Clustering for 21st Century Prosperity: Summary of a Symposium

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Clustering for 21st Century Prosperity

Summary of a Symposium

Charles W. Wessner, *Rapporteur*

Committee on Competing in the 21st Century:
Best Practice in State and Regional Innovation Initiatives

Board on Science, Technology, and Economic Policy

Policy and Global Affairs

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Preface

Responding to the challenges of fostering regional growth and employment in an increasingly competitive global economy, many U.S. states and regions have developed programs to attract and grow companies as well as attract the talent and resources necessary to develop regional innovation clusters. These state and regionally based initiatives have a broad range of goals and increasingly include larger resource commitments, often with a sectoral focus and often in partnership with foundations and universities. Recent studies, however, have pointed out that many of these efforts lack the scale and the steady commitment needed for success.[1] This has prompted new initiatives to coordinate and concentrate investments from a variety of federal agencies to develop research parks, business incubators, and other strategies to encourage entrepreneurship and high-tech development in the nation's regions. Understanding the nature of innovation clusters and public policies associated with successful cluster development is therefore of current relevance.

PROJECT STATEMENT OF TASK

An ad hoc committee, under the auspices of the Board on Science, Technology, and Economic Policy (STEP), is conducting a study of selected state and

[1]See, for example, Karen G. Mills, Elisabeth B. Reynolds, and Andrew Reamer, "Clusters and Competitiveness: A New Federal Role for Stimulating Regional Economies," Washington, DC: The Brookings Institution Metropolitan Policy Program, April 2008. See also Jonathan Sallet, Ed Paisley, and Justin R. Masterman, "The Geography of Innovation," Center for American Progress, September 2, 2009. Also see Mark Muro and Bruce Katz, *The New 'Cluster Moment': How Regional Innovation Clusters Can Foster the Next Economy,* Washington, DC: The Brookings Institution Metropolitan Policy Program, September 2010.

regional programs in order to identify best practices with regard to their goals, structures, instruments, modes of operation, synergies across private and public programs, funding mechanisms and levels, and evaluation efforts. The committee is reviewing selected state and regional efforts to capitalize on federal and state investments in areas of critical national needs. This review includes both efforts to strengthen existing industries as well as specific technology focus areas such as nanotechnology, stem cells, and advanced energy in order to better understand program goals, challenges, and accomplishments.

As a part of this review, the committee is convening a series of public workshops and symposia involving responsible local, state, and federal officials and other stakeholders. These meetings and symposia will enable an exchange of views, information, experience, and analysis to identify best practice in the range of programs and incentives adopted.

Drawing from discussions at these symposia, fact-finding meetings, and commissioned analyses of existing state and regional programs and technology focus areas, the committee will subsequently produce a final report with findings and recommendations focused on lessons, issues, and opportunities for complementary U.S. policies created by these state and regional initiatives.

THE CONTEXT OF THIS PROJECT

Since 1991, the National Research Council, under the auspices of the Board on Science, Technology, and Economic Policy, has undertaken a program of activities to improve policymakers' understandings of the interconnections of science, technology, and economic policy and their importance for the American economy and its international competitive position. The Board's activities have corresponded with increased policy recognition of the importance of knowledge and technology to economic growth.

One important element of STEP's analysis concerns the growth and impact of foreign technology programs.[2] U.S. competitors have launched substantial programs to support new technologies, small firm development, and consortia among large and small firms to strengthen national and regional positions in strategic sectors. Some governments overseas have chosen to provide public support to innovation to overcome the market imperfections apparent in their national innovation systems.[3] They believe that the rising costs and risks associated with new potentially high-payoff technologies, and the growing global dispersal of

[2]National Research Council, *Innovation Policies for the 21st Century: Report of a Symposium,* Charles W. Wessner, ed., Washington, DC: The National Academies Press, 2007.

[3]For example, a number of countries are investing significant funds in the development of research parks. For a review of selected national efforts, see National Research Council, *Understanding Research, Science and Technology Parks: Global Best Practices,* Charles W. Wessner, ed., Washington, DC: The National Academies Press, 2009.

technical expertise, underscore the need for national R&D programs to support new and existing high-technology firms within their borders.

Similarly, many state and local governments and regional entities in the United States are undertaking a variety of initiatives to enhance local economic development and employment through investment programs designed to attract knowledge-based industries and grow innovation clusters.[4] These state and regional programs and associated policy measures are of great interest for their potential contributions to growth and U.S. competitiveness and for the "best practice" lessons they offer for other state and regional programs.

STEP's project on State and Regional Innovation Initiatives is intended to generate a better understanding of the challenges associated with the transition of research into products, the practices associated with successful state and regional programs, and their interaction with federal programs and private initiatives. The study seeks to achieve this goal through a series of complementary assessments of state, regional, and federal initiatives; analyses of specific industries and technologies from the perspective of crafting supportive public policy at all three levels; and outreach to multiple stakeholders. The overall goal is to improve the operation of state and regional programs and, collectively, enhance their impact.

THIS SUMMARY

As the report of the STEP Board's second workshop on innovation clusters, this volume deepens the committee's review of policies to support innovation clusters. The first symposium explored, more generally, the role of clusters in promoting economic growth, drawing particular attention to the strategies of American states to promote cluster development.[5] In complement, the second symposium focused more on the Obama Administration's efforts to develop an integrated cluster initiative and on the role of research parks in promoting innovation and regional and national economic development. The second workshop also reviewed selected best practices in regional and cluster development from other countries.

This volume includes an introduction that provides an overview of the key issues raised at the second workshop as well as detailed summaries of each of the meeting's presentations. This workshop summary has been prepared by the workshop rapporteur as a factual summary of what occurred at the workshop. The planning committee's role was limited to planning and convening the workshop. The statements made are those of the rapporteur or individual workshop

[4]For a scoreboard of state efforts, see Robert Atkinson and Scott Andes, The 2010 State New Economy Index: Benchmarking Economic Transformation in the States, Kauffman Foundation and ITIF, November 2010.

[5]For a summary of the first STEP workshop on innovation clusters, see National Research Council, *Growing Innovation Clusters for American Prosperity: Summary of a Symposium,* Charles W. Wessner, Rapporteur, Washington, DC: The National Academies Press, 2011.

participants and do not necessarily represent the views of all workshop participants, the planning committee, or the National Academies.

ACKNOWLEDGMENTS

On behalf of the National Academies, we express our appreciation and recognition for the insights, experiences, and perspectives made available by the participants of this meeting. We are indebted to Pete Engardio for preparing the draft introduction and summarizing the proceedings of the meeting. We are also indebted to Sujai Shivakumar and David Dierksheide of the STEP staff for preparing the report manuscript for publication.

NATIONAL RESEARCH COUNCIL REVIEW

This report has been reviewed in draft form by individuals chosen for their diverse perspectives and technical expertise, in accordance with procedures approved by the National Academies' Report Review Committee. The purpose of this independent review is to provide candid and critical comments that will assist the institution in making its published report as sound as possible and to ensure that the report meets institutional standards for quality and objectivity. The review comments and draft manuscript remain confidential to protect the integrity of the process.

We wish to thank the following individuals for their review of this report: Rebecca Bagley, NorTech; Daniel Berglund, SSTI; Robert Geolas, Clemson University; Randall Jackson, West Virginia University; and Andrew Reamer, Brookings Institution.

Although the reviewers listed above have provided many constructive comments and suggestions, they were not asked to endorse the content of the report, nor did they see the final draft before its release. Responsibility for the final content of this report rests entirely with the rapporteur and the institution.

Charles W. Wessner Mary L. Good

I

OVERVIEW

Overview: The New Federal Role in Innovation Clusters

Ever since Silicon Valley and Boston's Route 128 gained global attention as fountains of dynamic new high-technology companies, state and local governments across America have tried to create innovation clusters of their own.[1] To this end, several states and universities have invested in science parks, business incubators to nurture start-ups, and an array of real and virtual research collaborations with private industry.[2]

[1]Robert Lucas has long argued that the clustering and density of talented people is a key driver of innovation and economic growth. See Robert Lucas, "On the Mechanics of Economic Development," *Journal of Monetary Economics,* 22:38-39. Richard Florida has popularized the characteristics and economic advantages of innovative clusters. See, for example, Richard Florida, *The Rise of the Creative Class*, New York: Basic Books, 2002. For an insightful review of interface of the entrepreneur in regional growth dynamics, see Sameeksha Desai, Peter Nijkamp, and Roger R. Stough, eds., *New Directions in Regional Economic Development: The Role of Entrepreneurship Theory and Methods, Practice and Policy*, Northampton, MA: Edward Elgar, 2011.

[2]For a review of policy initiatives around the world to develop research parks, see National Research Council, *Understanding Research, Science and Technology Parks: Global Best Practices—Summary of a Symposium*, Charles W. Wessner, ed., Washington, DC: The National Academies Press, 2009. For a review of selected state strategies to develop innovation clusters, see National Research Council, *Growing Innovation Clusters for American Prosperity: Summary of a Symposium*, Charles W. Wessner, Rapporteur, Washington, DC: The National Academies Press, 2011.

Box A
The Relevance of Innovation Clusters

Innovation clusters are regional concentrations of large and small companies that develop creative products and services, along with specialized suppliers, service providers, universities, and associated institutions. Ideally, they bring together a critical mass of skills and talent and are characterized by a high level of interaction among these entrepreneurs, researchers, and innovators.[a]

Prior to the second half of the 20th century, the limitations of communication and transportation technologies meant that industries most always developed in clusters. Consistent with this, U.S. manufacturing industries organically developed in clusters—for example, textiles in New England, cars in Detroit, and steel in Pittsburgh. Indeed, economists have studied industrial concentrations for over a century.[b]

Open global markets, rapid transportation, and high-speed communications of the 21st century should allow any company to "source anything from any place at any time." Nonetheless, economic growth and employment continue to be strongly associated with successful clusters.[c] Recognizing this, regional and national governments have sought to pursue policies that actively create and nurture technology clusters within their borders.[d]

Muro and Katz distinguish the phenomenon of innovation or industry clusters in general from specific Regional Innovation Cluster (RIC) initiatives, which they call "formally organized efforts to promote cluster growth and competitiveness through collaborative activities among cluster participants." Led in many cases by regional or national governments in partnership with universities and industry, these cluster initiatives often "sponsor education and training activities, encourage relationship building, or facilitate market development through joint market assessment and marketing, among many others."[e] Muro and Katz note that since RIC initiatives are a relatively new phenomenon, they do not yet have a sufficient empirical record, leaving the effectiveness of these cluster building strategies to be established.

