A Governor's Guide to Building State Science and Technology Capacity

Since their initial meeting in 1908 to discuss interstate water problems, the governors have worked through the National Governors Association to deal collectively with issues of public policy and governance. The association's ongoing mission is to support the work of the governors by providing a bipartisan forum to help shape and implement national policy and to solve state problems.

The members of the National Governors Association (NGA) are the governors of the fifty states, the territories of American Samoa, Guam, and the Virgin Islands, and the commonwealths of the Northern Mariana Islands and Puerto Rico. The association has a nine-member executive committee and three standing committees—on Economic Development and Commerce, Human Resources, and Natural Resources. Through NGA's committees, governors examine and develop policy and address key state and national issues. Special task forces often are created to focus gubernatorial attention on federal legislation or on state-level issues.

The association works closely with the Administration and Congress on state-federal policy issues through its offices in the Hall of the States in Washington, D.C. The association serves as a vehicle for sharing knowledge of innovative programs among the states and provides technical assistance and consultant services to governors on a wide range of management and policy issues.

The Center for Best Practices shares knowledge about innovative state activities, explores the impact of federal initiatives on state government, and provides technical assistance to states. The center works in a number of policy fields, including agriculture and rural development, economic development, education, energy and environment, health, social services, technology, trade, transportation, and workforce development.

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The responsibility for the accuracy of the analysis and for the judgments expressed lies with the authors; this document does not constitute policy positions of the National Governors Association or individual governors.

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Foreword

As it did 100 years ago, America enters a new century marked by an economic environment of free trade, international competition, and global business relationships. In such an environment, U.S. economic strength depends on the ability of each state to "compete" successfully in the world marketplace. Each state must exploit the unique advantages it has relative to other states and build on the strengths found in its local "clusters of innovation"—distinct groups of competing and cooperating companies, suppliers, service providers, and research institutions.

To help their clusters of innovation thrive and compete worldwide, governors will need to work with their educational institutions and the private sector to build a skilled labor force that is second to none. State governments will need to leverage public research dollars and coordinate efforts with industry to build the science and technology infrastructure that brings new ideas to the marketplace and new technologies to traditional industries. Finally, states will need to eliminate barriers to business innovation, workforce training, and international trade.

In partnership with the Council on Competitiveness, the National Governors Association (NGA) has conducted a year-long effort helping governors develop economic strategies for a global marketplace. These strategies are designed to provide lifelong learning and training for employers and employees, strengthen science and technology capacity, develop international markets, and bring prosperity to disadvantaged communities. This new approach to economic development is a major shift from the traditional approach—which chiefly relied on location-based tax incentives to attract large manufacturing entities—and represents a more effective strategy for competing in the global economy.

To implement this effort, which began in July 2001, the NGA and Council formed a Task Force on State Leadership in the Global Economy. Under the task force, the NGA and Council sponsored regional workshops for state policy teams from around the nation to teach and discuss the approaches for cluster-based economic development. The NGA and Council also published four reports providing tools and recommendations for governors on the following topics:

- how to build a cluster-based economic development strategy,
- programs and policies for building a 21st-century workforce,
- maximizing public leadership in promoting international trade, and
- the role of science and technology in fostering an economy based on innovation.

State economies are the economic engine of America. To achieve their potential—both in terms of technology and human capital—governors must have access to the most sophisticated tools available for helping workers and industry stay competitive. The tools provided to states under this initiative should help foster a new understanding of economic development and ready states for the 21st century.

State Leadership in the Global Economy Task Force

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Executive Summary

What Governors Should Know

Today's state leaders face two economic challenges: to maintain national leadership in job and wealth creation and to compete successfully in a global economy. The key to both of these goals is innovative capacity. Why? Because innovation drives productivity growth, which, in turn, drives prosperity and justifies higher wages. Moreover, it creates the advanced products and services that capture global market share. As the *2002 Economic Report of the President* makes clear, the longest economic boom in the nation's history was driven by the development of new knowledge and the deployment of new technologies.[1] Yet, the competitive challenges for states have never been greater for several reasons.

First, rapid globalization is changing the parameters for economic success. As Thomas Friedman observed:

"If the Cold War were a sport, it would be sumo wrestling. If globalization were a sport, it would be the 100-meter dash, over and over and over. And no matter how many times you win, you have to race again the next day. And if you lose by just one-hundredth of a second, it's as if you lost by an hour."[2]

Globalization is forcing states to compete head-to-head with international competitors whose access to technology, talent, and capital sometimes rivals or exceeds their own. Those assets—often combined with lower labor costs—are attracting high-value investments by multinationals. Competing for business investment requires that states remain a moving target in research and technology—ahead of the increasingly rapid and global diffusion of knowledge and know-how.

Second, the pace of technological change is straining the capacity of state workforces to keep up. Jobs requiring an advanced technical degree are among the fastest growing categories in the labor market. But the number of science and engineering (S&E) graduates nationwide is declining. No state can fuel an innovation economy—either leveraging technology to grow new industries or applying technology to transform older ones—without access to the right kind of technical talent.

Third, high-quality and rapid product deployment are no longer the sole determinants of competitiveness and market success. Rather, they represent the baseline requirements just to get into the game. The basis of market advantage today is specialization, focused through regional clusters and driven, in large part, by the ability to develop and to deploy the specialized research, talent, and technology, as well as the linkages that support them.

Policy Priorities for States

Prospering in the global economy requires new ways of thinking about economic development and new strategies to catalyze growth. To build a foundation to support business innovation, governors should focus on four key areas:

- building on core cluster strengths;
- investing in specialized research and research facilities;
- creating pools of specialized talent; and
- catalyzing knowledge transfer and technology commercialization.

Building on Core Cluster Strengths

Business clusters create a robust mechanism that drives state economies forward because they act as incubators for innovation—not just for new industries like information technology or biotechnology, but also for the more traditional industries that must integrate new business models and technologies to survive in the changing global economy.

Clusters organize and catalyze collaboration among companies, their suppliers and service firms, academic institutions and complementary organizations. Companies in strong industry clusters can innovate more rapidly because they draw on the local networks that link technology, resources, information and talent. Close ties between cluster companies and local universities and community colleges help refine the research agenda, train specialized talent, and enable faster deployment of new knowledge.

The most common pitfall for state policymakers is to attempt to create new clusters where there are no preexisting advantages to build upon. No cluster—from furniture to textiles to semiconductors—is inherently low-tech or less productive. Every cluster can leverage technology for product or process innovation—and gain market competitiveness. Every cluster can add to the economic growth prospects for the state.

Governors play a critical role in helping their states answer the core question: "What are we good at?" States can help benchmark industrial assets, research competencies, and talent concentrations to understand where their economic strength resides. Starting from scratch or bidding companies randomly into the region only diffuses the asset base and slows down the cluster-building process.

Investing in Specialized Research and Research Facilities

Investment in basic and applied research is a critical first step in the innovation process; it creates the cutting-edge technologies that fuel job and wealth creation. Investment in infrastructure is equally important; state-of-the-art research demands modern research facilities.

The problem for states is that federal government investment in research, historically the mainstay of research funding, is static or even declining as a share of national wealth. Moreover, the investment is geographically concentrated in just a few states and heavily skewed towards the life sciences. This places regions without a biotechnology or health sciences concentration at a competitive disadvantage.

