic poses a particular problem in the South, which has far fewer private venture capital funds available to entrepreneurs. Of the top 100 venture capital firms in the U.S. in 1986, only one was located in the STC region. Of the $29.8 billion pool of venture capital funds available in the U.S. in 1987, only 2.5 percent were held by venture capital firms in the region. Even more revealing, however, is data concerning where the nation's venture capital is concentrated. More than 60 percent of the venture capital available last year was invested in just four states, none of them in the South.

Early stage financing usually requires close proximity between investor and inventor, due both to the nature of the risk and to the investor's desire to follow the project closely. Yet without adequate venture funds in the region, southern inventors are left without the support—both financial and advisory—that they need to commercialize their ideas. In addition, private venture capital firms are most often interested in relatively large investments and/or investments with a proven track record. They may overlook the large number of potentially profitable smaller and first-time projects. As a result, venture capital investments are increasing primarily in the areas of later-stage financing, follow-up investments, and leveraged buyouts; they are decreasing in the areas of seed and start-up financing. The same problem applies to new products. Even well-established companies find it difficult to finance the development of new products, particularly when they are based on new technologies.

Equity financing is critical to the early stages of product development. The following strategies address public and private responses to the lack of venture equity capital for early stage commercialization by expanding the sources and improving the means to match investors with entrepreneurs and inventors.

A. *Create product development financing corporations.*

One mechanism that states can employ to overcome the lack of risk capital available to new firms and for stimulating innovation among small firms is a product development corporation (PDC). PDCs provide grants to targeted firms for specified product development costs in return for royalties should the product be marketed successfully. Established PDCs in northern states—Massachusetts, Ohio, Pennsylvania, and Indiana—have already reaped impressive returns. We suggest that **southern state legislatures** authorize state development agencies to establish product development corporations that target new, technology-based businesses.

Nurturing New Firms

The Commonwealth of Massachusetts created a technology development corporation in 1979, at a time when the state was in the midst of economic recession. It was a bold move to build on the technological know-how of its universities and to provide capital for new or expanding high-tech companies. In 1985, the agency realized net gains of $130,000 and is credited with having created 1,300 new jobs representing $30 million in payroll.

B. *Form seed capital funds.*

Venture capital is readily available for the later stage financing of projects proven sound. However, higher-risk, seed capital—traditionally an equity investment—is in short supply. One approach addressing the shortage of capital in the very early stages of product and business development is to establish seed capital funds that tap both public and private sources of capital. South Carolina recently created the Palmetto Seed Capital Fund to make equity capital available to new and very young businesses in the state. In return for investing money in the fund, private investors are given state tax credits on their investments, as well as on the income and capital gains derived from their investments in specially targeted areas of the state. We recommend that **state development agencies** and **private corporations** consider the use of seed capital funds as part of an overall strategy to spur innovation.

C. *Expand investor networks and matchmaking services.*

The informal capital market is generally inefficient due to a lack of information about investment and investor opportunities. New entrepreneurs and innovators often do not have much knowledge about or access to information on potential investors, and investors may not have the technical understanding to trust the manufacturability or marketability of a new idea. Some localities with strong entepreneurial climates will generate these services spontaneously, but in most cases a catalyst is needed. We recommend a public role—through **university business schools** or **state economic development agencies**—in facilitating or brokering matchmaker services that link potential investors—both within and without the region—with technology-based innovators in the South.

Corporate Venture Capital

Du Pont Company is one of 87 corporations that sponsor venture capital programs to promote intrapreneurship—that is, innovation and new business start-ups primarily among Du Pont's own employees but sometimes including outside entrepreneurs as well. One component of Du Pont's venture capital program is called SEED, a three-year-old internal grant program currently sponsoring 23 projects. In an effort to move ideas into the marketplace as quickly as possible, Du Pont conducts early market research on a given idea before investing large sums of money in product development.

Venture Exchange in Tennessee

The Venture Exchange Forum is a network of entrepreneurs, researchers, management consultants, and investors that coalesced in 1985 to support the ideas of aspiring entrepreneurs. The group has become a stable, dues-paying organization that meets regularly to discuss new ideas. Administrative support for the 200-member group is provided by the Tennessee Technology Foundation.

Objective 4
To Expand Special Support Services to New, Technology-based Businesses

During the 1990s and beyond, the South's economy will be characterized by a high rate of business formation for small, technology-based companies. Those firms that become most successful will be those innovative companies that establish specific market niches in new products and processes. Accordingly, our current state economic development strategies need to be refined to reflect the changing make-up of firms in our economy.

The support system needed to nurture new technology-dependent businesses is quite different than the incentive structure used to attract branch plants. For example, new technology-based businesses have unique infrastructure requirements. Their essential needs relate less to water and sewer extensions and more to access to telecommunications, capital, technical expertise, and information—resources which may actually be available but not easily accessible.

One of the earliest strategies implemented to address these needs has been the small business incubator, a sheltered environment in which fledgling businesses can share services and obtain assistance and advice. Although incubators serve a variety of businesses, a recent survey of such programs indicates a clear preference for high-tech industries (86 percent). While the jury is still out on the cost-effectiveness of such incubator facilities, the early findings suggest that with proper selection criteria and sufficient support, they do greatly improve the odds of success for technology-dependent firms.

The following strategies identify resources in the region that can be expanded to help foster an environment that nurtures the rapid proliferation of flexible and competitive technology-based businesses.

A. Develop or expand high-tech business incubators.

An incubator can be either an actual facility or, more simply, an organization of firms and services structured to sustain a new business through its early growing pains. Because costs are lower due to shared support services, technical assistance and advice, firms participating in incubators have demonstrated a higher success rate than those who from the beginning struggle on their own. For technology-based businesses, the shared services can extend beyond the traditional low-cost space, secretarial support, and accounting services to include marketing, technical assistance, technical training, and finance packaging. In addition, states can encourage the creation of incubators through special tax incentives to both incubator sponsors and tenants. We suggest that **state economic development agencies** consider establishing incubator programs for targeted technology-based businesses.

B. Link the resources and expertise of universities to the needs of new, technology-based businesses.

Much of the expertise and technical assistance needed by new technology-based firms already exists at universities, but mechanisms for welcoming and processing inquiries from innovators in the field are generally **not** in place. University industrial extension services, where they exist, work primarily with established industries on product and process development problems and are not prepared to cope with the problems of young firms who are in the early stages of commercializing an idea. We suggest that **universities** build upon existing outreach mechanisms—such as **industrial extension** and **small business development assistance centers**—to provide assistance commensurate with the needs of businesses converting to newer technologies. In places where such mechanisms do not exist, we recommend that **universities** in conjunction with **state economic development agencies** establish offices or programs to serve as liaisons between existing resources and potential users.