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[a]National Research Council, *Growing Innovation Clusters for American Prosperity: Summary of a Symposium*, Charles W. Wessner, Rapporteur, Washington, DC: The National Academies Press, 2011.

[b]See Alfred Marshall, *Principles of Economics*, London: Macmillan, 1920. The first edition of Marshall's classic textbook appeared in 1890. Marshall characterized clusters as a "concentration of specialised industries in particular localities" that he termed industrial districts.

[c]Michael Porter, "Clusters and the New Economics of Competition," *Harvard Business Review,* November-December 1998.

[d]Joseph Cortright, *Making Sense of Clusters: Regional Competitiveness and Economic Development,* Washington, DC: The Brookings Institution, 2006. Cortright notes that "the foundation of a regional economy is a group of clusters, not a collection of unrelated firms. Firms cluster together within a region because each firm benefits from being located near other similar or related firms." This means that economic development policy and practice can be effectively oriented toward groups of firms in a specialized region.

[e]See Mark Muro and Bruce Katz, *The New 'Cluster Moment': How Regional Innovation Clusters can Foster the Next Economy,* Washington, DC: The Brookings Institution Metropolitan Policy Program, September 2010.

The federal government has traditionally played an important supportive role in the development of innovative clusters around the country. Federally funded research and military procurement have been instrumental in the emergence of clusters that have formed around major research universities.[3] And through legislation, such as the Bayh-Dole Act of 1980, Congress has encouraged universities and national laboratories to commercialize federally funded research.[4] Unlike many Asian and European nations, however, the United States has traditionally not adopted explicit national policies to promote development of particular industries in specific regions.

The federal role is now evolving. In recent years, support has grown in Washington to a more direct federal role in assisting and accelerating innovation clusters around the country. In part, the impetus for change has come from a National Academy of Sciences Report, *Rising Above the Gathering Strom*, which warned that the United States is in danger of ceding global leadership in technology and innovation to nations with more ambitious and comprehensive policies to enhance their competitiveness.[5] Citing this report, Congress in 2007 passed with bipartisan support the America COMPETES Act, which included authorization—but not funding—to boost the development of innovation clusters.[6] The impetus for change has also come in response to the recent economic downturn—the most severe in decades. Recognizing clusters as important catalysts for creating good paying jobs, growing new small businesses, and forming new globally competitive industries, the government has actively sought to develop federal-regional partnerships to foster their development.[7]

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[3]For an analysis of the military role in the origins of Silicon Valley and the high-tech industry in Boston, see Stuart W. Leslie, *The Cold War and American Science: The Military-Industrial-Academic Complex at MIT and Stanford*, New York: Columbia University Press, 1993.

[4]The Bayh Dole Act of 1980 (P.L. 96-517, Patent and Trademark Act Amendments of 1980) permits the transfer of exclusive control over many government-funded inventions to universities and businesses operating with federal contracts for the purpose of further development and commercialization.

[5]National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* Washington, DC: The National Academies Press, 2007.

[6]The America COMPETES Act (P.L. 110-69), signed by President George W. Bush on August 9, 2007, directed national laboratories owned by the Department of Energy to establish Discovery Science and Engineering Innovation Institutes to co-develop applications for technology with universities and industry. On January 4, 2011, President Barak Obama signed P.L. 111-358, the America COMPETES Reauthorization Act of 2010. Section 603 of this act authorizes $100 million annually for the Commerce Department to implement a "Regional Innovation Program."

[7]National Economic Council, Council of Economic Advisers, and the Office of Science and Technology Policy, *A Strategy for American Innovation: Securing Our Economic Growth and Prosperity,* Washington, DC: Executive Office of the President, February 2011. Access at <*http://www.whitehouse.gov/sites/default/files/uploads/InnovationStrategy.pdf*>.

Consistent with this strategy, recent interagency clusters efforts, led by the Economic Development Administration, include the Jobs & Innovation Accelerator Challenge (implementing COMPETES Sec. 603) (<*http://www.eda.gov/InvestmentsGrants/jobsandinnovationchallenge*>); the i6 Challenge (<*http://www.eda.gov/pasti6*>) and the i6 Green Challenge (<*http://www.eda.gov/i6*>).

> "Regional innovation clusters have a proven track record of getting good ideas more quickly into the marketplace. The burning question becomes, 'How do we create more of them?'"
>
> Keynote Address by Commerce Secretary Gary Locke,
> National Academies Symposium on "Clustering for 21st Century Prosperity," February 25, 2010

To better understand ways in which the public sector can most effectively advance innovation clusters, the National Academies' Board on Science, Technology, and Economic Policy (STEP) partnered with the Association of University Research Parks (AURP) to convene a symposium on 'Clustering for 21st Century Prosperity.' This symposium brought together senior Administration officials and economic development professionals, academics, and venture capital investors from the United States and around the world.

This report summarizes the proceedings of this symposium, and this overview highlights the key issues presented and discussed at this forum. It has been prepared by the workshop rapporteur as a factual summary of what occurred at the workshop. The planning committee's role was limited to planning and convening the workshop. The statements made are those of the rapporteur or individual workshop participants and do not necessarily represent the views of all workshop participants, the planning committee, or the National Academies.

A. NEW INITIATIVES FOR GROWING CLUSTERS

Federal support of regional clusters has grown in recent years. The 2009 budget allocated $50 million in new funds, administered by the Commerce Department's Economic Development Agency (EDA), to assist regional cluster initiatives.[8] Also relevant is the American Recovery and Reinvestment Act of 2009, which directed the Department of Energy (DoE) to distribute $2 billion to manufacturers and component makers of lithium-ion batteries—many of them based in the Detroit area—to be used in next-generation electric vehicles.[9] And

[8]The fiscal 2009 budget provided $50 million in regional planning and matching grants within the Economic Development Administration to "support the creation of regional innovation clusters that leverage regions' existing competitive strengths to boost job creation and economic growth." See National Economic Council and Office of Science and Technology Policy, "A Strategy for American Innovation: Driving Towards Sustainable Growth and Quality Jobs," Executive Office of the President, September 2009.

[9]See symposium presentation by David Parks of the Michigan Economic Development Corporation Further, the STEP Board convened a symposium on "Building the Battery Industry for Electric Vehicles," in July 2010 to examine the key challenges and opportunities for the Department of Energy,

the Small Business Administration, working with state agencies and the Department of Defense, has helped launch robotics clusters in Michigan, Virginia, and Hawaii.[10]

In addition, the Department of Energy's Energy Regional Innovation Cluster initiative, or E-RIC, is devoted to developing technologies, designs, and systems for energy-efficient buildings.[11] E-RIC attempts to align the resources of several federal agencies around regional initiatives and to collaborate more closely with state and local governments, universities, and industry.[12]

State and Regional Support for Cluster Initiatives

Many state and regional governments have taken a pragmatic approach to fostering innovation clusters, targeting industries such as semiconductors, batteries, flexible electronics, and robotics. New York, Ohio, Michigan, and New Mexico are among states that have invested alongside corporations and universities in R&D centers, awarded cash grants to companies building manufacturing plants, and amassed sizeable funds to provide early-stage capital to start-ups.[13]

Symposium participants cited numerous other examples of innovation clusters that are sprouting in regions of the United States with varying degrees of state and local government intervention as well as industry participation. These initiatives are found in places like Kansas, the Pacific Northwest, and West Virginia. "All of this is occurring on an ad hoc basis without a formal U.S. policy," noted Ginger Lew, then of the White House National Economic Council, in her symposium remarks.[14]

Congress, Michigan and other states, and other federal agencies in developing a U.S. advanced battery industry.

[10]See symposium presentation by Small Business Administration Administrator Karen Mills in the proceedings section of this volume.

[11]For a critique of the Obama Administration's Regional Innovation Cluster policy, see Junbo Yu and Randall Jackson, "Regional Innovation Clusters: A Critical Review," *Growth and Change,* 42(2), June 2011.

[12]The Department of Energy plans to pool resources with six other agencies in the $129.7 million project. Agencies participating in E-RIC are the Department of Energy, the National Institute of Standards and Technology, the Economic Development Administration, the Small Business Administration, the National Science Foundation, the Department of Education, and the Department of Labor. See <*http://www.energy.gov/hubs/documents/ERIC_FOA.pdf*>.

[13]See presentations by Doug Parks (Michigan) and Rebecca Bagley (Ohio) in the proceedings section of this volume. For presentations on strategies deployed by New York, Pennsylvania, and South Carolina, see National Research Council, *Growing Clusters for American Prosperity*, op. cit. Also see Pete Engardio, "State Capitalism," *BusinessWeek*, February 6, 2009.

[14]See presentation by Ginger Lew, formerly of the White House National Economic Council, in the proceedings section of this volume.

B. AN ENHANCED FEDERAL ROLE?

Concerns over America's global competitiveness and high unemployment are prompting federal policymakers to take a harder look at whether Washington can do more to bolster these regional initiatives.

Improving U.S. Competitiveness

One reason is the realization that other nations are catching up with and even surpassing the United States in key benchmarks of competitiveness in science and technology. In his symposium presentation, Marc Stanley of the National Institute of Standards and Technology (NIST) described a number of "disturbing signs" of eroding American leadership. He pointed out that after years in which spending on R&D has remained flat, at around 2.5 percent of gross domestic product, the United States now ranks behind nations such as Israel, Sweden, Finland, Japan, and South Korea in R&D intensity.[15] His remarks echoed the warnings that were raised in the National Academies' 2007 report *Rising Above the Gathering Storm* of an "abrupt" loss of U.S. global leadership in science, technology, and innovation and its impact on the future prosperity of the United States.[16]

Perhaps more importantly, other nations appear to be mastering the so-called soft infrastructure associated with successful innovation zones in the United States. In fact, Dr. Good asserted that many countries around the world "are replicating our successes better than we are." China, Singapore, Hong Kong, Taiwan, and France are among those building modern science parks that promote synergies among businesses, governments, and university research programs in their regions.[17]

The growing movement among governments around the world to move away from outright subsidies to companies and poor regions and instead invest in public goods that enable industry and universities to cooperate and enable communities to compete represents "a new paradigm in regional policy," said Mario Pezzini of the Organisation for Economic Co-operation and Development.[18]

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[15]See OECD Science, Technology and Industry Scoreboard 2011 at < *http://www.oecd.org/document/10/0,3746,en_2649_33703_39493962_1_1_1_1,00.html*>.