Governors can help bridge that gap several ways. First, they can integrate the research dimension into the long-term vision and strategy for economic development, focusing attention on science and technology (S&T) needs and opportunities in the state (this includes working with the state higher education system to ensure that the missions of state colleges and universities support the economic goals of the state). Second, state leaders can set aside pots of funding, to be matched by federal, university, or private funding, to support the specialized research capabilities that advance the state's economic base. Third, they can use their bully pulpit to leverage existing resources by coordinating investments in curricula, research centers, and research infrastructure among the institutions of higher education in the state.

Creating Pools of Specialized Talent

One of the most important (and sometimes unappreciated) dividends from investment in research is technically trained talent, not just new technologies. The availability of a specialized workforce is a key driver of the innovation economy and, increasingly, an investment magnet for international companies. CEOs report that the availability of technically trained talent is their top priority—one that often determines where they locate high-value investments.

Governors play a key role in building their state's talent pool in several ways. Some have instituted programs to increase S&E enrollments through scholarships and have cemented those gains by coordinating internship and job placement programs that help keep new graduates in the state workforce. Women and minorities represent the largest untapped pool of potential recruits, and states should consider targeting these demographic groups. State leaders also can work with the governing bodies of their universities and with the private sector to ensure the availability of curricula and educational programs that target the specialized talent needs of local businesses. Moreover, they can recruit star faculty, which attracts the best companies and the brightest students. Finally, states can work to attract out-of-state graduates and retain in-state graduates with specific skills important to local businesses through college loan assistance programs, internships, mentoring programs, and other means.

Catalyzing Knowledge Transfer and Technology Commercialization

Although knowledge creation is a critical first step in the wealth-creation process, knowledge creates no wealth unless it is used. While universities have made enormous strides since the passage of the Bayh-Dole Act more than two decades ago, most still see themselves as passive economic assets rather than proactive partners for economic development.

Technology transfer must become a key element in a university's culture and mission, and state universities must be measured by their performance. Governors can use their influence through the bully pulpit, state budget process, and other means to encourage state universities to achieve these goals. But, governors should recognize that the process does not begin and end with the university technology transfer office. Often called a contact sport, technology transfer only succeeds when a network of linkages is established between university researchers and the business community throughout the research cycle. This includes exchanges of personnel, collaborative research projects, and technical assistance programs for small and medium-size enterprises.

Finally, universities must leverage their alumni networks and get them involved in development activities related to emerging businesses.

States leaders can also catalyze public-private linkages in the commercialization process by encouraging university-based incubators, science and industrial parks, and technology partnerships. Several states have jump-started this process with seed funding for technology commercialization.

I Building on Core Cluster Strengths

While universities and research facilities can serve as an anchor to local and state economies, they most often do so in the larger context of regional clustering and local specialization. Clusters—geographically close groups of interconnected companies and associated institutions in a particular field, linked by common technologies and skills—represent a new way of thinking about the structure of the U.S. economy. But just as important, clusters represent an effective way for states to analyze, organize, and catalyze their science and technology (S&T) platform.

Clusters significantly enhance the ability of state and local economies to build prosperity because, in many ways, they act as the incubators of innovation. They possess the primary elements needed to transform ideas into inventions—universities or research centers that churn out new knowledge; companies that transform knowledge into new services or products; suppliers that provide critical components or equipment; and marketing and distribution firms to deliver the product to customers. The results are impressive: states with successful clusters enjoy higher average wages, productivity, rates of business formation, and innovation.

A critical, often missed step in state economic development programs is an assessment of industrial strengths and innovation resources—the basis for cluster development—and innovation output. As states increasingly compete on a global scale, governors need to know more about their states' competitive advantages than can be gleaned from a few case studies or success stories.

As a first step toward creating a vision for their state's economic future, governors need a comprehensive, integrated inventory and benchmarking of their economy—one that examines industrial assets, research competencies, and talent. This is necessary to understand where economic strength resides. Successful benchmarking efforts:

- Provide leaders with answers to questions that will impact a state's or region's economic development. For example: What are the state's existing and emerging industry strengths? How strong are the state's innovation inputs? What is the state's rate of innovation?
- Arm state leaders with an action plan that leverages strengths to ramp up future innovative activity, economic development, and specialization across clusters, regions, and the state.

Recommendations

Governors should appoint a group, perhaps within the state's economic development arm or a standalone entity, to benchmark economic performance, general business climate (tax burden, cost-of-living, etc.), industrial strengths, innovation output, and innovation resources across time. The types of indicators that can be tracked and measured include wage rates, research and development (R&D) funding within the state from various sources, S&T student graduation rates, patent formation, and a host of other variables (see Table 1). Taken together, all of the chosen indicators can paint a picture of how well a state is doing to support its platform for innovation and whether the state is progressing or not. Over time, the state's "benchmarking group" can use its accumulated knowledge to draft an economic development strategy that attracts high-value investment and high-wage jobs.

While data collection and compilation can be tedious and time consuming, the payoffs can far exceed the costs. Several states are already heavily involved in such efforts. One of the most advanced benchmarking efforts has emerged in **Massachusetts**. For the past five years, the Massachusetts Technology Collaborative has published an "Index of the Massachusetts Innovation Economy," which charts the economic performance, innovation capacity, and human and physical resources for nine industry clusters.[3] The index not only provides vital and timely information on the economy, but it also provides a framework for state leaders to make strategic investment decisions—across the state and across a variety of industry clusters.

Generally, such efforts allow communities to:

- benchmark against the best in the nation and the world, and across time;
- provide sustained public leadership and advocacy for a strong S&T portfolio to continue to raise living standards and improve innovative capacity;
- catalyze mutually beneficial S&T and cluster partnerships among regions, states and communities—allowing each party to work together to improve strengths; and
- establish an S&T assets/activities clearinghouse that can feed into larger regional development and cluster initiatives.

Table 1: Examples of Indicators States Can Use to Assess Economic Performance

Economic Performance

Indicator	Source
Unemployment level	Institute for Strategy and Competitiveness (ISC)
Employment level/growth	ISC
Industry clusters by state and metropolitan area	ISC
Regional median wage and wage growth, median wage vs. nation	ISC
Payroll/employee	ISC
Exports as percentage of gross state product (GSP)	International Trade Administration, U.S. Department of Labor, Bureau of Labor Statistics (BLS)
Business establishment growth	U.S. Department. of Commerce, County Business Data Patterns

Science and Technology Infrastructure

Indicator	Source
State R&D (total and percent of GSP)	National Science Foundation (NSF)
State R&D funding by federal government, state government, corporations/other (totals and percentage of GSP)	NSF
State R&D performance by federal government, state government, corporations/other (totals and percentage of GSP)	NSF
Research facility expenditures	State-collected data

Table 1 (Continued)

Education Programs

Indicator	Source
Expenditures per pupil as percentage of GSP	National Center for Education Statistics (NCES), BLS
Graduation rates	NCES
SAT scores	College Board

Workforce Development

Indicator	Source
Technical degrees as percentage of workforce	NCES, U.S. Census Bureau
Science and engineering graduates as percentage of workforce	NSF, U.S. Census Bureau
Business and management degrees as percentage of workforce	NSF, U.S. Census Bureau

Technology Transfer and Commercialization

Indicator	Source
Number of university license agreements	Association of University Technology Managers (AUTM)
University revenue from licensing agreements	AUTM
Patents	Patent & Trademark Office
Venture capital investments—by state and/or sector	PricewaterhouseCoopers
"Angel" capital and seed capital	State-collected data
Initial public offerings—by state and/or sector	Hoovers.com