Incubating New Technologies

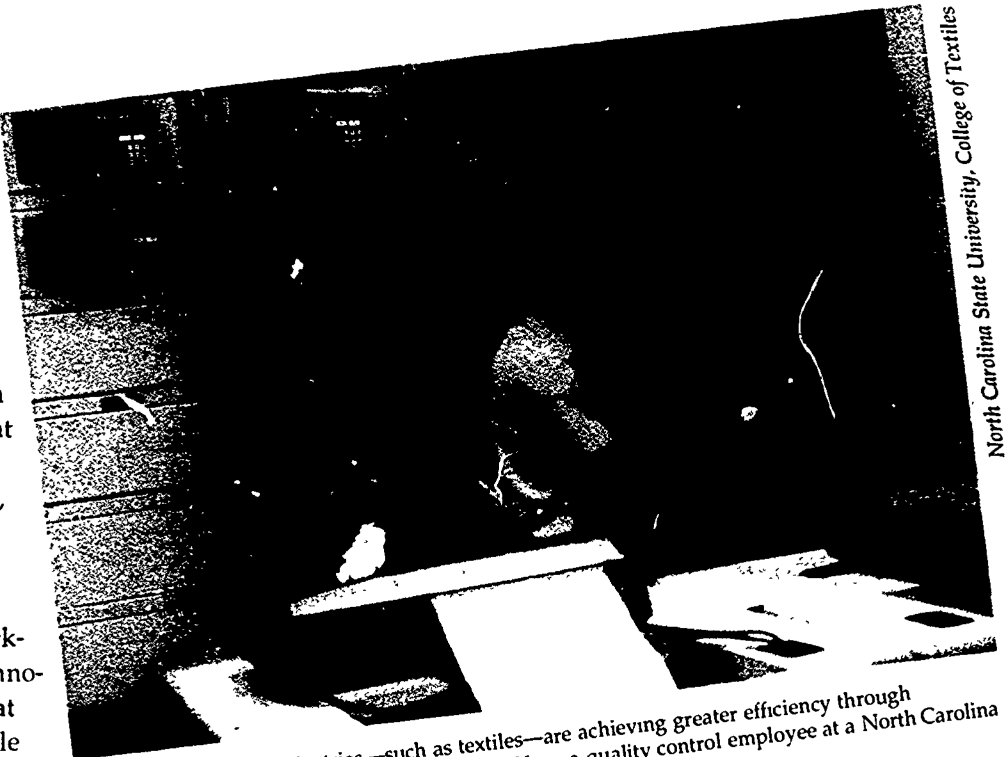
Georgia Tech's Advanced Technology Development Center (ATDC) serves as an incubator for technology-dependent start-ups and provides its tenants with the research expertise of the Georgia Institute of Technology. Created in 1980 as part of Georgia's comprehensive economic development plan, the ATDC provides both tenant firms and local industries with technical assistance, business management development, access to capital, and no or low-cost consulting services from faculty and private consultants. About 10 percent of ATDC companies are university spin-offs; the rest come from the local community. Since its inception, ATDC has worked with almost 100 companies, over 70 percent of which are still active. These firms now directly employ over 1100 persons, have combined annual revenues of more than $110 million, and generate about $12 million in state taxes.

C. Provide marketing assistance to new, technology-based businesses.

As the rate and scope of innovation continue to increase, the world is being flooded with new ideas and new products. Consequently, the need to identify specific market niches early in the innovation process becomes increasingly important. However, marketing expertise—including feasibility studies, market identification, distribution analysis, and servicing—is often beyond the capacity and resources of the small entrepreneur. Technology and marketing are the bacon and eggs of economic development, and the results are best when they are served together. We recommend that **universities**—with the cooperation of both their **business and engineering schools**—and **state economic development agencies** establish marketing programs to assist new, technology-based ventures in finding critical market niches.

Widespread Deployment and Effective Utilization of Technology

Commercializing new ideas and new technologies represents only one of the challenges to improved technology transfer. An equally important challenge is to put available innovations to use in our factories and offices so that southern businesses can operate with the greatest precision, highest quality, and shortest lead times.



North Carolina State University, College of Textiles

Traditional southern industries—such as textiles—are achieving greater efficiency through implementing advanced process technologies Here, a quality control employee at a North Carolina textile dye plant oversees a Supertex computer control system

Actually, many of these remarkable and seemingly recent technological advances are not all that new. Computer-programmable machine tools, industrial robots, and desktop computers have all been marketed since the 1960s, and statistical quality control methods have been known for decades. Yet moderately few businesses have taken advantage of their technological prowess to improve precision, quality, productivity, and services. A recent national survey indicates that less than 11 percent of all machine tools are computer-controlled, and fewer than half of all plants have even one computer-controlled machine. What's worse, more than a third of these plants have no programmable machines, have no plans to acquire any, and have not even considered such investments. Small southern firms, many of which are low-cost, labor-intensive operations, have been particularly slow to adopt new technologies and new methods.

If, as we contend, computer-based technologies and modern management techniques are vital to competitiveness, why have manufacturers and service providers in the South, particularly small and mid-sized firms, been so slow to invest in them? Has it been lack of information? Unavailability of capital? Risk avoidance? Deficiency of technical skills? Or lack of vision? In each instance, the answer is a qualified "yes." Is management up to the task? Do the new technologies live up to their promises? Is the public support structure inadequate? Again, the answer is affirmative.

Management, however, must accept some of the blame. Conventional accounting methods that favor short-term profits over long-term strategies, management practices that separate marketing design and production, and human resource policies that fail to maximize the skills and knowledge of the work force have each contributed to our low utilization rate of new technologies. As the Council on Competitiveness has pointed out, "The neglect of manufacturing arose largely out of the complacency of the 1950s and 1960s when the United States dominated international markets. Top U.S. managers began to focus on marketing and finance at the expense of manufacturing."

Policymakers also must share the blame. Until recent years, the importance of modernizing traditional industries in the manufacturing sector of the South's economy was not fully appreciated. The attention given to manufacturing was directed at the more glamorous, emerging high-tech industries—in hopes of producing another Texas Instruments or Data General—or at fledgling businesses. Too little attention was paid to the struggling traditional industries. This has been particularly true of the small and medium-sized enterprises.

Thus far, the major catalysts for modernization have been the vendors of new equipment, technical colleges, and, in some states, universities. Vendors, who have a strong interest in promoting sales, nevertheless are an important source of information about the latest technologies to the factory or office manager. In addition, some technical colleges and university industrial extension offices are equipped to go into the field and help manufacturers assess their needs and modernize their facilities. But these catalysts each have their limitations. The vendors are limited in scope, aiming first and foremost to sell their products, and at times overestimating the cost-saving benefits. The college and university-based programs are limited in scale, operating with too few resources and in too few places to adequately serve the tens of thousands of manufacturers and countless small service businesses in the South that could benefit from their services.

Now that the U.S. no longer securely leads the world in manufacturing quality and productivity, manufacturing support programs are making a comeback at the policy level. Many other countries are deploying new technologies more effectively and are advancing more rapidly than the U.S. in productivity. Reversing this trend is critical to the industrial future of the South. We believe that the region can set an example by raising its industries to world-class status. This effort would require public and private sector strategies to provide sophisticated technology transfer and technical assistance to existing industries, creative financing mechanisms to support innovation and technology utilization, and supportive infrastructure and environment for collaboration and cooperation among small, innovative firms.

Objective 1

To Make the "Best" Management and Production Practices "Routine" Practices Among All Manufacturers in the Region

The South's most productive manufacturers equal the best anywhere in the world. They are using the latest process and management technologies to their best advantage, often in new and innovative ways. They understand what it means to operate in a global economy and are aware of innovations occurring throughout the world. Obviously, these enlightened manufacturers are not the norm. They are most likely to be high-tech industries, large enterprises, or firms located in urban centers. Most southern manufacturers, however, are small enterprises in traditional industries located in rural areas at some distance from sources of up-to-date information and technical assistance.

More manufacturers—whether large or small, high-tech or traditional, urban or rural—must be elevated as quickly as possible to high standards of technology utilization. At present, only the most daring and far-sighted managers of small and medium-sized businesses are willing to risk investments in complex, often costly technologies.

It is possible, however, to accelerate the modernization process. One catalyst is the federal government. The Department of Defense, for instance, often favors contractors which have automated equipment. Thus, firms that bid on defense contracts are more likely to automate. Another catalyst arises within the private sector itself. With an emphasis on quality, precision, delivery, and service, successful buyer-supplier relationships are now based more often on long-term partnership arrangements than on the lowest bid. Larger, more sophisticated manufacturers find it beneficial to work closely with their regular suppliers, providing technical assistance, leased equipment, and even financing to meet production requirements.

State agencies and institutions of higher education can also become effective catalysts. The following strategies—which focus on technical and marketing assistance, training, and information about the latest technologies—are intended to make southern industry a model for the rest of the world through the use of the latest technologies and innovations.

A. *Establish or expand technology transfer centers and industrial extension for small and medium-sized manufacturers.*

Many small and medium-sized manufacturers lack the resources to adequately assess their technology needs or to solve their technical problems. Many others are simply unaware of the range of services already available to them.

Cooperative agricultural extension services have been widely touted as a model for American industry, and some southern universities have indeed established industrial extension services. The strength of cooperative extension lies in its accessibility. It offers localized, county-level services rather than centralized services housed at a state university. Through its statewide offices, Georgia Tech offers the most widely dispersed industrial extension services in the South, but most other industrial extension services operate out of single university-based offices.