[16]See National Academy of Sciences, National Academy of Engineering, Institute of Medicine, *Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future,* op. cit., p. 3.

[17]See presentations by Alberto Duque (Portugal), Francelino Grando (Brazil), and Nicholas Brooke (Hong Kong) in the proceedings section of this volume. For a review of the growth of science parks in China, Singapore, India, Mexico, and Hungary, see National Research Council, *Understanding Research, Science and Technology Parks: Global Best Practices—Summary of a Symposium*, op. cit.

[18]See presentation by Mario Pezzini of the Organisation for Economic Co-operation and Development in the proceedings section of this volume. See also Organisation for Economic Co-operation and Development, *National Innovation Systems,* Paris: Organisation for Economic Co-operation and Development, 1997, <*http://www.oecd.org/dataoecd/35/56/2101733.pdf*>.

Influential earlier works on global policies to promote innovation include Charles Freeman, *Theory of Innovation and Interactive Learning*, London: Pinter, 1987; Bengt-Åke Lundvall, ed., *National*

Strengthening the Structure of the U.S. Economy

The economic crisis that began in 2007 has added further impetus for the development of innovation clusters. As noted below, several senior Administration officials stated at the symposium that the collapse of financial markets and soaring unemployment in services and manufacturing has led to a focus not only on creating jobs and stimulating growth now, but also on resolving broader structural weaknesses in the U.S. economy.

Kristina Johnson, then Under Secretary of Energy, said that the enormity of the nation's economic needs, which include energy security, building 21st century infrastructure, and creating new growth industries, require that government must find new ways to accelerate the commercialization of technologies, mobilize funds, and attain large scale. "It's going to take trillions of dollars in investment, and it can't be something the federal government does on its own. It has to be a collaborative, cooperative partnership," Dr. Johnson said. "We don't get there by technology alone and by policy alone."[19] Assistant Secretary of Commerce for Economic Development John Fernandez observed that the deep recession "in many ways may have been . . . a bit of a wakeup call across the board, not only for the federal government but also for the private sector and in public agencies across the country."[20]

Improving Credit Markets

Some symposium participants noted that the collapse in the market for credit has made it difficult for manufacturers to build or expand capacity in order to bring new products to market. Venture and angel funding, which already had been concentrated in a few regions such as Silicon Valley, the Boston area, and metropolitan New York, dried up further in much of the rest of the country.[21]

In his remarks, Michael Borrus noted that traditional venture capitalists have grown more averse to supporting early-stage start-ups.[22] As a result, innovative small businesses are finding it more difficult to raise the capital they need to bring promising new technologies to market. In this credit-scarce environment, he noted, small companies are finding it difficult to survive the so-called Valley

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Innovation Systems: Towards a Theory of Innovation and Interactive Learning, London: Pinter, 1992; and Michael Porter, *The Competitive Advantage of Nations*, New York: The Free Press, 1990.

[19]See the summary of the presentation by Under Secretary Kristina Johnson in the Proceedings section of this volume.

[20]See the summary of the presentation by Assistant Secretary of Commerce for Economic Development John Fernandez in the Proceedings section of this volume.

[21]PriceWaterhouseCoopers and the National Venture Capital Association provide a region-by-region breakdown of venture capital investment on a quarterly basis. See <*https://www.pwcmoneytree.com/MTPublic/ns/nav.jsp?page=notice&iden=B*>.

[22]See the summary of the presentation by Michael Borrus of X/Seed Capital in the Proceedings section of this volume.

of Death, the 5 to 12 years it typically takes to turn an invention in the laboratory into a commercial product.

C. THE FEDERAL STRATEGY

Until recently, the United States has had no coordinated national effort under way to build new research parks or develop new innovation clusters. Traditionally, state and local governments and, in some cases, private foundations and other regional organizations have singularly or in combination sought to stimulate the development and growth of clusters.[23] In many cases, however, state and local efforts lack critical mass in terms of funding and facilities and, in some cases, the sustained policy support needed for success.

To address this apparent gap and to adjust to the changing international competitive environment, a number of policy institutes and nongovernment organizations have in recent years released studies urging the federal government to make regional innovation clusters a core element in economic development.[24] Andrew Reamer of the Brookings Institution and Jonathan Sallet of the Center for American Progress are among those who have urged federal agencies to make more effective and efficient use of resources they already deploy.[25]

While federal agencies, including the Small Business Administration (SBA), the Energy Department, the Department of Labor (DoL), NIST, the Department of Defense, and the National Institutes of Health have numerous programs intended

[23]A number of states have promoted clusters development, taking advantage of universities to do so, since the 1980s. An example of an early document guiding state clusters development policies is "Choosing to Compete: A Statewide Strategy for Job Creation and Economic Growth," published by the Commonwealth of Massachusetts in 1993. This report was prepared for Massachusetts Governor Weld in 1993 by a council led by Michael Porter. Reflecting support by both Democratic and Republican governors, the National Governors Association has been active in promoting and assessing state efforts over the past decade to develop innovation clusters. See Council on Competitiveness and the National Governor's Association, *Cluster-Based Strategies for Growing State Economies*, Washington, DC: Council on Competitiveness, 2007.

For a review of selected state initiatives, see National Research Council, *Growing Innovation Clusters for American Prosperity: Summary of a Symposium,* op. cit. Clusters have not been systematically identified and mapped across all U.S. regions. To address this, the Economic Development Administration is supporting a Cluster Mapping Project, led by Michael Porter of the Harvard Business School.

[24]See for example, Karen G. Mills, Elisabeth B. Reynolds, and Andrew Reamer, *Clusters and Competitiveness: A New Federal Role for Stimulating Regional Economies,* Washington, DC: The Brookings Institution Metropolitan Policy Program, April 2008. See also Ed Paisley and Jonathan Sallet, *The Geography of Innovation: The Federal Government and the Growth of Regional Innovation Clusters,* Washington, DC: Center for American Progress, 2009.

[25]Andrew Reamer, "Stimulating Regional Economies," in National Research Council, *Growing Innovation Clusters for American Prosperity: Summary of a Symposium,* op cit. See also Jonathan Sallet, "The Geography of Innovation: The Federal Government and the Growth of Regional Innovation Clusters" in National Research Council, *Growing Innovation Clusters for American Prosperity: Summary of a Symposium,* op cit.

to contribute to regional economic development, Reamer and Sallet argued in their presentations that these programs are often not coordinated with those of local development agencies, educational institutions, or nongovernment organizations that are pursuing similar aims.[26] To better leverage these federal investments, a 2009 Brookings Institution report called on the federal agencies to "link, leverage, and align" their resources with regional innovation cluster initiatives.[27]

According to Ginger Lew, the Brookings study not only drew attention to efforts by regional governments to grow innovation clusters, but also encouraged the Obama Administration "to link, leverage, and align federal, state, and regional resources" to accelerate development of innovation clusters.

Federal Collaboration with E-RIC

Ms. Lew suggested that the new Energy Regional Innovation Cluster effort, led by the DoE, therefore represents an important initial effort to coordinate these policy tools. In her presentation, she presented a diagram depicting how federal agencies are working together on the E-RIC. (See Figure 1.)

The lead agency in the middle, labeled "Agency X," in this case is DoE. Six other agencies (SBA, NIST, EDA, DoL, National Science Foundation [NSF], and Department of Education [ED]) pool resources to play a supporting role. The federal agencies, meanwhile, fund and convene an array of "regional partners" also working to advance the cluster, such as colleges, workforce training programs, private companies, nongovernment organizations, and local and state development agencies.

For example, she said, the Labor Department can team with community colleges to make sure a region has enough engineers and skilled workers to meet project demand for a cluster; NIST can work with university-industry research centers to accelerate development of core technologies; the SBA can provide seed capital for start-ups; and the U.S. Department of Agriculture (USDA) supports a variety of rural cluster activities.

Getting so many federal bureaucracies to think and work together is a big challenge, Ms. Lew admitted. Practical efforts required for greater coordination are daunting and can often drain managerial energy at the federal, state, and local levels. Nonetheless, she said that she hoped to learn from the experience of the E-RICs in order to fine tune the collaboration model that can eventually be used as a template to accelerate other clusters.[28]

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[26]Ibid.

[27]Karen G. Mills, Elisabeth B. Reynolds, and Andrew Reamer, *Clusters and Competitiveness: A New Federal Role for Stimulating Regional Economies,* op. cit.

[28]The Taskforce for the Advancement of Regional Innovation Clusters (TARIC), under the auspices of the National Economic Council, is overseeing the development and implementation of interagency clusters efforts described in the symposium and those that occurred afterwards. The TARIC was chaired by Ginger Lew before her retirement in June 2011.

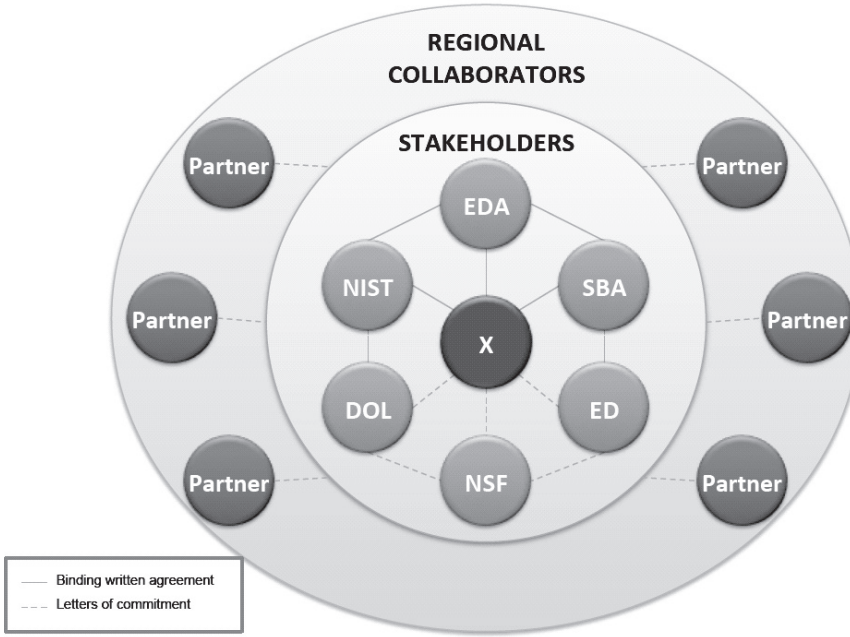

FIGURE 1 RIC operations.
SOURCE: Ginger Lew, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

DoE Energy Hubs

In her symposium presentation, DoE Under Secretary Kristina Johnson observed that given its broad mission of meeting the nation's energy needs, reducing carbon emissions, and now spurring economic development, the DoE must learn to leverage the efforts of other agencies and regional partners.