II Investing in Specialized Research and Research Facilities

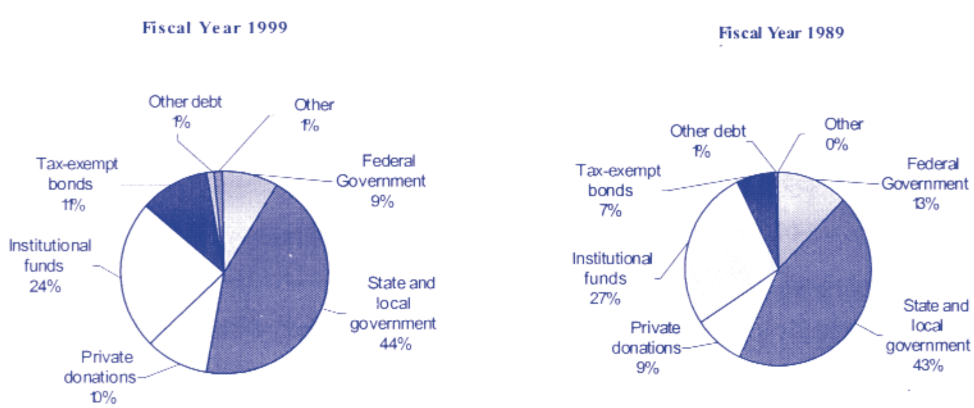
World-class research is a passport to success in the global economy. Industry can no longer compete by selling standard products made with standard processes and that could be produced anywhere in the world at lower cost. Businesses must constantly innovate to raise the quality of production, introduce new product lines or services, and add greater value to their outputs. For this reason, states must create an environment that supports continuous innovation. This requires investment in cutting-edge research, facilities, and equipment. Although industry research and development (R&D) investment is critical to economic competitiveness, it often is encouraged by robust government investment in research. Companies appropriately target their R&D spending on development, not on knowledge creation and discovery. Moreover, companies that spend significant R&D dollars tend to locate in areas rich in public R&D investment.

Most states face significant hurdles in creating a world-class research environment. The first is funding. The mainstay of funding for every state's university research is the federal government, which accounted for approximately 58 percent of R&D in 2000 (down from a high of 73 percent in the mid-1960s). Unfortunately, federal support for research as a share of national wealth today is well below the benchmark high of 3 percent of GDP. Moreover, the distribution of federal research funding is skewed institutionally, geographically, and by discipline. According to the National Science Foundation, the top 200 universities accounted for approximately 96 percent of R&D expenditures in 1999.[4] Just the top 100 universities received 80 percent of $22.1 billion in total federal research dollars.[5] And, nearly half of those dollars went to just five states: **California**, **Massachusetts**, **Michigan**, **New York**, and **Texas**.[6] Finally, the majority of research dollars go into the life sciences, with static or declining funding for the scientific fields that underpin most of the other industrial sectors in the economy.

Research infrastructure faces similar problems. According to a survey conducted by the National Science Foundation (NSF), state and local governments are the largest contributors to the new construction, repair, and renovation of research facilities at public institutions. From 1989–1999, state and local governments' shares of funding remained steady at 43 percent to 44 percent (see Figure 1).[7] In contrast, the federal government contributed a significantly lower and declining share, dropping from 13 percent to 9 percent over the same 10-year period.[8]

Despite the need for cutting-edge facilities, NSF found that from 1988–1998 the amount of laboratory space at universities requiring repair or renovation increased in every science and engineering field and doubled in

Figure 1. Funding Sources for New Construction and Repair/Renovation of Research Facilities at Public Universities and Colleges



Source: National Science Foundation, Science and Engineering Indicators 2002, *Volume 2.*

II

Michigan's NextEnergy Initiative[i]

In April 2002, Michigan Governor John Engler launched the NextEnergy Initiative, "a comprehensive set of actions and incentives designed to position Michigan as the world's leader in alternative energy technology research and development, education and manufacturing."[ii] Michigan officials have recognized that the rapid technology in new, alternative fuel systems, such as fuel cells, is likely to be the next major breakthrough in the automotive industry, with potential significant impacts on automobile design and engineering and jobs. According to the Center for Automotive Research, the advent of new power systems to replace the internal combustion engine has put as many as 200,000 jobs at risk.[iii] At the same time, the nascent fuel-cell industry represents a potential windfall for the state in terms of revenue and new job generation.

The NextEnergy Initiative utilizes a multipronged approach. A central component is establishing a NextEnergy Center modeled on a clusters approach. To accelerate the development of the alternative energy industry, the center will:

- assist universities and companies applying for federal research and commercialization funds;
- fund industry-university collaborative research and commercialization projects;
- serve as a clearinghouse on alternative energy companies, programs, projects and developments around the world;
- develop community college, undergraduate and graduate programs in power electronics, alternative energy-enabling technologies, fuel-cell technology, and other related fields;
- raise scholarship funds to increase the enrollment of students in these programs; and
- develop industry support services in market assessments, roundtables, and collaborative research partnerships with the Michigan NextEnergy Council.

The NextEnergy Initiative also will establish a federal research facility as part of the center. According to a Deloitte & Touche study, there is no single location for alternative energy research sponsored by the U.S. Department of Energy and other federal departments.[iv] The same study suggests the importance of further standard-setting for stationary and mobile fuel-cell technology to facilitate mass production of the technology.[v] The facility, then, would act as an "underwriter's laboratory" to develop standards and certification systems, and to identify research gaps and needs. Other envisioned functions include: a collaborative testing facility; collaborative industry-university research and development programs; and sponsorship of national conferences and workshops to build industry visibility and transfer knowledge.

To jump-start the process, the Michigan Economic Development Corporation (MEDC) and the state legislature has proposed a legislative package to help create a state authority to govern the NextEnergy Zone, including funding for a 700-acre area that will house the center, research facilities, incubators and other critical infrastructure. The bill also includes tax exemptions and credits for alternative energy companies and individuals purchasing stationary and vehicular devices using the alternative technologies.

i NextEnergy website: http://www.nextenergy.org. Accessed 14 May 2002.

ii *NextEnergy: An Economic Development Plan for the NextMichigan*. NextEnergy website: http://www.nextenergy.org. Accessed 14 May 2002.

iii Ibid.

iv Ibid.

v Ibid.

other fields.[9] In 1999 the total estimated cost for all deferred construction and repair renovation projects was approximately $13.6 billion.[10] Sixty-five percent of the cost was attributed to new construction and the remaining 35 percent to deferred repairs and renovations.[11]

While infrastructure is far from a "hot topic," the quality of research depends, in large part, on the sophistication of research facilities and equipment. Moreover, there is a strong link between state-of-the-art laboratories and a state's ability to attract top-tier faculty, students, and research dollars.

Despite tight budgets, state leaders must help to fill this funding gap. By making a commitment to fund research and strengthen the state's R&D infrastructure, the state can dramatically improve its ability to attract federal and private-sector research dollars. Nevertheless, funding alone cannot take the place of establishing a clear vision for R&D support. State leaders can create the vision and strategy for economic development and can integrate research capabilities into the overall goals for the state economy. Governors can help target investment in the research areas that underpin the state's economic base, directly relate these to the state's long-run vision for improving its economic indiators, and catalyze private-sector partnerships with university and government. Using their bully pulpit, governors also can encourage better collaboration among state institutions of higher education to leverage existing resources more effectively.

Recommendations

Develop Strategic Research Programs Based on Core Strengths. Although several states are strategically investing in specialized research, programs in California and Michigan illustrate some of the best practices for state leaders. In April 2002, **Michigan** Governor John Engler launched the NextEnergy Initiative, a comprehensive action plan and set of incentives to position the state as the world leader in alternative fuel energy and, more specifically, fuel cells, a scientific technology that may have enormous impact on the automotive industry in terms of automobile design, engineering, and jobs.[12] The development of fuel-cell technology has wider commercial implications and represents a potential windfall for the state in revenue and job generation.