We recommend that **state universities** support and expand such services and encourage the **federal government** to appropriate funds for a national industrial extension service, as authorized in the Omnibus Trade and Competitiveness Act of 1988. We further recommend that **state economic development agencies** carefully assess the work of the first Manufacturing Technology Transfer Centers of the National Institute for Standards and Technology (NIST) and consider replicating their most successful functions for other industrial sectors and in other regions.

New Federal Technology Transfer Initiative

The South's winning proposal for the first Manufacturing Technology Center, funded by the National Institute of Standards and Technology (NIST), is a collaborative effort among the University of South Carolina, Clemson University and the South Carolina State Board for Technical and Comprehensive Education. The Southeast Manufacturing Technology Center, established in December 1988, will aim its technology transfer activities at the small and medium-sized metalworking industries in South Carolina, with regional outreach to be carried out by the Consortium for Manufacturing Competitiveness, a network of thirteen technical colleges located throughout the South.

B. *Build and equip regional facilities to demonstrate and test process technologies.*

The risks of investing in new technologies are increased by the time required to apply them effectively. Firms rely heavily on vendors to identify applications and provide initial training. But in the early stages of modernization a demonstration facility where manufacturers could experiment with new equipment, train their employees and managers, and pilot test new processes or products on a sliding fee-for-service basis would further ease the risk and provide a more unbiasd assessment of future investments. Some universities and technical or community colleges have begun to develop such facilities, often in cooperation with equipment vendors, but most are still quite limited in scale and scope as well as underfunded. We recommend that **state development agencies, university colleges of engineering**, and the **private sector** expand the number and scale of advanced manufacturing demonstration and pilot facilities, seeking cooperative funds from users, private sector sponsors, and state government.

C. *Apply management practices that are appropriate to technologically advanced systems.*

Most industrial analysts now agree that authoritarian or Taylorist management methods inhibit innovation while participatory management stimulates it.

In other words, effective use of new process technologies is as dependent on innovations in *management* as in hardware and software. In fact, the most successful applications have occurred when firms reorganized to give production and technical service workers greater responsibility, autonomy and flexibility, and when production personnel began to work more closely with engineering and design personnel. If both **labor** and **management** are open to new relationships among the *entire* work force—workers, supervisors, managers, and engineers—then the application of new technologies is much more likely to achieve higher levels of manufacturing flexibility or service delivery effectiveness. We recommend that the **private sector** work with its employees and labor unions to devise and adopt management systems that support innovation and flexibility.

Consortium for Manufacturing Competitiveness

The Southern Technology Council (STC) has undertaken a pilot project—funded by the Appalachian Regional Commission, the Tennessee Valley Authority, the National Institute of Standards and Technology (NIST), and the U.S. Department of Education—to develop and demonstrate the capacity of two-year colleges to become catalysts for technology deployment. The Consortium for Manufacturing Competitiveness (CMC) consists of one demonstration technical college in each of the 12 STC states and West Virginia. It is developing procedures to help southern manufacturers modernize more effectively and also is providing outreach services as a regional arm of the federally-sponsored Southeast Manufacturing Technology Center in South Carolina.

D. Expand the missions of selected community and technical colleges to deploy manufacturing technology to small enterprises.

Thus far, two-year colleges in the South have been an underutilized resource in technology-based development. Through their special training programs for new and expanding industries, the schools have developed strong ties to the private sector and an explicit role in economic development. Their missions could and should, however, reflect a much more aggressive role in technology diffusion, especially to small and medium-sized businesses.

Such an expanded mission would require that schools upgrade their equipment and facilities, employ technically expert personnel, stay abreast of and disseminate information about new developments in manufacturing technologies, provide continuing education pertinent to manufacturing innovation, and generally support small and medium-sized businesses as well as larger firms and branch plants. We suggest that states' **two-year college** systems support technology deployment services among selected two-year schools by allocating funds for such programs outside the full-time enrollment funding formula.

E. Tighten buyer-supplier relationships to improve quality, delivery, and productivity.

American industry is learning the hard way that traditional buyer-supplier relationships that pit suppliers against one another for the lowest bid at the expense of quality, delivery and service do not result in globally competitive products and services. Today, higher quality standards, quicker delivery requirements, and needs for better service demand that manufacturers select their suppliers much more carefully and establish closer working relationships with them. The Japanese and Italians, for example, have strong links between suppliers and final producers, and their successes are being quickly emulated in other industrialized nations. Unfortunately, many small suppliers in the U.S. require technical assistance—usually from their larger, technologically sophisticated buyers, often in the form of loaned equipment and/or engineering and management assistance—to upgrade their production capabilities and reorganize their production methods to meet the new demands placed on them. We strongly urge that industry take the lead in promoting longer term, more cooperative and nurturing relationships with its suppliers in order to meet the technological challenges of the new economy.

F. Provide telecommunications access to all communities in the South.

Telecommunications networks are the highways of an information age. In fact, access to advanced telecommunications services rivals highways and airports in its importance to industrial competitiveness and location decisions. Closer links between buyers and suppliers and just-in-time inventory methods require immediate access to files for design changes, inventory inquiries, or new orders. Up-to-the-minute information on market fluctuations and industry developments around the globe is necessary to stay competitive. Furthermore, firms with access to telecommunications uplink and downlink capabilities can take advantage of informational resources, such as the National Technological University, which provides continuing management and engineering education to NTU members. Modern firms without access to digital switching devices today—and perhaps fiber optics tomorrow—cannot compete. We recommend that each **state legislature** use its regulatory authority to expand telecommunications access to as much of their state as possible, as quickly as possible.

Objective 2
To Increase the Availability of Debt Financing for Modernization and Expansion

Filling the financing gap that falls between venture capital and conventional lending is particularly important to the economy of the South, where the commercial banking industry in many states is on balance more risk averse than in other regions of the country and the venture capital industry is still quite limited. The modernization of the manufacturing sector will require individual firms to contemplate credit that both exceeds the risk profile demanded by most banks and does not yield the rates of return required by the venture capital industry.

The credit requirements of companies, particularly small companies, seeking to upgrade their technologies often outstrip the conventional risk limitations of traditional, deposit-based lenders for a variety of reasons. Advanced manufacturing technology can be difficult to assess using traditional accounting methods. It can also be expensive and difficult to value for collateral purposes. Further, its deployment often coincides with the expansion of working capital needs for design, training, marketing, distribution, servicing and similar requirements. Borrowers may simply need information about sources of credit—or they may need access to credit—which may exceed conventional limitations as a percent of assets or equity.

Other factors limiting investments in new technologies are the criteria on which costs are justified. Decisions to invest in new technologies are economic, as well they should be, but more importantly, they are also strategic. Traditional cost justification techniques used both by industry and its lenders are based on cost accounting principles that were designed for mass production in the days of stable markets and American industrial hegemony, not on the strategic needs of a global economy and its rapidly changing markets. In a recent national survey concerning how investment decisions in automation are made, only one out of 10 companies investing in computer-integrated manufacturing used strategic arguments to justify its investment.

Access to capital is even more difficult for minority and female-owned enterprises, when those enterprises are technology-based. The following strategies, which define a public role in expanding access to capital, present opportunities for targeting the modernization of the South's economy.

A. Assist conventional deposit-based lenders in establishing risk pooling mechanisms.

Traditional deposit-based lenders operating within strict regulatory guidelines and employing conventional underwriting criteria may not be able to meet the needs of small, technology-based companies. Many banks view all but the most routine small business lending as too expensive to be worth their time.

Deposit-based lenders can limit their risk by establishing pooled and specialized small business lending programs. Several banks acting as a consortium could finance the riskier portion of the debt requirements of their small business clients. Member banks would finance individually that portion of the borrower's credit needs which falls within their conventional risk limits, while the consortium would finance—using a pooled line of credit—the higher risk portion of the client's debt.

Also, some states are beginning to experiment with a new form of public loan guarantee that involves a cash contribution to a loan loss reserve fund established for each commercial loan that a bank makes. State contributions would permit the bank to build a higher loan loss reserve fund for higher risk projects. Such public contributions would be paid back to the state as individual loans are paid off without default or they could be rolled over to similar new loans that the bank might make. We recommend that **state economic development agencies** and **banks** explore various arrangements to assist conventional lenders in expanding small firm access to middle risk financing.