Describing DoE's fiscal year 2011 budget of $28.4 billion, she noted that $10.4 billion will go for energy and environmental programs, with sharp funding increases for solar, wind, geothermal, and nuclear energy. The DoE is also dispersing $3.4 billion under the American Recovery and Reinvestment Act (ARRA) for projects in carbon-capture sequestration, $4.5 billion for smart grid technologies, $12 billion for energy efficiency, and $2.4 billion for production of electric-vehicle batteries and components.

To accelerate basic scientific breakthroughs, the DoE is supporting 46 "engineering frontier research centers" with $140 million allocated under the Recovery Act. In its Fiscal Year 2011 budget request, the department seeks funding to make these centers permanent.

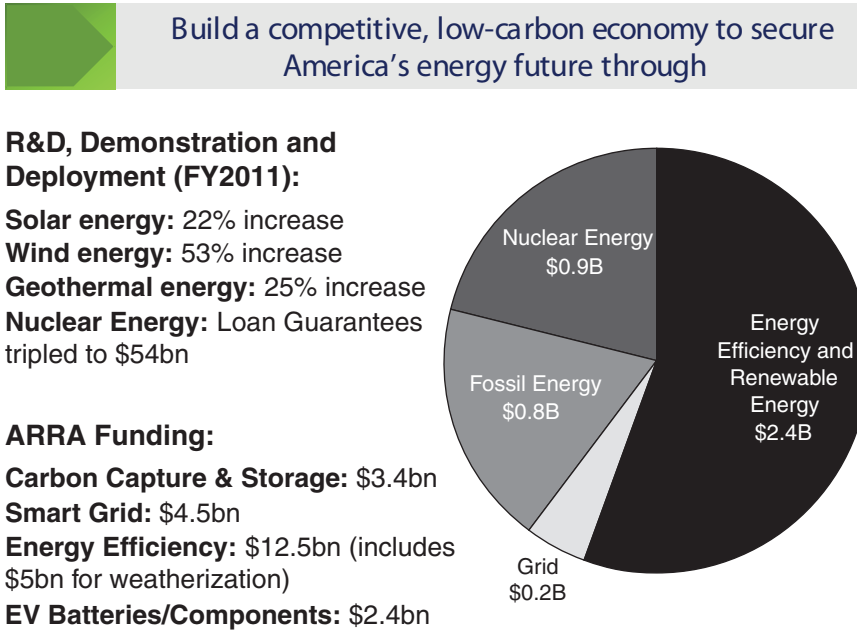

FIGURE 2 President's budget invests in clean energy.
SOURCE: Kristina M. Johnson, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

To speed up the commercialization of clean-energy technologies, the DoE also established the Advanced Research Projects Agency for energy, known as ARPA-E, funded with $400 million from the Recovery Act. The program strives to achieve "game-changing" technology advances that could result in large-scale, commercially viable production of fuels from cellulose, sugar, and algae, for example, Dr. Johnson said.

One major DoE initiative is to establish "energy-innovation hubs," or regional innovation clusters in solar power, energy-efficient buildings, nuclear energy, and batteries for storing energy. The first hub will focus on energy efficiency, because buildings account for 40 percent of U.S. energy consumption, 70 percent of electricity, and 55 percent of natural gas. The field also involves big industries from appliances and software to construction, which accounts for 9.5 percent of U.S. Gross Domestic Product (GDP) and employs nearly 10 million. Such agencies as the Labor Department, SBA, NIST, and NSF also have building-efficiency programs.[29]

[29]On August 4, 2010, the Department of Energy announced the selection for a grant of the Greater Philadelphia Innovation Cluster (GPIC), led by Pennsylvania State University, to run the Energy-

Dr. Johnson also noted that DoE also is looking to provide U.S. technology start-ups the financial "staying power" to survive the Valley of Death—a term that refers to the gap in funding that frequently occurs between inventing a product and bringing it to market. One way to do this is to provide additional rounds of funding, which gives companies three to five additional years to develop prototypes.

The SBA's New Role in Clusters

SBA Administrator Karen Mills noted that her agency is broadening its traditional role of providing advice, loan guarantees, and grants to small businesses.[30] The agency is now a partner in initiatives such as the Energy Regional Innovation Cluster and is organizing new cluster efforts.

In 2009, for instance, the SBA helped launch robotics clusters in Michigan, Virginia, and Hawaii. The agency sought another $10 million in fiscal year 2011 budget for clustering activities. Among other uses, the funds are intended to help develop public-private partnerships and launch training initiatives. These partnerships can be effective, Ms. Mills noted, citing her own prior effort to establish a successful cluster in Maine among boat builders that incorporates new composite materials and processes.

Administrator Mills noted that SBA has considerable resources to help clusters. The agency has a $90 million loan portfolio, 68 field offices, and 900 Small Business Development Centers across the nation. The SBA also is affiliated with SCORE, a small-business mentoring program with 350 chapters and 14,000 counselors. The SBA has special funding to add experts at its small-business centers to assist E-RIC.

The SBA began with the Michigan robotics cluster, Ms. Mills explained, because it saw an opportunity to help struggling automotive suppliers meet the Department of Defense's (DoD's) need for unmanned military vehicles, such as for detecting roadside bombs. The Detroit area's advantages include an advanced

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Efficient Buildings System Design Hub. This group is partnered with national labs, universities, and private companies. See <*http://energy.gov/articles/energy-efficient-building-systems-regional-innovation-cluster*>. The Department of Energy is also partnering with the Economic Development Administration and other agencies on a $12 million i6 Green Challenge. This competitively awarded grant will establish or expand Proof of Concept Centers for renewable energy technologies across the United States. See <*http://www.eda.gov/i6*>.

[30]Congress established the SBA with the Small Business Act of July 30, 1953, to "aid, counsel, assist and protect . . . the interests of small business concerns" and to ensure small businesses get a "fair proportion" of government contracts. The SBA guarantees small-business loans. In 1982, the Small Business Innovation Research (SBIR) program was established to administer small grants by various federal agencies to boost commercialization of innovations derived from federal R&D, among other things. For a recent assessment of SBIR, see National Research Council, *An Assessment of the Small Business Innovation Research Program*, Charles W. Wessner, ed., Washington, DC: The National Academies Press, 2008.

manufacturing supply base, automated tool suppliers, expertise in sensor technologies, and robotics R&D at Oakland University. Encouraging the development of regional networks, SBA helped organize a two-day meeting of DoD procurement officers and 200 Michigan businesses.

SBA also is helping organize similar cluster initiatives in Hampton Roads, Virginia (for robotics, unmanned systems, port security, sensors, modeling, and simulation) and in Hawaii (to develop unmanned vehicles to detonate unexploded ordinance.) Ms. Mills said the SBA will fund at least three more robotics clusters, and is studying five to seven more.[31]

Expanding the EDA Role

John Fernandez, Assistant Commerce Secretary for Economic Development noted that a key mission of the Economic Development Administration is to "prepare American regions for growth and success in the worldwide economy."[32] To promote regional innovation, now the agency's top priority, EDA is investing $50 million of the $150 million it received under the Recovery Act to support regional clusters.

The agency also has launched the Regional Innovation Strategies Initiative, which serves as a framework for its economic development activities. EDA is realigning all of its programs to support this initiative, Mr. Fernandez said. He added that his staff is developing a rich database of innovation cluster activities across the United States and new metrics to evaluate their performance.[33] EDA programs also offer technical assistance and disseminate best practices to economic development practitioners. For example, the agency offers an online, self-paced curriculum called "Know Your Region" that explains the benefits of regional planning, data on employees and companies in each county that could contribute to a cluster, and tools to formulate regional strategies.[34]

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[31]In September of 2010, SBA competitively funded 10 Innovative Economy Clusters, representing a wide range of geographic areas and industries and focusing on leading research and commercializing new products. SBA's funding was provided to each cluster's organizing entity to strengthen opportunities for small businesses within the cluster. See SBA News Release 10-50 at <*http://archive.sba.gov/idc/groups/public/documents/sba_homepage/news_release_10-50.pdf*>.

[32]Congress established EDA under the Public Works and Economic Development Act of 1965 to create and retain jobs and stimulate growth in economically troubled areas. See <*http://www.eda.gov/PDF/EDA%20Collateral%20Piece_With%202010%20Investment%20Policies.pdf*>.

[33]EDA, along with the Institute for Strategy and Competitiveness at Harvard Business School, has launched <*www.clustermapping.us*>, the U.S. Cluster Mapping Web site. EDA sees this Web site, which creates a national database of cluster initiatives and other economic development organizations, as "a new tool that can assist innovators and small business in creating jobs and spurring regional economic growth." See EDA Update, "U.S. EDA Announces Registry to Connect Industry Clusters Across the Country," October 6, 2011.

[34]According to EDA, the Know Your Region research project "explores regional and local approaches to economic innovation and competitiveness across the United States" and "is intended to

Finally, EDA is expanding the scope of its public works program to include critical infrastructure needs of the 21st century, such as research parks, incubators, and better access to capital. Mr. Fernandez said the agency also is supporting proof-of-concept and workforce training centers that are custom-designed to act as catalysts for specific technology clusters and serve the needs of communities.[35]

NIST: Letting the Private Sector Lead

Marc Stanley, then director of the National Institute of Standards and Technology Technology Innovation Program (TIP) noted that NIST was one of the first agencies to view support for innovation clusters as part of its mission of advancing scientific research, measurement standards, and new technologies.