Designed with a cluster approach, the NextEnergy Initiative is establishing a research center designed to accelerate the development of the alternative energy industry. The center is helping universities and companies apply for federal research and commercialization funds, funding industry-university collaborative research and commercialization projects, and raising scholarship funds in related curriculum.[13] Another initiative goal is establishing a federal research facility to develop standards and certification systems and to provide a collaborative testing facility for industry-university R&D programs.[14]

Nanotechnology, the application of science to control matter at the molecular level, is an emerging scientific field with potential for tremendous advances across a variety of industry sectors. **California**, with its top-tier research universities and history of strong federal R&D support, recognized its position to be a leader. In early 2001, Governor Gray Davis announced the state's commitment to invest $100 million over four years to create the California Center for Science and Innovation. As part of this initiative, the California Nanosystems Institute (CNSI) has been established on two University of California campuses, Los Angeles and Santa Barbara.

CNSI research focuses on developing energy-efficient technologies for lighting, computation, and communications; environmentally sustainable manufacturing approaches; and new biomedical and biomolecular technologies for medical diagnostics, molecular therapeutics, and sensing and responding to biotoxins. CNSI also recruits and trains graduate students and postdoctoral scientists and encourages technology commercialization via startup companies and joint CNSI/industrial research agreements.

As of fall 2001, the state's investment in CNSI has been leveraged with approximately $80 million in federal R&D grants awarded to the

California Nanosystems Institute (CNSI)

Nanotechnology, the application of science to control matter at the molecular level, has the potential for tremendous advances across a variety of industry sectors. Yet, despite the exciting possibilities of this field, its relative risk and novelty has not attracted significant private sector investment—as would be expected. Instead, as with most frontier research, federal agencies have taken the lead in funding. In fiscal 2001, the federal government committed approximately $495 million. Additionally, the National Science Foundation has established regional Nanoscale Science and Engineering Centers throughout the United States.

California has poised itself to be a big player in nanotechnology. In early 2001, Governor Gray Davis announced the state's commitment to invest $100 million over four years to create the California Center for Science and Innovation. As part of this initiative, the California Nanosystems Institute (CNSI) was established, based at the Los Angeles and Santa Barbara campuses of the University of California.

CNSI research is focused on developing energy-efficient technologies for lighting, computation, and communications; environmentally sustainable manufacturing approaches; and new biomedical and biomolecular technologies for medical diagnostics, for molecular therapeutics, and for sensing and responding to biotoxins. CNSI also recruits and trains a top-tier pool of young students and postdoctoral scientists and brings the discoveries to the marketplace via startup companies and joint CNSI/industrial research agreements.

As of fall 2001, the state's investment in CNSI has been leveraged with approximately $80 million in federal research and development (R&D) grants awarded to faculty at the Los Angeles and Santa Barbara campuses. Another $100 million in proposals has been submitted. CNSI has received more than 30 percent of its $31-million goal in corporate support.

North Carolina State University Centennial Campus[i]

Centennial Campus is North Carolina State (NC State) University's vision for a "technopolis" of university, corporate, and government R&D facilities and business incubators, with a town center, executive conference center and hotel, upscale housing, and recreational amenities. Currently, the campus is home to more than 100 large and small companies, government agencies, and NC State units.

A major advantage to corporate and government research and development (R&D) groups in locating on Centennial Campus is shared access to university research laboratories and equipment. The university has developed a fee-for-service policy for sharing these facilities. This arrangement provides access to millions of dollars in equipment to companies who do not own or desire to own such assets. The laboratories are staffed and monitored by highly trained university faculty and technicians, absolving corporate partners from personnel and maintenance costs.

Other partnership opportunities at Centennial Campus include:

- contract research conducted by university faculty and students surrounding a specific company problem;
- graduate students to supplement technical R&D teams, working as interns or employees;
- undergraduate interns, co-ops, or part-time employees;
- sponsorship of senior design projects for engineering students;
- collaborative research proposals to government- and industry-funding agencies;
- memberships in university centers of excellence, pooling R&D funds to solve major industry problems, and sharing ownership of the results; and
- licenses to commercialize products based on university-owned patents through NC State's Office of Technology Transfer and Industry Research (OTTIR).

For NC State, the cross-fertilization of corporate research partnerships pays dividends not only in increased financial support for research, but also in providing opportunities for students to adapt their training to the needs of the corporate world. Graduate students are a major research resource. In addition, undergraduate students play an increasingly important role as opportunities are created to combine research and academic programs through internships, corporate "shadow" programs, and cooperative education assignments.

The creation of Centennial Campus has resulted in approximately $35 million annually in government- and industry-sponsored research support for NC State programs. Even more impressive is the self-sustaining nature of this effort. The cumulative research funding on the Centennial Campus exceeds the total costs of campus development every seven to eight years.

[i] North Carolina State University Centennial Campus website: http://centennial.ncsu.edu. Accessed 30 May 2002.

faculty at the Los Angeles and Santa Barbara campuses. Another $100 million in proposals has been submitted. CNSI has also received more than 30 percent of its $31-million goal in corporate support.

Like the Michigan and California examples, several other states have targeted funding based on a careful review of their economies. For example, **Kentucky**'s New Economy Strategic Plan identified specializations, such as imaging, energy, and agricultural, with a strong or growing presence in the state.[15] Kenutcky is funding research centers connected to its universities and colleges. Likewise, **Kansas** supports its clusters in aviation, biomedical/pharmaceutical, information technology/communications, manufacturing, and polymers/advanced materials through centers of excellence affiliated with a local university. **North Carolina**, a state with a long tradition in textiles, provides financial support for the Hosiery Technology Center (HTC) and its research and testing facility. HTC has taken the lead in helping local hosiery companies adopt new technologies and materials to compete in an industry driven by low costs.[16]

Optimize Existing and New Research Infrastructure Through Public-Private Partnerships. By its nature, basic science is a risky proposition—a large amount of resources can be expended with no guaranteed return. Thus, publicly supported research facilities shared among businesses and academic institutions create a competitive advantage for states and an effective use of public dollars. For example, corporate and government R&D groups located on **North Carolina** State University's Centennial Campus share access to the university research laboratories and equipment through a fee-for-service system.[17] This arrangement provides access to millions of dollars in equipment to companies that do not own or desire to own such assets. Additionally, university faculty and technicians staff and monitor the laboratories, absolving corporate partners from personnel and maintenance costs.

The National Institute for Aviation Research (NIAR) founded in 1985 and housed at **Kansas**' Wichita State University, provides 47 full-time employees, more than 100 student and graduate research assistants, as well as 16 applied research testing labs for Wichita's aerospace cluster.[18] The institute has proposed a five-year budget of $45 million with approximately 60 percent of funding coming from the state, 27 percent from the federal government, and the remaining share from industry. NIAR, which focuses on aerodynamics, crash dynamics, CAD/CAM, and composite and advanced materials, intends to upgrade its capabilities in aerodynamics, aviation safety, and aviation manufacturing technology. As one institute peer reviewer noted, "NIAR provides significant benefit to its local customers in the aviation industry. The benefits of its research show up in the form of improved competitiveness, improved aircraft performance, new jobs, and retained jobs."[19]

The **Georgia** Research Alliance (GRA), founded in 1990, is a partnership among Georgia's research universities, the business community, and state government. Its mission is to foster economic development within Georgia "by developing and leveraging the research capabilities of the research universities within the state and to assist and develop scientific and technology-based industry, commerce, and business."[20] To fulfill this mission, GRA focuses on constructing new research facilities, installing state-of-the-art equipment and instrumentation, and recruiting top scholars in three strategic areas: advanced communications, biotechnology, and environmental technologies.[21] Through fiscal 1999, Georgia has invested approximately $242 million via GRA in R&D programs located at the major universities, which has been matched by $65 million in private funds.[22] These investments helped attract $600 million in additional sponsored research.[23]

Georgia Research Alliance[i]

The Georgia Research Alliance (GRA), a nonprofit organization founded in 1990, is a partnership among Georgia's research universities (Emory University, Georgia State University, Georgia Institute of Technology, University of Georgia, Clark Atlanta Colleges, and the Medical College of Georgia), the business community, and state government. GRA's mission is to foster economic development in Georgia "by developing and leveraging the research capabilities of the research universities in the state and to assist and develop scientific and technology-based industry, commerce and business."