Access to Working Capital

In western North Carolina, firms that are able to finance equipment purchases still have difficulty finding sources of working capital. With the assistance of the Southern Technology Council, the Center for Community Self-Help in Durham, and the Center for the Improvement of Mountain Living at Western Carolina University, a small group of high-growth, technology-dependent firms is organizing a loan guarantee cooperative. Their combined deposits will improve their leverage and terms with banks, as well as give them greater access to short-term working capital on shorter notice than they could expect as independent, small businesses. Each firm will be able to borrow up to 80 percent of the total amount pooled after approval from the co-op's industrial review committee.

B. *Develop non-deposit-based financing institutions.*

A few states have begun to experiment with the design and development of non-deposit-based financing institutions known as Business and Industry Development Corporations (BIDCOs). These institutions seek to invest in firms that fall in the risk financing gap between conventional bank financing and venture capital, and they are capitalized by private investors rather than through customer deposits. They provide secured or unsecured debt just like a commercial bank, but, unlike a bank, they may take equity positions in the borrower. Moreover, BIDCOs usually provide more managerial and technical assistance to the borrowers than would a conventional bank. BIDCOs can be regulated by the state to help prevent fraud, self-dealing and mismanagement and to assure the private investor public oversight. However, such regulation should not attempt to limit the flexibility of BIDCOs by determining the degree and type of risk-taking. We recommend that **state legislatures** assist in the formation of state or regional BIDCOs and consider investing in or loaning public funds to BIDCOs to provide some incentive for their initial capitalization.

C. *Adapt cost accounting principles and procedures sensitive to the strategic value of investments in new technologies.*

Technology and technology development functions are treated as cost centers rather than strategic investments. Today, traditional accounting models that employ standard costs, allocate overhead to all new projects, and use standard payback period or cash flow comparisons send the wrong signal to investors and too often ignore strategic criteria such as expanding capacity, building flexibility, or improving quality to take advantage of new opportunities. Since investment decisions are fundamentally the responsibility of the private sector, we recommend that **businesses and financial**

institutions consider new accounting principles appropriate to new technologies and stategic investments. We also ask that **state legislatures** make sure that tax policies allow non-traditional accounting and encourage new investments that provide strategic advantages.

Objective 3
Increase Cooperation Among Firms and Industries to Achieve Greater Economies of Scale and Scope

The key to wider deployment of technology, we contend, will be cooperation. The conclusion of a national study for the Office of Technology Assessment and the National Science Foundation states:

> The most important thing that state industrial development organizations can do to assist small firms is to foster the development of new institutions—ones that support closer relations between suppliers and customers and help change the entrepreneurial culture, from one of go-it-alone small business driven by fear of cut-throat competition and believing that secrecy is necessary to protect competitive advantage, to one of 'cooperative competition,' where basic technical information is widely shared.

Cooperation is the secret to the industrial renaissance that has taken place since the early 1970s in the Emilia-Romagna region of northern Italy. By sharing resources and creating networks among small and often micro-enterprises, the region has managed to move from seventeenth to second in per capita income in Italy while maintaining its share of manufacturing employment at 38 percent. Service organizations, funded by the regional government and member firms, assist firms with financing, technology development, technical assistance, and overhead functions, while the firms themselves concentrate on what they do best—quality production.

Author David Osborne (*Laboratories of Democracy*) told participants at the 1988 annual meeting of the Appalachian Regional Commission that Appalachia needs to emulate Emilia-Romagna's collaborative approach to economic development. Cooperation can take many forms, he said, such as sharing information, training, and even equipment. The high initial costs of computerized equipment may be just the incentive needed for small and medium-sized firms to cooperate. Shared facilities, operated either independently or by colleges, could be used for testing, training, prototypes, or small batch production. The first steps toward shared advanced manufacturing in the U.S. are already underway in experimental pilot projects on shared flexible manufacturing facilities supported by the U.S. Department of Commerce, and by the Department of Defense in four states, including Mississippi.

The following strategies are designed to facilitate cooperative behavior among firms and industry sectors in an attempt to improve their ability to use new technologies for competitive advantage.

A. *Facilitate networking among small businesses.*

Cooperative manufacturing networks have become a new strategy for more effective marketing and production in much of Europe. Networks are formed as needed for cooperative

Network Support in Europe

The *Confederazione Nazionale dell' Artigianata* (CNA) in Emilia-Romagna is the largest small firm association in the region with 74,000 members out of a possible 139,000. The CNA handles general accounting for 44,000 of its member firms, prepares payroll for another 16,000, and files tax returns for more than 110,000 employers. In addition to providing fundamental business services, CNA has developed low-cost industrial parks, delivered technical training and managment education, assisted in trade shows and exhibitions, organized loan guarantee cooperatives, and negotiated contracts with labor unions. In addition to the CNA, ERVET (a regional service center established by northern Italy's regional government in 1974) manages a number of sectorally specific service centers that provide production, technical, and marketing assistance to their firms.

production, marketing, financing, equipment sharing, training, R&D, overhead, testing and quality certification Some firms in the U.S. are already successfully working together informally, but they have not yet begun to tap the potential of more formal networking practices. We believe such practices represent the wave of the future, and we recommend that **state economic development agencies** be the catalysts for network formation by providing technical assistance and supporting pilot projects.

B. *Review antitrust regulations and state action doctrine.*

Even though most cooperative initiatives among small businesses are probably not in violation of current antitrust law and doctrine, most small business owners (and quite possibly many attorneys who assist these companies) believe that cooperation is totally forbidden by federal statutes. Fear of antitrust litigation and the threat of treble damages, no matter how remote or unfounded, stifles the cooperation that might otherwise take place among small businesses. Although the U.S. Congress is currently considering legislation to amend federal antitrust statutes and to send a clear signal to the small business community that collaborative activity is not only legal but also encouraged, such legislation will take time.

Meanwhile, states should consider action at the state level to encourage cooperation among small businesses. Under the "state action doctrine" of antitrust law, the states may regulate certain classes of business in such a way as to remove those businesses from enforcement under the federal antitrust laws. Utilities and insurance companies are examples of industries exempt from federal antitrust enforcement by virtue of state regulation. We recommend that **state legislatures**, under the state action doctrine, offer the clear assurance of similar protection from federal antitrust enforcement for small firm collaboration and that the region support current efforts to enact federal legislature safeguarding cooperation among small enterprises.

C. *Expand participation in international trade—both in marketing and in acquiring new technologies and products.*

Small southern manufacturers are at a particular disadvantage in foreign trade. Few small firms are able to keep up with new advances in other nations or to know how to market their products and services effectively overseas. They lack sufficient knowledge of the language, metrics, and standards of the other nations. Export trading companies have been recommended by southern leaders, but they have not yet reached most manufacturers. With foreign markets growing rapidly and more new manufacturing technologies coming from other nations, international connections are more important than ever to technologically advanced firms. Yet, it is clear that only the largest firms have the resources to to explore international markets and resources without some outside assistance. We recommend that **trade agencies** expand their responsibilities and expertise through a cooperative approach to help more small, technology-based firms to engage in international trade and to provide greater technical assistance.

Integration of Science and Technology into State Policy

Arkansas Governor Bill Clinton joins Dr. Zhen Gzhi Sheng and Dr. Allen Herman, both of the University of Arkansas at Fayetteville, for a demonstration of supercomputer activity.

Robert Melhorn, Arkansas Governor's Office

Increasingly global economic competition, depletion of resources, rapid technological change, and growing concern about the natural environment are among policymakers' most persistent challenges and problems. In this dynamic setting, the promotion and application of science and technology for the survival and development of society have acquired added importance. Indeed, ad hoc, short-term, and unintegrated approaches to science and technology policy and planning are gradually being replaced by longer-term, more holistic strategies.

Today, almost all governments—in both industrialized and less-developed countries—are actively involved, directly or indirectly, in such pursuits. In Japan, for example, even though government funds account for only about two percent of total industrial R&D, the Ministry of International Trade and Industry (MITI) plays a powerful role in the development of industrial technology. Similarly, governments in Europe, via the European Community, are closely involved in setting science and technology-based development agendas. Even some of the least developed countries such as Nepal and Bangladesh, whose budgetary resources are far more meagre than those of most of our states, have created viable institutions and structures to undertake policymaking and planning for science and technology as instruments for national development.