In 2007, NIST launched its Rapid Innovation and Competitiveness initiatives whose goals are to increase the nation's return on its scientific investment, accelerate technological innovation, stimulate the economy, and enhance U.S. competitiveness. Mr. Stanley said that TIP, the Manufacturing Extension Partnership (MEP), and other agency programs are being deployed to help regional clusters.[36]

NIST's strategy is to let private industry take the lead in terms of defining technological needs and research priorities. It first pilot program, the Nanoelectronics Research Initiative, illustrates this approach.[37] This project, which will involve more than $200 million in federal funding, is a collaborative effort between industry, government, and academia to develop semiconductor

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help local officials, economic development practitioners, community leaders and citizens assess local and regional assets, needs, and visions in a global context, leading to long-term regional prosperity and sustainability." See EDA Web site at <*http://www.knowyourregion.org/about*>.

[35]In September 2011, the winners were announced for the $37 million Jobs and Innovation Accelerator Challenge, a multiagency competition to support the advancement of 20 high-growth, regional industry clusters. Investments from three federal agencies and technical assistance from 13 additional agencies will promote development in areas such as advanced manufacturing, information technology, aerospace, and clean technology in rural and urban regions in 21 states. Projects are driven by local communities that identify the economic strengths of their areas, with funding awarded to the best proposals. Access the EDA press release at <*http://www.eda.gov/NewsEvents/PressReleases/20110922_Media_Advisory.xml*>.

[36]The Technology Innovation Program (TIP) was established in 2007 under the America COMPETES Act, P.L. 110-69. It awards grants to fund high-risk, high-reward R&D projects addressing critical national needs. The Manufacturing Extension Partnership (MEP) is a national system of over 400 centers, field offices, and partners that encourages the creation and adoption of improved technologies and provides firms information and resources to develop new products that respond to changing market needs. Recent MEP awards support the development of regional innovation clusters in Colorado and Kentucky, among other regions. See NIST news release, "NIST Manufacturing Extension Partnership Awards $9.1 Million for 22 Projects to Enhance U.S. Manufacturers' Global Competitiveness," October 5, 2010.

[37]The Nanoelectronics Research Initiative (NRI) is a consortium of companies in the Semiconductor Industry Association that receives support from NIST and has research partnerships with 30 universities. The goal is to demonstrate novel computing devices capable of replacing the CMOS transistor as a logic switch by 2020.

technologies that eventually will replace CMOS.[38] The alliance includes corporations such as IBM, Advanced Micro Devices, Freescale, Micron Technology, and Texas Instruments, as well as 35 universities.

NIST relies heavily on industry input to define technology roadmaps for next-generation semiconductors, Mr. Stanley explained. Under the initiative, four nanotechnology research centers have been set up at different universities around the United States. The largest, an 11-university consortium called Index, is based at the State University of New York-Albany. Other centers are at the University of Texas-Austin, the University of California at Los Angeles, and Notre Dame University. NIST contributes $2.75 million annually to the centers. States and corporation contribute $20 million.

Early results are encouraging, Mr. Stanley said. The nanotechnology initiative so far has generated 13 patents and 239 publications, and supports the work of 152 graduate students and post-docs. The program also is getting federal agencies, state governments, industry, and universities to collaborate and co-fund critical research, he said, serving as "the benchmark of where we have to go" with innovation initiatives.

Box B
A Leadership Role for the Regions

What role can federal agencies play to enhance local initiatives to develop innovation clusters? Addressing this issue at the symposium, Secretary of Commerce, Gary Locke emphasized that regions must take a leadership role in this process. "The federal government can facilitate and encourage stakeholders to work together. But regions will know where their unique strengths and abilities lay," he said, adding that the federal government can "shine a spotlight on the importance of clusters but it can't replace a region's knowledge of what it does best." EDA Administrator Fernandez concurred. "We can't legislate this stuff," he said, "but we can support it."

D. THE STATE AND REGIONAL GOVERNMENT ROLE

Participants at the symposium from Michigan, Ohio, and Texas described some of the most creative and determined experiments with cluster development that are taking place at the state level. Learning from the success of Silicon Valley, Boston's Route 128, and Research Triangle, these state strategies often involve leveraging research universities as catalysts of economic development.

[38]CMOS, patented by Frank Wanlass in 1967, stands for complementary metal-oxide semiconductor. CMOS is a technology for constructing integrated circuits that is used in devices such as microprocessors, static random-access memories, and image sensors.

As Mary Good remarked, universities are increasingly being expected to take on an economic development role.

As these participants also pointed out, state governments also are intervening actively to support private industry. They are going far beyond traditional incentives long used to attract large factories and corporate headquarters, such as tax breaks, free work training, and low-cost land and utilities, and are increasingly providing funding, including early-stage capital, to established companies and start-ups. They also are investing alongside universities, industry, and federal laboratories to establish major research centers devoted to core applied technologies required for a targeted cluster.

Building on Michigan's Battery Initiative

Doug Parks, of the Michigan Economic Development Corp (MEDC), said that Michigan has been one of the boldest states in subsidizing new investment. The recession and financial crisis hit Michigan and its auto industry especially hard, he noted, spurring government efforts to diversify the industrial base.

MEDC worked with the private sector, universities, and federal agencies to launch a program to identify emerging industries where the state enjoyed strategic advantages and had a good chance of succeeding globally. From this process, MEDC selected the advanced energy-storage systems, equipment for wind and solar power, and bio-fuels industries as key emerging industries for Michigan. These sectors were seen to leverage Michigan's strengths in manufacturing, natural resources, parts and materials suppliers, and extensive university and corporate R&D. Some 80 percent of auto-related R&D in the United States, Mr. Parks noted, takes place in the Detroit area.

MEDC developed detailed roadmaps for each cluster to facilitate cooperation among participants from government, industry, and academia. The MEDC was particularly inspired by Sweden's "triple helix" model of tight collaboration between industry, government, and universities, Mr. Parks said.[39] The state legislature funded university-based research programs called "Centers of Energy Excellence" to support each cluster. Companies and universities also contribute funds.

Michigan offers some of the nation's most generous financial incentives for opening manufacturing facilities. It invests in start-ups through a 21st Century Jobs Fund and provides loans and grants to help larger companies commercialize manufacturing and green-energy technologies. The state also offers a variety of refundable tax credits, including special programs for manufacturing advanced batteries and solar-power equipment, companies that invest in smaller Michigan

[39]Triple Helix in the study of knowledge-based innovation systems refers to interaction among universities, industry, and government. See Henry Etzowitz, *The Triple Helix: University-Industry-Government Innovation in Action,* London: Routledge, 2008.

companies, and companies that invest at least $350,000 for new strategic innovation relationships.

According to Mr. Parks, the most striking success has taken place in the advanced battery cluster—a new industry for the state. In addition to being essential for new electric cars, next-generation lithium-ion storage systems are in growing demand by utilities and the military. Michigan's early efforts to build a cluster helped it win $1.3 billion in federal funds, encouraging companies such as A123, General Motors, Johnson Controls, XTreme Power, and South Korea's LG to build lithium-ion cell or battery-pack factories in the state. These federal and state investments also are crowding in $5.2 billion in private investment. Mr. Parks estimated that Michigan's advanced energy storage industry will create up to 40,000 new jobs over the next five years.

Lastly, Mr. Parks noted that Michigan also has been making impressive strides in attracting out-of-state manufacturers of photovoltaic cells and modules for solar energy and in helping local suppliers win military contracts.

Cluster Building in Northern Ohio

Speaking at the symposium, Rebecca Bagley said that universities, large and small businesses, and state and regional governments in the northeast Ohio region are working to diversify an economy whose manufacturing base has eroded over time. She said that economic development officials in the state are developing road maps to nurture clusters in energy storage, smart grid technology, electric transportation, and conversion of biomass and waste into energy.

NorTech—an organization funded by foundations and business associations—promotes development of the high-technology economy in a 21-county region that contains 42 percent of Ohio's population, including the cities of Cleveland, Akron, and Youngstown. As NorTech's CEO, Rebecca Bagley noted that her organization sets the long-term vision and strategy for the region's efforts to build innovation clusters. It also acts as a "quarterback," she explained, by coordinating resources and programs from a wide range of stakeholders. Partners include private companies, government agencies, and universities. Nonprofit allies include JumpStart Inc., which helps develop early-stage business, and the Manufacturing Advocacy and Growth Network (MAGNET), which helps manufacturers adopt best practice and new technologies.

The Ohio government also lends substantial support. Ohio is investing $1.6 billion over 10 years in cluster-building initiatives and has received strong voter approval for another $700 million for four more years.[40]

The region's biggest effort is the Advanced Energy Initiative. Northeast Ohio has over 400 companies in the advanced-energy space, Ms. Bagley noted.

[40]Ohio's Third Frontier, a 10-year, $1.6 billion project to re-energize Ohio's economy by investing in emerging technologies, was passed in May 2010 with 62 percent of the vote.

NorTech believes the region is strong in 10 energy areas, including bio-fuels and technologies for electric vehicles. Specific projects include an advanced-energy incubator in Warren, Ohio, a city hit especially hard by the loss of auto-related manufacturing jobs.

She added that NorTech also is focusing on flexible electronics, or electronic devices such as displays, solar cells, batteries, and sensors that bend and fold. Northeast Ohio has a strong legacy in core technologies: The University of Akron and regional companies are leaders in polymers that can be used for printable electronics, while Kent State University has been a pioneer in liquid-crystal displays.

Overall, NorTech's strategy is to ensure that technologies invented in the region are then manufactured in the region. The region, Ms. Bagley noted, has learned from past experience when LCD technologies invented in northern Ohio did not lead to the establishment of large local industries. Instead, production of LCD displays for computers and televisions were dominated by Asian companies. To avoid a repeat of that experience, she said, NorTech's FlexMatters program is working with established companies, universities, and regional agencies to build a flexible electronics manufacturing base in Northeast Ohio.

Betting on Research Universities in Texas

In his presentation, University of Texas (UT) at Dallas President David Daniel said that Texas is investing heavily in new research universities, which can be catalysts for clusters of new companies and knowledge industries. He said that Dallas-Fort Worth, which, despite having one of the nation's strongest regional economies, lacks a major research university, is a leader in this effort.