GRA focuses on constructing new research facilities, installing state-of-the-art equipment and instrumentation, and recruiting top scholars in three strategic areas: advanced communications, biotechnology, and environmental technologies. The facilities and equipment encourage the collaborative use of research infrastructure by industry and establish new, leading-edge research programs. The funding is dedicated to the construction of new research facilities and/or the renovation or build-out of existing research facilities. This includes state-of-the-art equipment and instrumentation used to conduct applications-based research by collaborative teams of researchers led by one of the member universities. In addition, GRA's Eminent Scholars Program recruits leading national and international researchers to Georgia through university posts and up to $5 million of equipment per researcher.

These initiatives are funded by the public and private sectors. Each year, the GRA recommends expenditures on scholars, programs, and infrastructure to the state. Private-sector donors can specify the use of their contributions by endowing chairs at one of the six universities and by helping the GRA locate professors to fill those chairs.

Between 1990 and 1999, Georgia has invested approximately $242 million through GRA in research and development programs. The state's investments have been matched by $65 million in private funds, which have helped to attract $600 million in additional sponsored research.[ii] Further, 37 eminent scholar chairs have been established.

i Georgia Research Alliance website: http://www.gra.org. Accessed 17 May 2002.

ii Ibid.

III Creating Pools of Specialized Talent

"The *sine qua non* of a modern economy is a well-educated, versatile workforce able to conduct research and development (R&D) and to convert its results into innovative products, processes, and services."[24] What's different with the New Economy is that intellectual capital drives prosperity—and the states that create a readily available pool of technically trained talent turbocharge their economic development strategies.

The decreasing availability of science and engineering talent is a premier challenge for state leaders—and, indeed, for the nation. The U.S. Department of Labor projects that new jobs requiring science, engineering or technical training will increase by 51 percent between 1998 and 2008—the fastest growing of any job category. Yet, the numbers of new graduates in most science and engineering disciplines has been flat or declining for nearly a decade.[25] Moreover, the dependence on foreign enrollments to fill out the technical workforce is problematic for two reasons. First, the terrorist attacks of September 11 will almost certainly make it more cumbersome for foreign nationals to obtain student visas. Second, the growth in high-technology industries overseas makes it less likely foreign students will remain in any state to work after they graduate.

The challenge for governors is clear. State government must play a role in providing incentives for students to study science and engineering and in creating internship and job placement programs that encourage those students to remain in the state to work after they graduate. More women and minorities need to be in the science and engineering (S&E) pool; the largest untapped source of new talent is among these demographic groups. States need to create public-private partnerships that attract star faculty to the state universities and create cutting-edge research environments that attract the best students as well as the leading companies.

Recommendations

Increase Enrollment in Science and Technology Disciplines and Retain Graduates. States can build the S&E workforce by encouraging greater enrollment in science and engineering disciplines and creating opportunities to keep graduates in state. Data from the College Board indicate that the cost of higher education is consuming an ever-increasing share of household income, particularly of middle and lower income households. At the same time, subsidized tuition assistance has declined significantly. Although the total value of student aid has increased, most of the growth has been in the form of loans—about half of which are at market rates. Given the higher costs of education and declining aid, students are likely to be increasingly influenced by financial incentives when choosing their discipline.[26]

With all of these factors in mind, **Pennsylvania** created the SciTech scholarships to expand S&E enrollments. SciTech offers up to $3,000 a year (for a maximum of three years between sophomore and senior years) to full-time Pennsylvania students earning a bachelor's degree in science and engineering.[27] Along the same lines, **Maryland** offers a Science and Technology Scholarship to students who attend a college in Maryland and enroll in a science and technology (S&T) academic program that addresses career shortage areas in the state.[28]

Of course, growing and attracting a high-quality scientific workforce requires more than just scholarships. Governors need to identify a wide range of options and incentives to retain S&E graduates (in fact, each state should measure graduate retention rates in critical fields as part of its overall benchmarking effort). Internships and mentoring programs—both of which often lead to employment opportunities after graduation—are just two approaches state leaders can pursue. Intern partnerships are a key element of **Oklahoma**'s efforts to prepare students for careers in a scientific or technical field. A recent study by The Southern Technology Council of the Southern Growth Policies Board offers another, perhaps more controversial, approach. The council notes that state leaders may be "well served by lowering out-of-state tuition for 'arrivers'—those graduates of a state's institutions who attend high school elsewhere but stay in the state after college to work." State leaders should examine whether such an approach, targeted primarily at S&E students, may be in the best economic development interest of their state in a world

Pennsylvania Science and Engineering (S&E) Workforce Programs

Under the leadership of former Governor Tom Ridge, Pennsylvania has developed several programs to address the entire science and engineering pipeline—preschool through college.

Cyberstart Initiative [i]

Cyberstart bridges the digital divide and provides every child with access to technology and computer-based learning, regardless of economic situation or location. The program is not designed as a grant, but as a tool to help licensed day-care facilities for children ages three to five find the resources they need to utilize technology.

The Cyberstart program has researched and gathered a variety of sources as starting points for Pennsylvania's child day-care providers and also for parents looking for information on curriculum, technology, health and safety, and child development. The program is especially beneficial to children in low- to moderate-income level families who do not own personal computers.

Pennsylvania has implemented Cyberstart in several stages. Phase I lasted from July 2000 to June 2001, and included 115 child day-care facilities in 32 counties. Phase II runs from July 2001 to June 2002, and hopes to include up to 1,500 participants statewide. If funding continues, the more than 4,000 licensed facilities in Pennsylvania may be able to participate in the program.

Link-to-Learn Program [ii]

Link-to-Learn is a multiyear, $166-million initiative to expand the use of technology in the classroom, and it includes new or upgraded computers for schools and high-technology training for teachers. It is a catalyst for the effective use of information technology to enhance education, promote community partnerships, and support economic growth in a knowledge-based society. The creators of Link-to-Learn believe that "technology is the great enabling force that is allowing Pennsylvania to change the way it does everything."[iii] Traditionally, technology has automated existing educational processes, but not invented new methods of delivering education.

The Digital School District is a component of the Link-to-Learn program. It is a statewide competition to select and fund new education models enabled by technology. Pennsylvania is investing $10 million over two years to create Digital School District models. These models will be resources and demonstration centers, providing examples of how technology can improve education, achieve cost savings, and deliver education in new ways.

"SciTech" Scholarships [iv]

The SciTech Scholars program was a key initiative of Governor Ridge's administration to reverse the high-technology "brain drain" that threatened Pennsylvania's technology-intensive business development. Launched on October 12, 1999, the program prepares Pennsylvania's workforce for the technology-based economy of the 21st century and stems the migration of Pennsylvania's graduates to other states.