In a democratic society, the role of the government in technology and science for civilian purposes is not to mandate or control but to *initiate*, *coordinate*, *guide*, and *promote*. The federal government in the United States has played this role in basic research for a long time through its various funding agencies. Now state governments are providing the vision and leadership to champion the cause of science and technology for economic development. But these efforts are still only "halfway home and a long way to go."

This is not to suggest that state governments have not taken any steps toward the making and coordinating of science and technology policy. Many states have established government or quasi-governmental agencies and given them primary, if not always comprehensive, roles in formulating and coordinating science and technology policies. Several states have appointed interdisciplinary advisory committees; some have even prepared multi-year science and technology plans.

It is vital that structures and mechanisms for science and technology policy at the state level be built where they do not exist and strengthened where they are already in place. State governments must formulate comprehensive and consolidated policies for the development of science and technology with short and long-term goals in sight. Such policies should strive to broaden the base of the policy process; to build consensus to the extent possible; and to convince the public that the science and technology policies so evolved are sound, feasible, and in its best interest. People from all walks of life—public officials and business leaders, scientists and engineers, teachers and journalists, experts and laymen—should be encouraged to learn more about the thoughtful applications of new technologies and invited to participate in discussions of technological alternatives.

Despite its potential, science is not a panacea for all problems. To the contrary, those considering strategies for technology-based economic development should also recognize that efforts to develop technologies can fail, that technologies can have unintended side-effects, and that, in some cases, they can result in potentially dangerous consequences. For instance, scientific and technological priorities may clash with environmental concerns, or vice versa. Policymaking and planning for science and technology ought to be socially responsible. Differences may never be completely resolved in a heterogeneous and democratic society, yet ways can be found to minimize conflict through structural adjustments, open dialogue, persuasion, and understanding. Science and technology are inherently neutral instruments; used wisely, however, they can provide untold benefits.

For science and technology to be accepted into the maintream of economic development, it must be accepted into the mainstream of popular culture and life. Science and technology are still somewhat a mystery to the average citizen, especially to the average television viewer. All too frequently, the scientist is portrayed by the media—and thus perceived by youth—as a little odd, somewhat of a recluse, and perhaps slightly deranged. "Dr. Strangelove" lingers in the public imagination as a typical portrayal. Until these images are changed for the better, the region—and the nation, too—may have trouble both attracting youth into scientific fields and convincing governments to appropriate adequate resources for research and development.

The following objectives and actions are recommended to help improve the stature of science and technology, to coordinate the states' technological strategies and synthesize them more fully with the states' overall economic development policies, and, finally, to protect the environment.

Objective 1
To Improve States' Science and Technology Policy and Planning

Science and technology initiatives at the state level are relatively new concepts. Traditionally, such concerns have been the purview of the federal government and of the private sector. During the 1960s, however, responsibility for regional economic development began to shift toward state capitals. In the 1980s, this policy of remanding responsibilities to the states has been pursued even more vigorously. Cutbacks in federal support for social and economic programs, increasing international competition, and a declining economy in the early 1980s compelled governors to take charge of economic and industrial development in their states. It was in this climate that state governments began to focus on science and technology as instruments of economic development. Our region was no exception. In fact, it has contributed both leadership and fresh approaches to integrating science and technology into state policymaking and planning.

If the state governments are to continue to play a leading role in championing the cause of science and technology, there ought to be a clear demarcation of the areas where state intervention is considered most critical and a careful delineation of exactly how these interventions are to be made. Science and technology programs and economic policies too often evolve in isolation from each other causing duplication, confusion, and inefficiency. To safeguard against these outcomes, the structure and mechanisms for science and technology policy and planning must be clearly defined and institutionalized. Coordination is a critical part of a sound policy process. The structures must have stable links with other agents of state's economic development policy, as well as external linkages with those whose cooperation in the making and implementation of the science and technology policy would be critical.

In addition, there must be sufficient political support, government authority, and technical expertise for these interventions to be viable and effective. Should, for example, states support the development of science and technology all across the board or should they concentrate on selected fields and projects? How should the federal and state governments collaborate in these efforts? Should state intervention be confined to research and development, or should it extend into areas of application by way of subsidies and grants to industries to capitalize on advanced technologies for plant modernization and related needs? Should there be state-level mechanisms to evaluate state-funded programs, or should evaluation be left to the agencies actually implementing programs and projects? Obviously the answers to these and similar questions will be decided by states' priorities and circumstances. The following actions are intended to help clarify positions on these matters, define policies, and set future courses of action.

A. *Establish a cabinet level office of science and technology in each state.*

The functions of this office would be five-fold:

1) to act in an advisory capacity on states' roles and formulate intervention strategies in science and technology;

2) to collect, collate and disseminate "vital statistics" on science and technology capabilities, achievements, and needs in each state;

3) to assist in the preparation of science and technology plans;

4) to provide the governor and legislature information and advice necessary to make rational decisions on science and technology matters; and

5) to monitor the progress of state-funded science and technology programs

We recommend that each **governor** maintain a cabinet-level office of science and technology with adequate staff support to perform these functions.

B. *Appoint a task force to identify the information needs for technology policy and planning.*

Data on science and technology indicators in the southern states are inadequate for most public policy purposes. Much of the available data are dated and scattered among many federal and state agencies and universities. The Council recommends that a task force be appointed to identify the type of data needed to best inform science and technology policy and to estimate the costs and benefits of such data collection and its dissemination. The recommended **office of science and technology** should then build a computerized data base (with the chosen indicators arranged in a standardized format), update the files regularly, and both observe and analyze trends. The **Southern Technology Council** would assist in standardization of data and the data collection procedures. The STC would also consolidate the data from various states and publish a regional report on a yearly basis.

C. *Create special structures for science and technology policy, planning, resource allocation, and assessment.*

As the experiences of some southern states suggest, the time for ad hoc approaches is past. Permanent structures for science and technology policy and planning must emerge. We suggest that **southern governors** take the lead in appointing permanent councils, commissions, or authorities for science and technology—providing them with a clear mandate and the authority to take a broad view of states' science and technology needs and to undertake science and technology policymaking, planning, implementation, and monitoring. These official bodies, reporting directly to the governor, would include representatives from government, industry, labor, education, and the scientific community and would be supported in their work by the recommended **office of science and technology**.

D. *Establish legislative committees for science and technology.*

Ever increasing state investments in R&D and technology place more and more responsibility on the legislatures to make informed decisions regarding allocations of funds. Legislators would benefit from specialized expertise that would help them to evaluate the merits and priorities of their state's science and technology plans, to make better resource allocation decisions, and to initiate necessary legislative action. A few states have such committees or subcommittees, but most states subsume science and technology under economic development and/or higher education. We suggest that the **state legislatures** create specific committees or subcommittees to handle issues related to science and technology, as the United States Congress has done.

A Legislative Initiative

The Florida legislature, under the leadership of House Speaker Jon Mills, established a committee on science and technology. Last year current Speaker Tom Gustafson expanded the committee into a committee for science, technology, and industry, with separate subcommittees set up for public utilities, science and technology, and industry. The committee's concerns include incentives to ensure the state's premier role in telecommunications, accelerating the development of space-related industry, and enhancing the educational infrastructure for science and technology.

E. *Prepare time-bound science and technology plans.*

Very few southern states have formal science and technology plans. This is not surprising, for even the federal government does not have such a plan for the nation as a whole. We recommend that the above mentioned **science and technology commissions** or councils work with state **legislative committees** to prepare science and technology plans at regular intervals. The purpose of the proposed plans would be to set long-term and short-term goals, assign responsibilities, recommend resource allocations, and outline implementation strategies. The plan might consolidate existing programs as well as initiate new ones. It would also become a working document for various state agencies to set their own science and technology goals and priorities in the light of the plan's goals and priorities. The **Southern Technology Council** could assist the planning process at the state level as well as coordinate the making of regional science and technology plans.

F. *Include science and technology representatives on boards and committees for state and local development.*

The effects of technology on the economy and the environment are—like the skills and knowledge required to assess them—truly vast. Incorporating these concerns into the various aspects of state planning is, therefore, an imperative. We recommend that **state departments of education, economic development**, and **natural** resources include on their planning boards and committees sufficient representatives with the proper expertise to help integrate science and technology into social and economic development planning.