Dr. Daniel noted that in June 2009, Texas set up a $50 million fund to establish faculty chairs, graduate student fellowships, and support research. Universities in Texas compete for the funds and must match them with private gifts. The state also established the National Research University Fund, a $500 million endowment to support emerging research universities. The goal, he said, is to expand this endowment to $5 billion over the next decade.

Dr. Daniel explained in his presentation that he was able to convince Texas state legislators to allocate funds by pointing out how badly the state lagged others: Texas has just 3 of the nation's 60 most important research universities—the University of Texas at Austin, Rice, and Texas A&M. In comparison, California has 9, New York 7, and Pennsylvania 4. He also explained to Texas lawmakers how this paucity of research universities could cost the Texas economy over the long run. Although Texas has 8 percent of the U.S. population, it receives only 4.5 percent of the nation's venture capital investment, for example. Although Dallas-Ft. Worth boasts many electronics and defense companies and is second only to Silicon Valley in technology workers, it produces little innovation because it has no research university. The Massachusetts Institute of Technology (MIT), by contrast, earned 133 patents and launched 20 companies alone in 2004. Texas

also has a large net outflow of high school graduates who pursue advanced science and technology degrees at out-of-state universities.

These arguments, Dr. Daniel said, have been persuasive. UT-Dallas has received $15 million from the state endowment and raised $17.3 million in private gifts, money it is using to aggressively recruit faculty. Master's level student applications for next year are up 45 percent, and doctoral applications are up 70 percent. Research spending at UT Dallas, publications, and spinoffs are rising sharply, and more companies are looking to locate R&D laboratories close to campus. Such success has bolstered support in the state legislature for expanding the endowment program, Dr. Daniel said.

E. LESSONS FROM ABROAD

As many speakers noted in the symposium, innovation clusters themselves are neither new nor invented in the United States. The phenomena of "many firms relating to each other and being competitive did not happen first in Silicon Valley," Mario Pezzini of the Organisation for Economic Co-operation and Development pointed out in his presentation, "It happened in many other places."

When it comes to dynamic new innovation zones, however, U.S. regions such as Route 128 in Massachusetts, Silicon Valley and San Diego's Torres Pines biotechnology park in California, and Research Triangle Park in North Carolina are viewed as the global exemplars. Seeking to replicate their success, national and regional governments around the world are making often substantial investments in science and research parks as catalysts of the development of innovation and innovative clusters that support rapid economic growth and attract a talented and educated workforce.[41] According to Steve Lehrman, aide to U.S. Senator Mark Pryor (D-AR), "Now it is up to us to learn from their lessons in how to modernize our systems here in the United States."

A "New Paradigm" in Regional Policy

This interest in regional innovation clusters has been accompanied with a new perspective on how they should be developed. Mr. Pezzini observed in his symposium remarks that in the past, regional economic strategy tended to be about compensating for economic disparities. Federal governments in Japan, southern Italy, northern Europe and other places acted like Robin Hood, taking funds from rich locales and giving them to poor ones. Many governments also provided subsidies to small business entrepreneurs.

Such central government investments tended to "produce cathedrals in the

[41]For a selected review of programs to grow research parks, see National Research Council, *Understanding Research, Science, and Technology Parks, Global Best Practices—Summary of a Symposium,* op. cit.

desert," said Mr. Pezzini, who early in his career had sought to oversee economic development in Italy's Emilia-Romagna Region. These reallocation efforts not only failed to erase regional disparities but also subsidized companies that never achieved the scale or ability to differentiate their products so they could compete globally, he said.[42]

Now, Mr. Pezzini noted, governments around the world are relying less on subsidies to local firms and regions. Instead, governments increasingly are getting regions to identify their comparative advantages and are focusing on strengthening university research, workforce training, and small-business mentoring. These investments are viewed as infrastructure that communities can use to build innovation-driven economies. "We are dealing with a new paradigm in regional policy," he said. Other nations also are adapting their strategies to the increasingly open, networked, and interdisciplinary global innovation process.

Brazil's New Innovation Policy

Brazil's Secretary of Innovation, Francelino Grando, noted in his presentation that his country has made impressive progress in the past decade in improving innovation. Documenting this progress, he noted that between 2000 and 2008, the number of master's degrees awarded annually by Brazilian universities has doubled, to more than 36,000. Awards of doctorates had also doubled to nearly 11,000. He said that there also has been explosive growth in intermediate technology training. Thanks to $550 million in government investment from 2002 through 2010, the number of technology schools has risen from 140 to 366, creating 500,000 new student positions.

Such investments in education are paying off, Dr. Grando added. There have been sharp increases in published scientific papers, small-business incubators, and technology start-ups. Private investment in R&D has swelled nearly threefold, to $24.8 billion. Brazil boasts one of the world's top aircraft manufacturers (Embraer), and, as a leading producer of bio-fuels, is now self-sufficient in oil.

Although Brazil has spent heavily to upgrade higher education, it lacked until recently a strong national innovation policy to leverage those investments, Dr. Grando said. There also was poor communication among federal agencies and with local development organizations. To address this challenge, Dr. Grando's Innovation Secretariat has been working to establish a system for the Ministry of Development, Industry and Foreign Trade and five other agencies to coordinate activities to advance new clusters.[43]

[42]Mario Pezzini, *Cultivating Regional Development: Main Trends and Policy Challenges in OECD Regions,* Paris: Organisation for Economic Co-operation and Development, 2003.

[43]These agencies are the National Development Bank, the National Institute of Intellectual Property, the Industrial Development Agency, the Export Promotion Agency, and the National Institute of Metrology, Standardization and Industrial Quality (INMETRO), which is modeled on the U.S. National Institute for Standards and Technology.

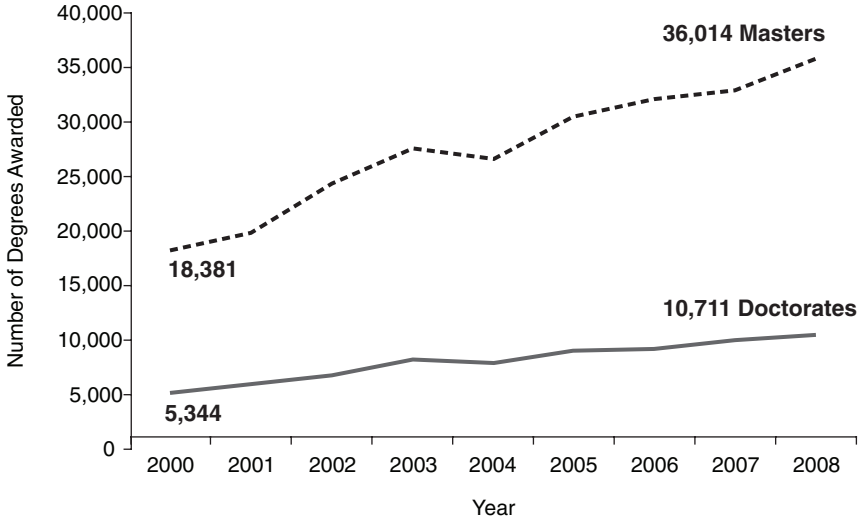

FIGURE 3 Increasing knowledge.
SOURCE: Francelino Grando, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

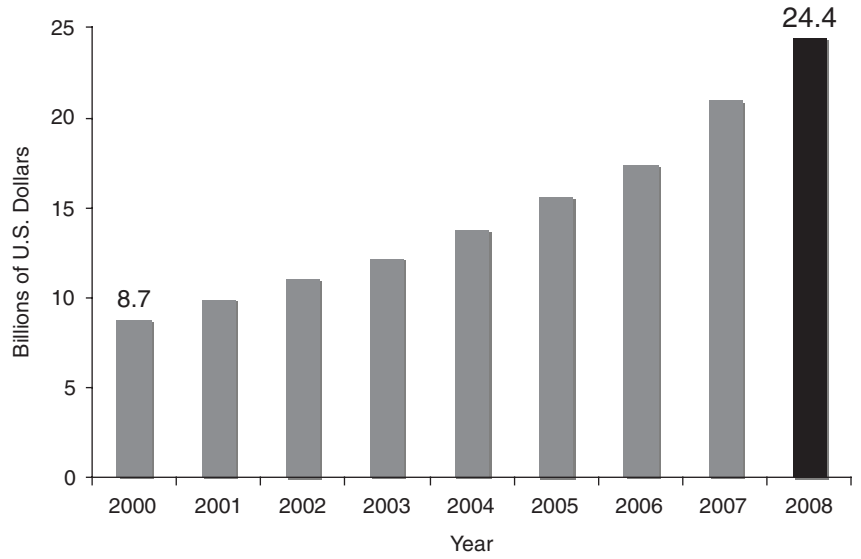

FIGURE 4 R&D expenditure in Brazil.
SOURCE: Francelino Grando, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

The federal government is backing this innovation push with money. The Ministry of Science and Technology, for example, has a $20 billion program to develop a "science and technology action plan," Dr. Grando said. Ministry officials will lead teams responsible for nurturing clusters in industries such as information and communication technology, biotechnology, and nuclear power.

Enhancing Innovation Clusters in Brazil's Minas Gerais State

Minas Gerais offers a glimpse of Brazil's innovation strategy at work at the state level. With 20 million people and a territory roughly the size of France, Minas Gerais has a diversity of industries, spanning biotechnology, metals, and agriculture. Its universities have 91,000 students and spend $1.3 billion annually on R&D. There also are 282 private institutions employing 15,842 researchers.

The big challenge, though, "is how to transfer this science and technology into production, productivity, quality, competitiveness, and better employment," explained Alberto Duque Portugal, the Minas Gerais Secretary for Science, Technology and Higher Education. The state especially wants to speed development in the poor, less densely populated north, which includes portions of the Amazon.

The state has spent some $300 million in four years to enhance the regional innovation system. It has targeted emerging clusters such as microelectronics, bio-fuels, and software. It also identified hundreds of local "poles of excellence" in traditional industries across the state to further develop. To coordinate the initiative, Minas Gerais created Sistema Mineiro de Inovação, or SIMI.