The program will provide scholarships of up to $3,000 a year, for a maximum of three years, to full-time Pennsylvania students earning a bachelor's degree in select fields of study in science and technology. Scholarships are available for the second through fourth years of study. Eligible students must maintain a 3.0 grade point average, complete an internship with a technology-intensive Pennsylvania company, and work in the state for one year for each year of scholarship assistance (otherwise the scholarship reverts to a loan that must be paid back). When fully implemented, the SciTech Scholars program will assist approximately 14,500 Pennsylvania students a year at an annual cost of $43.5 million.

The number of SciTech scholarship awards has increased rapidly. In 1999–2000, 358 students received scholarships. One year later, the number of recipients jumped to nearly 2,400.[v]

i http://cyberstart.org.

ii : http://www.l2l.org.

iii Ibid.

iv http://www.unisys.com/news/releases/1999/mar/03106665.html.

v Ibid.

where competition is heating up for technical talent.[29] Finally, state higher education systems should implement policies that allow high-perfoming students in community colleges to matriculate easily into college and university degree programs.

Increase Participation of Women and Minorities in Science and Engineering. States can target programs to increase the participation and advancement of women and under-represented minorities in science and engineering. Over the past three decades, women have steadily increased their participation in the workforce, accounting for more than half of all workers.[30] Hispanic and African American populations represent the fastest growing demographic groups in the country.[31] Yet, both women and minorities are dramatically underrepresented in the science and engineering pool, which is overwhelmingly composed of white males, many who are reaching retirement age.[32] Women and minorities remain an underutilized source of intellectual capital for increasing the labor pool of scientists and engineers.[33]

Creating programs that attract and retain women and minorities in science and engineering should be a top priority for governors. To date, such initiatives have received relatively little attention at the state level. Within states, some universities are addressing the high dropout rate of women and minorities from S&E programs, creating mentoring programs and modular curricula for those with less experience or background. At the national level, the federal government has funded a new public-private partnership called BEST (Building Engineering and Science Talent) to expand participation by these groups. Governors can significantly impact the process because they can tie quality math and science education at the K–12 level to enrollment incentives. State leaders can also support mentoring and internship programs that build a pipeline of technical talent.

Through institutional awards and expanded grant mechanisms, including scholarships, fellowships and

Oklahoma Center for the Advancement of Science and Technology (OCAST)

The Oklahoma Center for the Advancement of Science and Technology (OCAST) is the state's sole agency focused on technology and its development, transfer, commercialization, and economic impact.[i] OCAST's legislative mandate is to:

- support basic and applied research and development;
- facilitate technology transfer and commercialization;
- stimulate seed-capital investment in firms commercializing new technologies; and
- encourage manufacturing competitiveness through modernization.

A flagship program of OCAST, the Oklahoma Applied Research Support (OARS) Faculty and Student Internship, helps build a technology-oriented workforce.[ii] The program acknowledges that the principal resources of higher education institutions are its people— the faculty and students. It has several goals, including improving Oklahoma's research and development (R&D) base by supporting student and faculty internships in R&D facilities in Oklahoma; encouraging more students to prepare for careers in scientific and technical fields; and enhancing a faculty member's background to provide a better teaching environment.

Intern partnerships involve one or more students and/or faculty working at an R&D facility in Oklahoma. Funding for the partnership supports one- to two-year projects requiring a minimum of $10,000 a year and a maximum of $50,000 per year of OARS funds.[iii] Most of the programs have interns working in an Oklahoma industrial laboratory on an applied research project with an industry mentor. The firm provides half of the intern's salary and fringe benefits as the required match and OCAST provides the other half.

The internship program is funded at 13 higher education institutions and companies in 16 cities statewide. Each project has five common features:

- An Oklahoma college or university must be the fiscal agent.
- An equal match of the OCAST funds from non-state appropriated funds is required.
- Research must be performed in an applied research facility, located at a firm, a non-profit research institute, or an institution of higher education. The mentor is from industry or an academic with a documented success record of applied research.
- An Oklahoma firm or farm must benefit.
- A majority of the project reviewers is from outside of Oklahoma with backgrounds in industry, academia, and government research.

To date, 63 undergraduate students have interned at 47 Oklahoma firms, farms and applied research centers. Of the interns that have earned their initial bachelor's or associate's degrees, 29 have chosen to pursue advanced degrees and 19 are employed in the state.[iv]

i Oklahoma Center for the Advancement of Science and Technology website: http://www.ocast.state.ok.us.

ii Oklahoma Center for the Advancement of Science and Technology website: http://www.ocast.state.ok.us/oars.htm.

iii Ibid.

iv Ibid.

internships, state leaders can go a long way in attracting more women and minorities. One successful early model is Purdue University's Women in Engineering Program. Launched in 1969, it was the first of its kind in the United States. Since inception, the percentage of Purdue's engineering students who are women has grown from 1 percent to 25 percent—compared to just 18 percent nationally.[34]

Recruit Star Faculty. States that can offer the best minds and the best facilities attract leading-edge companies. Proximity to the frontiers of knowledge and technology gives companies a decisive "first-mover" advantage—and the dividends for the state come through high-value investments and high-wage jobs.

There are many examples of states successfully enhancing the capacity of their science and technology faculty and workforce:

- When **Texas** decided to pursue an information technology (IT)-based economic development strategy, it hired more than 100 new professors in computer sciences to build the base.
- In **Kentucky,** the "bucks for brains" program has set up a $220-million pool of matching public-private funds to create endowed chairs and professorships to attract national respected researchers and scholars.[35]
- The **Georgia** Research Alliance has leveraged public and private funding to create world-class research capabilities focused around its existing and emerging business base.[36]
- **New York**'s State Office of Science, Technology & Academic Research (NYSTAR) manages the state's Centers for Advanced Technology Program. The program offers initiatives to provide funding for major capital investments to create world-class research facilities and centers of excellence (STAR Centers). STAR Centers attract faculty with an entrepreneurial mindset and work to capture federal, venture capital and private industry funds. Governor George Pataki's fiscal 2002 budget included funding for three centers of excellence: the Center of Excellence in Bioinformatics at Buffalo; the Center of Excellence in Photonics & Optoelectronics at Rochester; and the Center of Excellence in Nanoelectronics at Albany.[37]

Governors must also recognize the tight linkage between R&D funding, particularly at universities, and the size and caliber of its science and engineering talent pool. Top-tier faculty attracts federal funding, which often includes stipends for graduate students. This is an important benefit because the share of students supported by federal stipends has declined since 1980 while tuition has substantially increased.[38]

IV Catalyzing Knowledge Transfer and Technology Commercialization

No government—whether federal, state, or local—invests in basic research simply because scientists do amazing things. They invest because the economic returns are enormous—but only when the knowledge and capability is actually deployed.

It is the role of the private sector to turn knowledge into products, processes, and services. Companies innovate, governments do not. However, state governments, and the universities they support, play an increasingly important role in catalyzing the transfer of knowledge and creating the environment for the rapid deployment of that knowledge.

Universities are a linchpin in this process. For decades, their role was limited to education and research, but this has changed since passage of the technology transfer legislation of the 1980s, including the Bayh-Dole Act. These laws and policies gave universities the incentives (through the ownership of intellectual property) to bring new ideas to the marketplace and leverage discoveries for wealth creation.