One Southern S&T Policy Mechanism

Arkansas established a Science and Technology Authority in 1983. Its board of directors consists of government, business, and university representatives appointed by the governor and reporting directly to him. The Authority oversees Arkansas' science and technology efforts in relation to the state's economic development objectives, and its chairman and president advise the governor on matters related to science and technology. Notable among these initiatives are: Basic and Applied Research Grants, the Business Incubator Program, and the Seed Capital Investment Program.

Objective 2

To Change Public Perception of Science and Technology from "Threat" to "Opportunity"

Technology has always been viewed positively by some and negatively by others, although negative views of technology have generally declined over time. In industrialized countries, negative perceptions of technology are usually based on four assumptions: that technology displaces labor; that it may alter traditional life-styles; that it poses a threat to the natural environment and to human health; and that it clashes with religious beliefs and traditional morality. These assumptions tend to be stronger in rural communities than in urban areas. They have been instrumental in spawning powerful anti-science and anti-technology movements all over the world, and these movements have sometimes stood in the way of scientific and technological progress. Some religious sects reject modern technology because they see it as destructive to their traditional values and way of life. One suspects that countless other Americans as individuals might also share similar views, although they may not be as vocal and demonstrative about them.

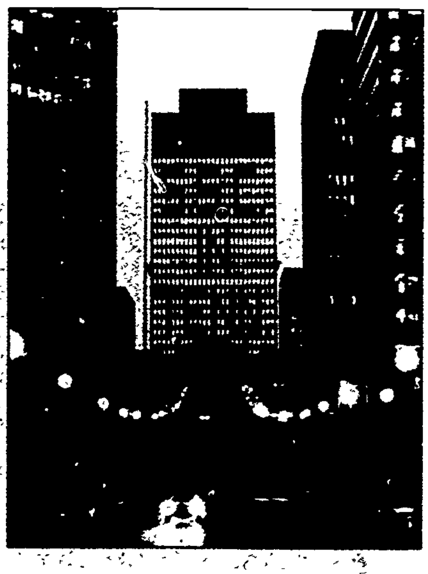
What needs to be communicated to the public is that the potentially dangerous consequences of technology can be avoided, and that technological opportunities for the betterment of the human condition far exceed the threats posed by them. These opportunities need to be explained in terms of concrete economic and social benefits, including new business opportunities, more and better jobs, better health and education, more comfortable lives, and improved public services. It should be easy to explain and demonstrate how automation has removed drudgery and danger from manufacturing; how it has improved the quality and quantity of manufactured goods without reductions in the work force; how electronics and computers have revolutionized our classrooms, offices, homes, hospitals, farms, and factories; and how small manufacturers and entrepreneurs have used modern technologies to build highly competitive and profitable enterprises—in short, how the common person has benefited from technological progress.

The following recommendations aim at informing the public about the benefits of technology and at suggesting that its potentially negative consequences are avoidable.

A. *Encourage more discussions of science and technology policy issues in public forums.*

The prestige of high-ranking public officials and community leaders can be brought to bear upon the task of creating a positive image of technology in the general public. Governors, legislators, contenders for public office, and academic and business leaders can discuss science and technology issues as part of their social and economic development agend› They can include these

Building Community Support for Science



Tennessee's approach to bidding on the Superconducting Supercollider (SSC) exemplifies the way that a community can become involved in science policy. Before a decision was made to bid for the project, the governor held planning meetings with all affected legislators, public officials, and community leaders to present the pros and cons and solicit their advice. He identified a single spokesperson at the state level whom any citizen could call over a toll-free 800 number with questions or comments. The state regularly conducted highly publicized community meetings throughout the process. Even though Tennessee ultimately was not selected as the SSC site, community support for science and technology grew as a result.

concerns in their major speeches. They can organize discussion groups in schools, colleges, and communities. They can write articles and op-ed pieces explaining their perspective. They can help to create community and statewide associations for the promotion of science and technology. The **Southern Technology Council** recommends that the state officials and business and community leaders initiate more debate and discussion on science and technology issues in diverse public forums.

B. *Encourage the media to highlight the social and economic potential of new technologies.*

The media, particularly television, has a strong influence in shaping and reshaping American images, attitudes and values. Television, oriented as it is toward commercial interests, has given scant attention to matters concerning technology and science. Most of the so-called "scientific programs" are simple science fiction—fairytales such as E.T. and Star Wars—aimed at capturing the imagination of children. But programs such as Bronowski's *Ascent of Man* and Carl Sagan's astronomy series were highly popular, presenting the rarefied dimensions of theoretical physics, astronomy, genetics, and evolution in everyday language. Why not produce a similar series on the more applied dimensions of technology and science in everyday life? Television programs like *Nova* and *Beyond Tomorrow* would be wonderful teaching and learning material in our elementary and secondary school science curricula. Television does occasionally inform and bring about positive images of modern medicine. But it does not do even half as much to inform the public about other social and economic development potentials of science and technology. We recommend that the **media** help inform the public more thoroughly about these potentials.

Objective 3
To Adopt a More Responsible Management and Stewardship of Technology

As noted, technology's potential to accomplish good for society is vast. But the misuse of technology can be immensely harmful. Disposal of toxic wastes is already causing insurmountable problems in the region's cities, forests, lakes ... ways. At the national level, the Congressional Office of Technology Assessment (OTA) has the responsibility to warn the nation about the potential hazards of new technologies. In the 1980s, industry has shown an increased environmental consciousness, but economic planning for the future must continue to be watchful. Users of technology must be equally responsible for its consequences. The role of state governments in building this responsibility at different levels of decision making through appropriate policies and programs cannot be overemphasized. More stringent laws concerning the proper use of the natural environment and the misuse of technologies must be legislated in the near future. New technologies are needed right away to clean the environment, and more attention must be paid to the development of environmentally sound new technologies.

A. *Regularly assess impacts of technology on economic, social and natural environments.*

Technology can be misused in a variety of ways. Poor standards of safety in consumer goods and factories; misuse of fertilizers and pesticides in food production and processing; indiscriminate destruction of land and forests; and irresponsible disposal of industrial effluents are just a few examples where neglect and/or selfish motives can cause great damage to the environment and, consequently, to the health and well-being of the South's people.

State governments and technology-based industry and services ought to evolve institutionalized mechanisms for assessing the impacts of technologies on economy and society. Such mechanisms may include technology assessment offices; groups or committees in the government and in industrial enterprises; consulting firms specializing in technology assessment; and citizen lobbies. Besides the OTA, many such groups exist in the nation. We suggest that southern **legislatures** and **industries** build similar institutional capabilities. The main criteria for the effectiveness of such groups would be the appropriate expertise and political mandate to participate in technological decisions by the government and corporations.

Pollution Prevention Pays

North Carolina has adopted the "pollution prevention pays" philosophy for environmental protection. This state program provides technical assistance, research and education, matching grants, tax incentives, and awards to reduce, recycle, and prevent wastes before they become pollutants. Matching grants are provided for the cost of the needed personnel, material, and consultants. The program staff help identify funding sources and refer firms to appropriate state or federal agencies. State laws allow firms to deduct the cost of equipment from state taxes and to exclude the equipment and facilities from property taxes.

B. *Provide incentives for minimizing adverse effects of technology.*

Numerous state and federal laws, public agencies, and non-governmental watchdog groups are already in place for the protection of environment. Yet most governmental regulation tends to be punitive, while most of the informal approaches are merely informative. A more positive and committed approach on the part of both government and industry is needed Technology users should be made aware of the positive and negative consequences that would follow compliance or non-compliance with certain standards. A system of monetary incentives in the form of tax credits along with honorific awards for industries who comply with environmental standards should be established. We recommend the establishment of ad hoc government-industry environmental groups in each state to examine these issues in collaboration with state economic development agencies, the state office of science and technology, and the state science and technology council or commission.

TAKING ACTION

Technological change is inevitable. Just as farming was not able to sustain the southern economy as it moved toward mid-century, prevailing industrial recruitment strategies will not sustain it into the 21st century. States must expand their development horizons to consider the impact of technology in their basic growth strategies.