In addition to promoting science parks, incubators, and training programs, one of SIMI's key jobs is to establish linkages between government programs, local efforts, and investors and to connect researchers and entrepreneurs across the state with each other. For instance, SIMI is trying to consolidate scattered "pools of excellence" into hubs based in one place, so that they can achieve greater scale, support bigger concentrations of public and private R&D, recruit more scientists with doctoral training, and draw more corporate investment. SIMI also is building an outreach program to bring new technologies and design help to small companies around the state, an extensive network of workforce training centers, an entrepreneurial training program, and a Web 2.0 portal connecting Minas Gerais researchers with entrepreneurs and potential investors.

Hong Kong's Innovation Push

Hong Kong's innovation strategy also illustrates the new paradigm for regional development described by Mario Pezzini. In the case of Hong Kong, the bid to build innovation clusters was accelerated by the Asian financial crisis in 1997. According to Nicholas Brooke of the Hong Kong Science and Technology Parks Corp., the four years of deflation that followed this crisis exposed the

territory's overreliance on industries such as financial services, property development, tourism, and logistics.

To diversify Hong Kong's economic base, its government has invested $1.5 billion so far to build the first two phases of a science park that houses 250 companies—80 percent of them foreign—and employs 7,000 people. When a third phase is completed, the science park expects to have 450 companies and employ 15,000, Mr. Brooke said.

The park's strategy is to pick clusters based on existing strengths in electronics, green technology, information and communication technology, precision engineering, and biotechnology, and to capitalize on Hong Kong's position as a world-class business environment with strong legal protections, as well as its location across the border from Shenzhen, China.

Mr. Brooke noted that the science park's Phase III facilities will focus on new clusters, such as thin-film photovoltaic panels, environmental engineering, and energy management for buildings. The park's laboratories, design center, and incubators focus on niche technologies within these broad areas, such as chips for wireless telecom devices, smart cards, and RFID applications, areas where Hong Kong already is strong. In all, the goal is to create in Hong Kong an important integration platform for technologies from around the world, serving markets in China and elsewhere in Asia. Many of the 250 companies in the park conduct sensitive R&D in Hong Kong and manufacture their products in China. DuPont, Philips, Freescale, Xilinx, and Nvidia are among the multinationals using this "Hong Kong-Shenzhen model."

F. A NEW ROLE FOR NATIONAL LABORATORIES

Participants at the symposium also discussed how National Laboratories in the United States, rich reservoirs of scientific and applied technological research, have still to reach their full potential as regional economic catalysts. In the 1980s, Congress began encouraging federal laboratories, most of them established after World War II to meet national defense and energy needs, to commercialize their technology and encourage regional growth.[44] Provisions of the 2005 Energy Policy Act have further sought to promote technology transfer by national laboratories.[45]

[44]In addition to universities, the Bayh-Dole Act of 1980 made it easier for national laboratories to transfer technology. The Federal Technology Transfer Act of 1986 (P.L. 99-502) required every federal laboratory to transfer technology.

[45]Title X, Sections 1001, 1002, and 1003 of the Energy Policy Act of 2005 (P.L. 109-58) contained several provisions to promote technology transfer and commercialization by federal laboratories, including establishment of a technology-transfer coordinator at the Department of Energy, a working group of laboratory directors, an energy commercialization fund, a technology infrastructure program, and a small-business assistance program.

Sandia As a Regional Growth Catalyst

Sandia National Laboratories in Albuquerque, New Mexico, was among the first national laboratories to expand its mission beyond national security and assume "a significant leadership role" in commercializing government-sponsored research, Sandia Chief Technology Officer J. Stephen Rottler explained in his presentation.

The focal point of this effort is Sandia's 12-year-old science park.[46] The park now is home to 30 high-tech companies employing 2,000 people in industries as diverse as solar energy and software to nano-materials and semiconductor manufacturing equipment. The jobs in Sandia Park pay twice as much as the average for Albuquerque. The park's biggest success is solar-equipment manufacturer Emcore, which moved its headquarters to Albuquerque after buying a Sandia spinoff. The park is still expanding and hopes to account for 6,000 jobs in a decade.

Spin-offs, prompted by the Sandia's Separation to Transfer Technology program, have been an important element in Sandia's success, Dr. Rottler explained. The program allows scientists who work at Sandia National Laboratory to take leaves of absence for up to two years to join or help start up companies. If a business venture doesn't work out, the scientists can return to their jobs. Since 1994, 138 Sandia scientists and engineers have left the laboratory in New Mexico and its California affiliate, Lawrence Livermore National Laboratory, to enter business. At least 91 companies have been started or expanded as a result.

Box C
Conflict of Interest and Technology Transfer from Federal Laboratories

The success of Sandia Science and Technology Park notwithstanding, efforts to transfer technology from national laboratories have often stalled over concerns about conflict of interest and bureaucratic red tape. In his presentation Jonathan Epstein, an aide to Sen. Jeff Bingaman (D-NM), said that conflict of interest is a genuine issue when a federal employee "is working under the taxpayer's dollar and [is] making decisions on how taxpayer dollars are spent."

The potential for conflict of interest is reduced when a federal laboratory has an explicit mission to work with the private sector, noted Ken Zweibel of the George Washington University Solar Institute at the symposium. Citing the case of the National Renewable Energy Laboratory (NREL) in Boulder, Colorado, whose mission is to support research by private industry, Mr. Zweibel noted that NREL scientists and laboratory facilities have helped launch most of America's successful solar-power companies.

[46]National Research Council, *Industry-Laboratory Partnerships: A Review of the Sandia Science and Technology Park Initiative*, Charles W. Wessner, ed., Washington, DC: National Academy Press, 1999. The review provided an early validation of the park's concept, rationale and current plans, as well as identified potential operational and policy issues that helped to guide the growth of Sandia S&T Park.

Sandia is leveraging its core strengths in high-performance computing and simulation, nanotechnologies, micro systems, and "extreme environments" in projects aimed at developing the New Mexico economy. It is a partner in a state supercomputing project and in a small-business assistance program that is credited with creating and retaining 1,020 jobs. In California, meanwhile, Sandia is converting a portion of its Lawrence campus into i-Gate, a public-private partnership that will serve as an innovation hub for green-transportation technologies.

Kennedy Space Center's Exploration Park

NASA is developing Exploration Park, situated adjacent to NASA's Space Life Sciences Laboratory (SLSL) at Kennedy Space Center as an innovation cluster.

According to Robert Cabana, director of NASA's Kennedy Space Center, Exploration Park has the potential to draw on the significant specialized talent found at the Kennedy Space Center to commercialize research out of the Center as well as to maintain and attract the knowledge base that is essential to advance NASA space missions. He noted that the Center's 25 fully equipped laboratories are helping a broad range of new companies that are tapping the space center's R&D.

Dr. Cabana noted that most Kennedy Space Center commercial R&D projects are funded through NASA's Innovation Partners Program and are collaborations with companies, universities, and other national labs. Partnerships with Carnegie Mellon University, a space exploration center in Hawaii, Caterpillar, ASRC Aerospace, and the Colorado School of Mines, for example, are developing technologies and equipment to mine and develop natural resources on the moon. Other R&D partnerships are developing technologies that will enable plants to grow in space, wires made of polymers that detect and repair flaws by themselves, sensors that monitor the human body for radiation damage to DNA, and solar arrays that cleanse themselves of dust. These technologies can have significant commercial applications as well.

Exploration Park will have 5,000 researchers, technicians, and support staff. The campus will border both Kennedy Space Center's secured campus and the University of Central Florida, which has a major engineering school. The Center's commercial R&D efforts could get a boost from President Obama's proposed 2011 budget, Mr. Cabana said,[47] which calls for a $6 billion increase over five years.

G. UNIVERSITY-BASED CLUSTERS

Ever since Stanford University created a business park next to its campus in 1953, American universities have been regarded as global pioneers in leveraging

[47]Details of the NASA budget can be found at "Fiscal Year 2011 Budget Forecast," National Aeronautics and Space Administration, <*http://www.nasa.gov/pdf/420990main_FY_201_%20Budget_Overview_1_Feb_2010.pdf*>.

science and technology research as a catalyst for new industry.[48] University-linked research parks such as Research Triangle Research Park in North Carolina, Cummings Research Park in Alabama, Purdue Research Park in Indiana, and others quickly followed. The trend spread globally to nations such as England, Taiwan, France, Canada, and Singapore.[49] By 2007, according to a study by the Battelle Technology Partnership Practice and the Association of University Research Parks, companies housed in 134 research parks in the United States and Canada employed more than 300,000 workers and created another 350,000 jobs outside their borders.[50]

As several participants at the symposium noted, the role of university research parks also has evolved. Most early parks were regarded as real estate developments for corporate research labs. In subsequent decades, they became strategically planned campuses designed to foster collaboration, innovation, and commercialization of technology.[51] They also integrated a variety of industries, research partners, and small-business services. These changes come as many state governors are calling on universities to assume even bigger roles as engines of innovation and regional economic development. "That is going to take a little getting used to on the part of our university people," Dr. Good observed. "But I don't think we will be able to get out from under that necessity."[52]

America's Fading Advantage

According to Brian Darmody, president of the Association of University Research Parks (AURP), there is growing concern that the United States is ceding its

[48]AnnaLee Sexanian has argued that Stanford's heavy involvement in fostering local technology companies was a major reason Silicon Valley surpassed the Boston area in high-tech electronics, where the Massachusetts Institute of Technology had a hands-off attitude toward start-ups. See AnnaLee Saxenian, *Regional Advantage: Culture and Competition in Silicon Valley and Route 128*, Cambridge: Harvard University Press, 1994.

[49]National Research Council, *Understanding Research Science and Technology Parks: Global Best Practices—Summary of a Symposium,* op. cit.

[50]Battelle Technology Partnership Practice and the Association of University Research Parks, October 2007, <*http://www.aurp.net/more/FinalBattelle.pdf*>.

[51]Ibid.

[52]Nevertheless, university technology-transfer programs still come under considerable criticism for generating too little licensing revenue and launching too few new enterprises. A report by the Marion Ewing Kauffman Foundation, for example, finds that university bureaucracies often slow the transfer of technology to private industry. These challenges come on top of other obstacles facing university researchers, including the difficulty of securing research grants for applied research and tenure and promotion policies that favor publication of scientific papers, rather than work on applied technologies or commercialization. To improve university technology transfer, the Kauffman report recommends major reforms, such as allowing university researchers to sell intellectual property directly to industry. See Robert E. Litan, Lesa Mitchell, and E. J. Reedy, *Commercializing University Innovations: Alternative Approaches,* Boston: National Bureau of Economic Research, Working paper JEL No. O18, M13,033, 034, 038. Last accessed on October 8, 2010 at <*http://papers.ssrn.com/sol3/papers.cfm?abstract_id=976005*>.

leadership in research parks to China, which *now* has the world's largest research parks. Further, he noted that nations such as the United Kingdom now claim to have developed more efficient systems for transferring technology from universities.