Some universities have stepped up to plate, becoming proactive rather than passive assets for economic growth. Most have not. One of the key lessons of nearly two decades of experience with technology transfer is that the process itself does not begin and end with legal negotiations over licensing rights. The most successful universities develop a network of connections with the private sector that:

- spans the continuum of research activities;
- facilitates placement of university researchers in industry laboratories and accommodates private-sector researchers at the university; and
- develops the curriculum and research programs that support the needs of local firms, particularly small and medium-sized enterprises.

Technology transfer is often called a "contact sport" for good reason—it requires human connections between companies and centers of knowledge and learning.

The states can play a critical role in this process by providing incentives for state universities to develop a range of programs. It is often said that the metrics determine the standards for achievement. Therefore it is important to develop broader metrics for technology transfer than the current, rather narrow, licensing and patenting indicators. New measures could include the number of university researchers working in industry labs as well as the number of industry researchers working on university campuses. It might also include the number of students engaged in industry-sponsored research at universities or the number of companies that have received technical assistance from university faculty. Often in partnership with universities, state governments are creating incubators, science or industry parks, and common laboratory facilities that support technology development in existing and emerging areas of economic strength.

State governments also can play an important role in helping new startups find the seed capital they need to bring ideas to market. State programs designed to boost the availability of venture and seed capital include direct investment in the venture capital (VC) market (often using a very small portion of pension funds), creating networks between local entrepreneurs and venture capital sources, and providing tax incentives to VC investors in local businesses. This kind of support helps bridge the so-called "Valley of Death"—the investment gap between knowledge breakthrough and commercialization. This gap is caused, in part, because VC funds are industry-specific (e.g., concentrated heavily in biotechnology, information technology, and communications), geographically concentrated, and focused on technologies that are ready for immediate market deployment. A more extensive discussion on this topic can be found in a report commissioned by the National Governors Association, *Growing New Businesses with Seed and Venture Capital: States Experiences and Options*.[39]

Governors are ideally positioned for this leadership role. Unlike the federal government, which is hamstrung by ideological differences over industrial policy, state leaders have far more political flexibility to tailor commercialization programs to their state's economic needs.

Recommendations

Encourage State Universities to Be Mission-Driven. States can encourage research universities to develop missions, programs and policies that facilitate technology transfer and support economic development. Although high-technology regional economies are almost always anchored by great research universities, not all great research universities are surrounded by a booming regional economy.[40] The universities can make a difference—and state leaders can be both a catalyst to and a beneficiary of their involvement in economic development.

Perhaps the best known example of a university outreach and technology transfer program is the University of **California** at San Diego's CONNECT program. Founded in 1985, CONNECT was designed to link entrepreneurs with critical resources for success—technology, money, markets, management, partners, and support services.[41] While the program was initiated by the business community, the program is worth consideration by state leaders. Early programs included "Meet the Entrepreneur" and "Meet the Inventor" evenings, which helped very different communities bridge cultural barriers and gain practical knowledge on how each conducts business.[42]

Today, CONNECT continues to provide networking opportunities as well as expertise to San Diego's technology-based firms. It does this through partnerships with the region's industry-specific organizations and individuals; and resources, such as the School of Medicine, Jacobs School of Engineering, San Diego Super Computer Center, and Scripps and Salk Institutes.[43] Since its inception, CONNECT estimates more than 800 technology companies have been assisted.[44] Further, the success of its programs has generated enough membership dues and grants to make it self-sustaining.[45]

Another example of an outward-facing research institution is the **Virginia** Polytechnic Institute and State University, also known as Virginia Tech.[46] Virginia Tech is the largest four-year public university in the state with $169.2 million in research expenditure in fiscal 1999. It adopted the following mission as part of its August 2001 strategic plan:

> Through its focus on teaching and learning, research, and outreach, the university creates, conveys, and applies knowledge to expand personal growth and opportunity, advance social and community development, foster competitiveness, and improve the quality of life.[47]

Virginia Tech's strong tradition of research in engineering and life and environmental sciences is organized into research units, such as centers or institutes. The university also has a vice provost of outreach and an associate vice president for strategic partnerships.

Finally, **Michigan** has taken a unique approach through its SmartZone program.[48] The SmartZone program allows designation of "zones" in the state that are intended to aid development of recognized clusters of new and emerging businesses. The focus of the program is on commercializing ideas, patents, and other opportunities surrounding university or private research institute R&D efforts. The SmartZones will be allowed to capture the growth in property taxes within the boundaries of the zone for use within the zone. All the local property taxes may be captured, and up to 50 percent of school operating taxes may be captured for up to 15 years. The captured revenue can be used for a variety of activities, including:

- Creating and operating an incubator to house high-technology companies; and
- Creating publicly owned high-technology support facilities like R&D labs, training centers, testing labs and telecommunication centers

Establish Incubators and Centers that Leverage Public-Private Research. States can support incubators and centers that leverage local and federal research capabilities to develop, assist, and spin off companies. For example, **Ohio**'s Edison Technology

University of California, San Diego (UCSD) CONNECT[i]

UCSD founded CONNECT in 1985 at the request of San Diego's business community. Today, UCSD CONNECT is widely regarded as one of the nation's most successful regional programs linking entrepreneurs with critical resources for success—technology, money, markets, management, partners, and support services. CONNECT provides expertise to San Diego's technology-based business community through partnerships with the region's prominent industry-specific organizations and individuals; and world-class UCSD resources, such as the School of Medicine, Jacobs School of Engineering, San Diego Super Computer Center, and the Scripps and Salk Institutes.

With CONNECT's success has come financial independence from the university and the state. The organization relies on membership dues, course fees, and corporate underwriting for specific programs. Some of CONNECT's initiatives include the following.

Springboard

In 1993 CONNECT launched its flagship program, Springboard, to assist aspiring entrepreneurs in transforming their business visions into reality. The program helps all levels of emerging companies and guides entrepreneurs through business development, corporate strategy, and raising capital. Entrepreneurs accepted into the program spend four weeks to eight weeks in coaching sessions with experienced business people to help develop their business plan.

Upon completion of the program, the entrepreneur is invited to make a presentation of their idea to a select group of CONNECT sponsors and members. This group usually consists of a venture capitalist, an accountant, a corporate and/or patent attorney, a marketing professional, and an executive from a successful company in the same industry. Experts are also drawn as required from insurance, real estate, human resources, and other areas.

CEO CONNECT

The goal of CEO CONNECT is to provide an intimate peer group of approximately 12 technology CEOs to learn from and teach one another, as well as to hear from experts in their respective fields. Each board-like group has 10 monthly meetings over a yearlong timeframe. Professional facilitators attend each meeting and offer one-on-one time prior to each session. Participants are expected to provide confidential information, such as financials, and are not placed with competitors.

CONNECT Entrepreneurs' Roundtable

The Entrepreneurs' Roundtable, a monthly program designed for capital providers, CEOs, founders, members of the board, and presidents of San Diego-based, early-stage, high-technology companies:

- fosters the development of early-stage, high-technology companies in San Diego by facilitating growth opportunities and strategic alliances among companies;
- incubates and nurtures high-technology startups by exposing new concepts to established entrepreneurs and capital providers;
- provides participants with current information on technological advances, and regional environment trends, as well as status reports on local and national high-technology contemporaries; and
- provides entrepreneurs and corporate leaders a safe haven for creative and informational exchanges.

San Diego Tech Coast Angels (SD TCA)

SD TCA is a group of private investors who invest in and assist early-stage, Southern California companies. The members are accredited investors with a wide range of backgrounds, including CEOs, entrepreneurs, and professional venture capitalists. The group makes individual investment decisions and meets monthly to review opportunities and to share due diligence. SD TCA supplies many seed and early-stage companies with sufficient capital and expertise to launch their businesses or grow them to the next stage of development.