Throughout this report, we have established a set of goals and objectives which we believe the South must achieve if we are to produce and use technology effectively. We have also suggested actions that can be taken to move us toward these goals. These recommendations are based upon successful programs already in place that could be emulated or expanded and upon innovative ideas from a variety of sources that we believe would be worth pursuing. Each state should set its own priorities for achieving these goals and objectives, either to adopt them outright or to adapt them to fit its own circumstances. We also encourage states to formulate new ways to achieve the objectives.

Above all, the Council wants to make the following point very clearly: Taking *no* action to advance the South's capacity to produce and use new technologies will not simply maintain the status quo. It will set us back.

State government action is only part of the picture. Many other actors in the regional economy have roles and responsibilities in bringing about the desired changes. **Businesses** will need to consider new ways to produce, use, and manage technology to remain competitive. The **federal government** will have to provide national leadership and share the costs of resources. **Workers** will have to be willing to learn new and higher-order skills and to accept new responsibilities. **Educators** will have to alter both curricula and teaching methods to accommodate the ways that technology affects the content of work and relationships in the workplace. And the **public** will have to acquire a better knowledge and appreciation of technology to participate in public decision-making regarding its applications.

The Council hopes this report will stimulate discussion and debate among government, business, education, labor, and the interested public. If it leads to disagreement, constructive criticism, or alternative objectives and action, those results will be every bit as valuable as acceptance and implementation. Ultimately, we want to spur "good" economic development. Good in this context means development that provides challenging and well-compensated work, that is not harmful to the environment, and that promises long-term stablity and a better quality of life for all.

We hope this plan will be given serious consideration by southern policymakers and that it will set an example for other regions in the nation to follow.

LEAD ACTORS FOR IMPLEMENTATION

GOAL 1 *Technically Proficient New Entrants in the Labor Market*	SGPB	STC	Business	Trade Organizations	Labor	Federal Government	State Legislatures	Governors' Offices	State E&T Agencies*	State ED Agencies**	State Higher Educ. Agencies	State E&S Educ. Agencies***	Universities/Colleges	E&S Schools****	2 Year Colleges	Non-profit Organizations
OBJECTIVE 1: To Raise Levels of Math and Science Competencies by High School Graduation																
A. Magnet schools to enrich education							●									
B. Less abstract and more concrete curricula												●	●			
C. Applied math and science in vocational programs												●				
D. Computer-assisted and distance learning techniques		●														
E. Practical experiences for math and science teachers			●									●				
F. Informal science education			●											●		●
G. R&D centers in math and science education						●							●			
OBJECTIVE 2: To Increase the Participation of Women and Minorities in Scientific and Technical Occupations																
A. Enrichment programs for women and minorities			●									●		●		
B. Balanced enrollments in enrichment programs							●									
C. School visits to talk to students about careers			●									●				●
D Support for HBCUs	●						●				●					
E. Transitional programs for women and minorities											●		●			
OBJECTIVE 3: To Produce More Flexible, Adaptable, and Innovative Technicians																
A. Identify technical skills for the future		●									●				●	
B. Require business experience and teaching skills											●	●				
C. Metrics for all students							●					●		●	●	
D. Coordinate high school and college curricula											●	●				
OBJECTIVE 4: To Increase the Number and Quality of Scientists, Engineers, and Technicians																
A. Loan forgiveness or subsidy programs						●	●									
B. Counseling institutes for technical carreers												●				
C. Domestic and international exchange programs			●										●			
D. Upgrade manufacturing engineering											●		●			
E. Expanded co-op engineering programs													●			

GOAL 2 *Upgrade the Skills of the Current Work Force*	SGPB	STC	Business	Trade Organizations	Labor	Federal Government	State Legislatures	Governors' Offices	State E&T Agencies*	State ED Agencies**	State Higher Educ. Agencies	State E&S Educ. Agencies***	Universities/Colleges	E&S Schools****	2 Year Colleges	Non-profit Organizations
OBJECTIVE 1: To Expand and Improve Continuing Education for More Technically Demanding Work																
A. Literacy and numeracy skill instruction			●						●			●				
B. Management of technology programs			●										●			
C. Simulate business settings			●						●	●						
D. Distance learning for technical instruction													●			
E. Unemployment insurance funds for retraining							●									
OBJECTIVE 2: To Improve the Private Sector's Technical Education and Training																
A. College transfer credits for work-based education			●								●		●			
B Basic competencies assesements			●									●				
C. Release time and rewards for skill upgrading			●													
D. Cost-sharing of training for technological change			●				●		●							
OBJECTIVE 3: To Encourage Workers to Invest Time and Resources into Upgrading and Expanding Skills																
A. Tax incentives for investing in retraining						●	●									
B. Increased cross-training as well as re-training			●		●											
GOAL 3 *Improvement and Expansion of Research and Technology Development*																
OBJECTIVE 1: To Attract and Retain Distinguished Reseaichers in the Region																
A. Stipends for talented graduate school candidates			●										●			
B. Increased salaries and endowed chairs			●										●			●
C. Environment of autonomy and recognition for R&D			●										●			
OBJECTIVE 2: To Target State Resources on Research and Technology Development in Strategic Areas																
A. Identify the strategic research needs		●						●								
B. R&D for strategically important technologies		●					●									

	SCPB	STC	Business	Trade Organizations	Labor	Federal Government	State Legislatures	Governors' Offices	State E&T Agencies*	State ED Agencies**	State Higher Educ. Agencies	State E&S Educ Agencies***	Universities/Colleges	E&S Schools****	2 Year Colleges	Non-profit Organizations
OBJECTIVE 3: To Increase Total Public Spending for R&D																
A. Extend and broaden EPSCoR						●										
B. Upgrade and share advanced research facilities							●						●			
C. Incentives for faculty to seek grants													●			
D. State tax policies to encourage investments							●									
OBJECTIVE 4: To Enlarge Multi-institutional Collaboration and International Exchanges																
A. Identify opportunities for collaborative R&D										●						
B. Regional large-scale research initiatives		●														
C. Preference for collaborative R&D						●				●						
D. International exchange and collaboration			●				●						●			
OBJECTIVE 5: To Expand R&D Opportunities for Small Firms																
A. Set aside state R&D funds for small businesses							●									
B. Expand participation in SBIR program										●						
C. Gap supplements between Phase I and Phase II							●			●						
GOAL 4 *Rapid Commercializaion of New Ideas and New Technologies*																
OBJECTIVE 1: To Encourage More Entrepreneurial Behavior on the Part of Universities and their Faculties																
A. Intellectual property management policies							●						●			
B. Non-academics' use of university resources													●			
C. University participation in new companies			●										●			
D. Participation in high-tech trade shows													●			

	SGPB	STC	Business	Trade Organizations	Labor	Federal Government	State Legislatures	Governors' Offices	State E&T Agencies*	State ED Agencies**	State Higher Educ. Agencies	State E&S Educ. Agencies***	Universities/Colleges	E&S Schools****	2 Year Colleges	Non-profit Organizations
OBJECTIVE 2: To Accelerate the Dissemination of Research Results																
A. Joint symposia			●										●			
B. Regional data base of resou. ᴗ and research										●						
C. Technology information brokers											●					
OBJECTIVE 3: To Increase Access to Equity Capital for Early Stage Financing																
A. Product development financing corporations							●			●						
B. Seed capital funds			●							●						
C. Matchmaking services										●			●			
OBJECTIVE 4: To Expand Special Support Services to New, Technology-based Businesse<																
A. High-tech business incubators										●						
B. Link resources and expertise to new businesses										●			●			
C. Marketing assistance to new businesses										●			●			
GOAL 5 *Utilization of Technology* **OBJECTIVE 1: To Make the "Best" Managemꞇnt and Production Practices "Routine" Practices Among All Manufacturers in the Region**																
A. Technology transfer for small manufacturers						●				●			●			
B. Build and equip regional facilities			●							●			●			
C. Improved management practices			●	●	●											
D. Expand the missions of selected community colleges											●		●		●	
E. Matching final market producers and suppliers			●													
F. Telecommunications access to the South							●									
OBJECTIVE 2: To Increase Access to Debt Financing for Modernization and Expansion																
A. Risk pooling mechanisms			●							●						
B. Non-deposit based financing institutions							●									
C. Cost accounting for strategic investments			●				●									