[i] UCSD CONNECT website: http://www.connect.org. Accessed 8 May 2002.

Centers, launched in 1984, have benefited companies of all sizes.[49] Surveys have shown the centers contribute to significant increases in sales, profits, and market share of many companies. The Edison Technology Incubators, a feature of the centers, nurture small technology and manufacturing businesses during the start-up stage and offer entrepreneurs the ability to concentrate on the development of a product or service.[50] The centers also help link industry with academia and government in partnerships to enhance technology development. They have carried out more than 1,000 projects to accelerate technology utilization by participating companies. Through these relationships with world-class universities and federal research facilities, the centers offer participating companies state-of-the-art basic and applied research in technologies that can improve company productivity and product quality.

In 1999 **Pennsylvania** founded the Pittsburgh Digital Greenhouse (PDG), an economic development initiative to build an industry cluster around the application of System On Chip (SOC) technology in the digital multimedia and digital networking markets.[51] Companies eligible for membership are involved in the development of processes or components for SOC or are systems manufacturers that incorporate SOC technology into their products and processes. PDG is supported by membership dues and Pennsylvania's universities, private foundations, regional development organizations, and state and local government.

PDG develops programs in SOC education and training, SOC research, talent recruitment, electronics infusion, and expansion support. The goal is to create regional jobs by attracting established companies, helping local member-companies grow, and fostering startups. Of particular interest are the factors that determine where technology companies locate, grow, and prosper, including access to technology, talent, markets, partners, and a business-friendly environment. Members direct PDG's research and provide input to its education and training programs as participants on a technical advisory board. To date, PDG has funded 41 programs from regional corporations and universities totaling more than $7 million.

Establish Research Zones. States can designate land for research and development. In the late 1950s, San Diego, **California**, residents voted to dedicate Torrey Pines, a sizable chunk of prime real estate, to the University of California for research.[52] This decision helped spur San Diego's world-class biotechnology and pharmaceutical cluster. The Salk and Scripps Institutes, two early residents of Torrey Mesa, are now joined by more than 400 health-care technology organizations.[53]

Similarly, **Michigan**'s NextEnergy Initiative is establishing a research zone at a state-owned site in close proximity of the University of Michigan and the Detroit Metropolitan Airport.[54] The initiative features legislation that provides refundable small business tax (SBT) credits equal to the personal income tax generated by the payroll of companies located in the zone and the designation as a tax-free Renaissance Zone, which fully abates all local and state taxes.[55] Additionally, Michigan is dedicating funds for site improvements, incubators, and speculative building construction.[56]

Facilitate Access to Capital. States can facilitate access to capital through state-sponsored seed and venture funds, as well as by providing technical assistance. **Kansas** launched the Kansas Technology Enterprise Corporation (KTEC) in 1987 to promote advanced technology economic development in the state. Funded in part by revenues from the Kansas Lottery and Racing Commission, KTEC has provided small businesses with seed capital and assistance in securing federal grants, such as Small Business Innovation Research (SBIR) awards. The Applied Research Matching Fund (ARMF) program provides direct investments to companies conducting applied engineering or scientific research to develop a specific commercial product or technology in turn for royalties or an equity position on the eventual product sales.

KTEC has also created a SBIR bridge fund of up to $50,000 for Kansas companies that win SBIR Phase I awards and are applying for Phase II awards. Further, KTEC has developed a program that provides a grant of up to $5,000 for SBIR proposal preparation.

Enacted by law in 1978, the **Massachusetts** Technology Development Corporation, (MTDC), is a venture capital firm that addresses the "capital gap" between startup and expanding companies within Massachusetts. Among other things, the MTDC seeks to attract and leverage private investment in local companies. From 1980 through 2000, MTDC's total cumulative investments from all of its programs were more than $45 million in 100 companies. The corporation has become self-supporting based upon returns from previous investments. MTDC estimates their investments have generated 10,500 jobs and added $569.6 million to the state's annual payroll.[57]

Kansas Technology Enterprise Corporation (KTEC)[i]

Launched in 1987, KTEC is a state-owned corporation that promotes advanced technology economic development in Kansas. The organization's funding is determined each year by the state legislature and comes from the Economic Development Initiative Fund created by revenues from the Kansas Lottery and Racing Commission. To manage the state's investment, KTEC leverages its state funds with private-sector and federal government funding.

The organization strives to meet the technical needs of Kansas companies by providing access to individuals with expertise and state-of-the-art equipment and facilities. KTEC also provides or assists in securing financing for research and development. KTEC's key programs include the following.

Information Research Corp. (IRC)

IRC provides crucial business information at affordable prices "to enhance proposals, make companies more competitive for federal funding, facilitate decisionmaking, and assist in commercialization and market expansion." All the work performed by IRC is customized for the client to provide the most beneficial information. Key services include preliminary patent search, government funding sources, company profiles, competitive intelligence, and industry reports.

Small Business Innovation Research

KTEC has developed programs to help small companies and researchers compete for federal Small Business Innovation Research (SBIR) awards. The competitive three-phase award system allows small companies to propose innovative ideas that meet the specific research and development needs of federal agencies.

- *SBIR Proposal Preparation Grant Program*. This program assists small businesses in obtaining federal SBIR awards by providing grants of up to $5,000 to support SBIR proposal preparation.
- *SBIR Bridge Funding*. KTEC started the SBIR Bridge Fund program in 1996 to provide low-interest loans to Kansas companies that have won Phase I awards and are applying for Phase II awards. Companies selected for bridge funding can receive up to $50,000 to help them meet operating expenses during this critical period between awards.
- *State Small Business Innovation and Research (SSBIR)*. This program is a partnership among the federal government, state government, and private industry. It facilitates cooperative funding among the federal agency sponsoring the SBIR topic, the state where the small business is located, the principal investigator performing the work, and a commercial partner.

Applied Research Matching Fund (ARMF)

KTEC's ARMF program provides funding to companies seeking to turn new technologies into market-driven products that will lead to retention or expansion of the company's market share and produce added skilled job opportunities. The program provides direct investments to companies that are conducting applied engineering or scientific research to develop a specific commercial product or technology. A key role of the funding is providing a buffer from the risk companies take in new product development.

Centers of Excellence

KTEC has established five university-based research centers of excellence with individual technology specializations: aviation, biomedical/pharmaceutical, information/telecommunications, manufacturing, and polymers/advanced materials. Each center conducts innovative research and provides technical assistance to create new companies, strengthen existing companies, and serve as expert resources to other KTEC programs. Services provided by the centers include basic and applied research, product and process development, technical consulting, training, seminars, and networking.

[i] Kansas Technology Enterprises Corporation: http://www.ktec.com. Accessed 3 May 2002.

Two programs established in the last year, **Kentucky**'s Commonwealth Seed Capital (CSC) LLC and **Arkansas**' Seed Capital Investment Program (SCIP), are addressing the gap in funding for startup companies in various industries. CSC has $11 million for investment in technology companies based in Kentucky. The funding provides financial support for scientists and researchers who want to commercialize on their ideas. To secure an investment from CSC, private venture capital funds must commit to investing at least three times the amount invested by CSC.[58]

The SCIP provides working capital up to 25 percent, or a maximum of $500,000, toward a company's total financing needs to help support its initial capitalization or the expansion of existing technology-based companies located in the state. Investments made by the SCIP fund can be repaid through a variety of instruments, including direct loans, participations, and royalties. SCIP has available funds of nearly $3 million in a revolving investment fund.[59] As of August 2001, more than 30 SCIP loans have been awarded in Arkansas.[60]

Endnotes

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