	SCPB	STC	Business	Trade Organizations	Labor	Federal Government	State Legislatures	Governors' Offices	State E&T Agencies*	State ED Agencies**	State Higher Educ Agencies	State E&S Educ. Agencies***	Universities/Colleges	E&S Schools****	2 Year Colleges	Media
OBJECTIVE 3: Increase Cooperation Among Firms and Industries to Achieve Economies of Scale and Scope																
A. Networking among small businesses										●						
B. Review anti-trust regulations							●									
C. Participation in international trade				●												
GOAL 6 *Integration of Science and Technology into State Policy*																
OBJECTIVE 1: To Improve States' Science and Technology Policy and Planning																
A. Cabinet level office of science and technology								●								
B. Task force to identify the data needs		●						●								
C. Mechanisms for science & technology policy making								●								
D. Legislative committees for science and technology							●									
E. Time-bound science and technology plans		●					●	●								
F. Science and technology representation									●	●	●					
OBJECTIVE 2: To Change Public Perception of Technology from "Threat" to "Opportunity"																
A. Science and technology policy in public forums			●					●	●				●			
B. Media to highlight potential of new technologies																●
OBJECTIVE 3: To Adopt a More Responsible Management and Stewardship of Technology																
A. Assess impacts of technology			●				●									
B. Incentives for minimising adverse effects			●				●									

* State Employment and Training Agencies, e.g. Employment Security Commissions, Employment and Training Councils
** State Economic Development Agencies, e.g. Departments of Commerce, Industry, or Trade
*** State Elementary and Secondary Education agencies, i.e. Departments of Public Instruction
**** Elementary and Secondary Schools, i.e. public and private schools and school districts

RESOURCES

Akin, James N., *1988 Teacher Supply/Demand* (Addison, IL. Association for School, College, and University Staffing, Inc., 1988); supplemented by unpublished data for 1989.

Apco Associates, *Federal Re rch & Development in the Sunbelt States* (Washington, DC. The Sunbelt Institute, 1988).

Baily, Martin Neil and Alok K. Chakrabarti, *Innovation and the Productivity Crisis* (Washington, DC: Brookings Institution, 1988).

Barke, Richard, *Science, Technology and Public Policy*, (Washington, DC: CQ Press, 1986).

Carnevale, Anthony P., Leila J. Gainer, and Ann S. Meltzer, *Workplace Basics: The Skills Employers Want* (Washington, DC: American Society for Training and Development, 1988).

Collins, Eileen L., "Meeting the scientific and technical staffing requirements of the American economy," *Science and Public Policy* 15 (October 1988), pp. 335-342.

Committee on Agricultural Education in Secondary Schools, Board on Agriculture, *Understanding Agriculture: New Directions for Education* (Washington, DC: National Academy Press, 1988).

Council on Competitiveness, *Picking Up the Pace. The Commercial Challenge to American Innovation*, 1988.

Dewey, John, *Democracy and Education* (New York: MacMillan Company, 1916).

Glasmeier, Amy, *Bypassing America's Outlands. Rural America and High Technology*, unpublished report, (Washington, DC: Rural Economic Policy Program, October 1988).

Government-University-Industry Research Roundtable, *Nurturing Science and Engineering Talent. A Discussion Paper* (Washington, DC: National Academy of Sciences, July 1987).

Henderson, Bruce E. and David C. Mowery (eds) *The Future of Technology and Work. Research and Policy Issues* (Washington, DC: National Academy Press, 1988).

Holmes, Barbara J. and Joslyn Green, *A Quality Work Force: America's Key to the Next Century* (Denver, CO. Education Commission of the States, 1989).

International Association for the Evaluation of Educational Achievement, *Science Achievement in Seventeen Countries* (Oxford, England: Pergamon Press, 1988).

Jackson, William M., "Black Colleges and Universities. A National Resource for Black Science and Engineering Manpower," in Antoine Garibaldi (ed) *Black Colleges and Universities. Challenges for the Future* (New York. Praeger Press, 1984), pp. 78-92.

Kelley, Maryellen R. and Harvey Brooks, *The State of Computerized Automation in U. S. Manufacturing* (Cambridge, MA: John F. Kennedy School of Government, Harvard University, October 1988).

Landau, Ralph and Nathan Rosenberg (eds), *The Positive Sum Strategy. Harnessing Technology for Economic Growth* (Washington, DC: National Academy Press, 1986).

Lapointe, Archie E., Nancy A. Mead, and Gary W. Phillips *A World of Difference: An International Assessment of Mathematics and Science* (Princeton, NJ: Educational Testing Services, January 1989).

Lillard, Lee A. and Hong W. Tan, *Private Sector Training: Who Gets It and What Are Its Effects?* (Santa Monica, CA: Rand Corporation, March 1986).

Magaziner, Ira C. and Robert B. Reich, *Minding America's Business*, (Harcourt, Brace, Jovanovich, 1982).

Mullis, Ina V. S. and Lynn B. Jenkins, *The Science Report Card: Elements of Risk and Recovery* (Princeton, NJ: Educational Testing Service, September 1988).

National Center on Education and the Economy, *To Secure Our Future* (Rochester, NY: National Center on Education and the Economy, 1989).

Neuschatz, Michael and Maude Covalt, *Physics in the High School: 1986-87 Nationwide Survey of Secondary School Teachers of Physics* (New York: American Institute of Physics, June 1, 1988).

Office of Technology Assessment, *Elementary and Secondary Education for Science and Engineering. A Technical Memorandum* (Washington, DC. Government Printing Office, December 1988).

Project 2061, *Science for All Americans* (Washington, DC: American Association for the Advancement of Science, 1989).

Radnor, M., A. Ahmad, and A. Wad, "Some Perspectives for Strengthening R&D Management in Developing Countries," in D. F. Kocaoglu, ed., *Management of R&D and Engineering*, North-Holland Publishing Company (in press).

Rosenfeld, Stuart A., "Sowing the Seeds for Growth: State Support for R&D in the South" *Economic Development Quarterly* 1 (May 1987).

Rosenfeld, Stuart, Emil Malizia, and Marybeth Dugan, *Reviving the Rural Factory. Automation and Work in the South* (Research Triangle Park, NC: Southern Growth Policies Board, 1988).

SRI International Public Policy Center, *The Higher Education-Economic Development Connection. Emerging Roles for Public Universities in a Changing Economy* (Washington, DC: American Association of State Colleges and Universities, 1986).

Schneiderman, H. A., "Making University Partnerships Work", *Across the Board*, May 1987, p. 28.

Shanklin, William L. and John K. Ryans, Jr., *Marketing High Technology*, (Boston, MA: Lexington Books, 1985).

Southern Technology Council, *Regional Centers of Excellence* (Research Triangle Park, NC. Southern Growth Policies Board, 1987).

Southern Technology Council, *Science and Technology in the Sunbelt, 1987*, (Research Triangle Park, NC: Southern Growth Policies Board, 1987).

Triangle Coalition for Science and Technology Education, *The Present Opportunity in Education* (College Park, MD: Triangle Coalition for Science and Technology Education, September 1988).

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Creating Strategies for Economic Development—the credo of the Southern Growth Policies Board—captures the new spirit and direction of the South's efforts to develop its economy and people. The twelve member states and Puerto Rico, who comprise the membership of the Board, have a new dedication to a healthy and sustained growth from within rather than without. This new model of internal economic development focuses on a new set of strategic issues, such as quality education, technology, cutting edge infrastructures, capacity building, and global sophistication. It also places new-found importance on the role of *state* government policies, the focus of the Board's work.

Created by southern governors, the Southern Growth Policies Board is a unique vehicle for regional cooperation and planning, as well as public-private partnership building. It is often referred to as the "think tank" for the South on economic development issues. Its small, high-level staff is led by the executive director and is located in the Research Triangle Park of North Carolina.

Inquiries concerning the Board's regular and special publications, conferences and meetings should be addressed to the Southern Growth Policies Board, P.O. Box 12293, Research Triangle Park, N.C. 27709. Telephone (919) 941-5145.

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P.O. Box 12293 • Research Triangle Park, N.C. 27709 • (919) 941-5145