Citing a new AURP report, he offered a set of suggestions for improving technology commercialization in the United States.[53] These include a call for the Office of Management and Budget to change accounting rules to make it easier for principal investigators to commercialize federally funded research. He also recommended that the federal government expand the corporate R&D tax credit, increase funding for researchers to develop prototypes, ease U.S. export-control rules, and include entrepreneurship. "We need to embed entrepreneurship in all of our projects and policies," Dr. Darmody said.

Challenges in University Commercialization

A recent study by the Association of University Technology Managers (AUTM) reveals a mixed record of university technology-transfer programs.[54] In his presentation, AUTM President-elect Ashley Stevens analyzed survey data collected from member institutions since 1991. He noted that AUTM data reveal dramatic increases over the past two decades in the number of university inventions, licensing revenue, and expenditure on full-time technology-transfer specialists and patent application. The number of start-ups launched by AUTM members also has climbed steadily, from 200 in 1994 to nearly 600 in 2008.

Dr. Stevens noted that when one looks at the productivity of university technology-transfer programs, however, the picture is unimpressive. Successful patent applications and the number of licenses have remained flat for the past decade. Only 59 percent of 19,554 invention disclosures by universities in 2009 resulted in U.S. patent applications, meaning that the rest never made it out of the lab, Dr. Stevens observed. Just 26 percent led to signed licenses, and only 16 percent resulted in U.S. patents issued. Just 3 percent of those inventions led to the formation of start-up companies. This weak performance is remarkably consistent across U.S. institutions, even well-endowed research universities such as Stanford and MIT, Dr. Stevens reported.

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[53]Brian Darmody, "The Power of Place 2.0: The Power of innovation—10 Steps for Creating Jobs, Improving Technology Commercialization and Building Communities of Innovation," Association of University Research Parks, March 5, 2010, *<http://www.matr.net/article-38349.html>*.

[54]See Paul M. Swamidass and Venubabu Vulasa, "Why University Inventions Rarely Produce Income? Bottlenecks in University Technology Transfer," *The Journal of Technology Transfer*, 34(4), 2009. This analysis of the Association of University Technology Managers periodic Licensing Activity Surveys of 1995-2004 indicates that "the annual income generated by licensing university inventions was 1.7 percent of total research expenditure in 1995 and 2.9 percent in 2004. Some consider this and the rate of commercialization of university inventions to be too low." The authors point out that some analysts believe that this "slow rate of commercialization of university inventions may be due to the lack of adequate trained staff and inventions processing capacity in University Offices of Technology Transfer (UOTT)."

Invention Disclosures	19,554	(Percent)
New U.S. Patent Applications filed	11,626	59
Licenses Signed	5,002	26
U.S. Patents Issued	3,156	16
Start-Ups formed	584	3
Active Licenses	30,920	

FIGURE 5 2008 Licensing activity survey.
SOURCE: Ashley J. Stevens, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

(Percent)

- Academic inventions are embryonic
- Average success rate 25.6
- Median success rate
  - All institutions 21.7
  - More than $200 million research 22.9
  - Over 100 disclosures 19.7
  - MIT 18.8
  - Stanford 24.3
  - WARF 19.7

FIGURE 6 Why is this so hard?
SOURCE: Ashley J. Stevens, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

Even more troubling, Dr. Stevens said, are data showing that 52 percent of the 130 technology-transfer programs studied lose money for their universities. Only 16.2 percent reported that their programs are financially self-sustaining, meaning they do not depend on the university operating budget to remain in operation.

A big reason for their struggling finances, Dr. Stevens suggested, is that universities are rarely able to reap big returns by selling stakes in successful public companies. Universities also lack sufficient staff and funds to shepherd fledgling companies through the Valley of Death until they have marketable products. One way Washington can help, he said, is by funding post-doctoral fellowships lasting several years for Ph.D. students who want to commercialize their research.

Improving the Johns Hopkins Model

Cultural attitudes at major universities have been another obstacle to commercialization, noted Johns Hopkins University technology-transfer director Aris Melissaratos in his presentation. While Johns Hopkins is among the biggest recipients of federal research dollars, 93 percent of that coming in health sciences, it has lagged in technology transfer. "In fact, it was an anathema among our faculty," said Mr. Melissaratos, a former Westinghouse Electric executive. "At Hopkins, you were not even thought of being capable for tenure if you had even thought about starting a company."

To change that culture, the university set up programs to link scientists with entrepreneurs. A new business school, an idea Johns Hopkins trustees had rejected in the past, will offer entrepreneurial training for researchers. And a new building on campus that serves as a research park is nearly filled with start-up companies and is facilitating R&D collaborations between the university and private firms. "We want every professor, every researcher, every department head, and the deans of every school to be interested in and applaud the current change in attitude," Mr. Melissaratos said.

As a result, Johns Hopkins has spun off 22 new companies in the past two years that have attracted $89.5 million in venture investment. That compares to an average of four per year for the previous decade. Licensing revenue is rising steadily. So is investment in new R&D facilities. The National Cancer Institute recently announced it will build a headquarters at Johns Hopkins' campus in Montgomery County, Maryland. Ultimately, Mr. Melissaratos contended, investment in university research remains the most powerful catalyst for creating new businesses and industries and achieving economic growth.

West Virginia's Mix of Models

West Virginia University (WVU) is developing three complementary approaches to growing innovation clusters, President James Clements explained in his presentation. The first is the traditional "linear" model where research faculty

help convert research ideas into local businesses that then spawn other businesses. A second is to build a cluster around the needs of locally based U.S. laboratories and agencies. A third is to leverage location, building industries in which regional assets such as natural resources or proximity to R&D institutions offer an edge.

A good local example of the linear model at work, he said, is Protea Biosciences, a developer of technologies to discover new proteins in human blood and tissue samples. The fast-growing company began as a research project at WVU, moved to a campus incubator, and then opened its own facility in Morgantown, West Virginia, where it continues to collaborate with university researchers on new products. Protea, in turn, is stimulating the development of other new companies.

According to Dr. Clements, West Virginia's energy innovation cluster leverages the state's traditional endowments of coal, gas, and timber. Morgantown also is home to the National Energy Technology Laboratory. The state recently organized the Advanced Energy Initiative, which is building public-private R&D research partnerships in areas such as liquefied coal for transportation fuel, environmentally safe access to natural gas reserves, bio-fuels, and carbon sequestration. WVU is part of an alliance that includes nearby Carnegie Mellon and the University of Pittsburgh and that recently won a $435 million research contract.

Morgantown's rapidly growing biometrics cluster, by contrast, is an example of how WVU is tapping local research expertise to target a promising technology niche. West Virginia has a history of more than 40 years in technologies used to identify individuals through distinguishing biological traits,[55] Dr. Clements noted, and WVU has had a research partnership with the Federal Bureau of Investigation for more than a decade. Interest by law enforcement surged after the 2001 terrorist attacks. WVU established one of the nation's first degree-granting programs in biometrics. Morgantown then became home to CITeR,[56] a National Science Foundation center that serves as a hub for identification technology research conducted around the country. Booz Allen Hamilton, Northrup Grumman, Lockheed Martin, and other affiliates have Morgantown operations, and corporate investment is surging, Dr. Clements said.

H. SUSTAINING FEDERAL-STATE SYNERGIES

U.S. regional economies face mounting global competitive challenges. No longer do U.S. states and cities compete only among themselves for talent,

[55]For a concise history of the development of West Virginia's biometrics cluster, see Kim Harbour, "WV Biometrics: Fertile Ground for Innovation," on the West Virginia Department of Commerce Web site, <*http://www.wvcommerce.org/business/industries/biometrics/fertileground.aspx*>.

[56]CITeR stands for the Center for Identification Technology Research. It is an Industry/University Cooperative Research Center (I/UCRC) funded by the National Science Foundation. The center was founded by West Virginia University and is the I/UCRC's lead site for biometrics research and related identification technologies.

investment, and entrepreneurs in technology-intensive industries. As seen in the case of Brazil and Hong Kong (reviewed in this report), they also compete against committed national and regional governments that are executing comprehensive strategies that seek to create regional innovation clusters in many of the same high-potential, emerging industries being pursued in the United States. Indeed, governments around the world are backing up these strategies with heavy investment in state enterprises, new and renewed universities, public-private research collaborations, workforce training, early-stage capital funds, and modern science parks, all reinforced by strong policy attention from top leaders.

As described by various participants, this new competitive landscape is prompting federal, state, and regional authorities in the United States to take creative and comprehensive approaches to developing innovation clusters. Federally funded research programs at universities and national laboratories are in some cases being oriented toward the activities of local industrial clusters. Backed by strong White House leadership, government agencies such as the departments of Energy and Commerce are aligning a wide range of programs to accelerate the development of strategic technologies within regional clusters. In many instances, federal agencies are sharing best practices with regional agencies and are facilitating networking among researchers, investors, and support organizations across the United States. There is much greater awareness of the potential benefits of clusters and a concerted effort to create synergies across multiple federal and state programs.

Sustaining Funding for Clusters

The federal and state initiatives described in this symposium, while promising, face a number of challenges. Perhaps foremost is a sharp decline in the availability of federal funds for these types of initiatives. Current budget limitations already run the risk of providing resources that are inadequate to meet the often expansive objectives of the federal and state agencies. Addressing the issue of whether such funding can be sustained over a period of time, Mr. Darmody pointed out that many regional innovation cluster initiatives are premised on the assumption of continual flows of federal R&D dollars. With the prospect of looming federal budget deficits, he asked what the implications for the program would be should federal R&D investments substantially decline.

State governments also are under financial duress. Mr. Parks of the Michigan Economic Development Corporation noted that his state is facing a budget deficit exceeding $1 billion. In Arizona, which also faces a budget crisis, the legislature has slashed millions of dollars from public-private research programs.[57]

[57]Arizona Daily Star, "Budget Cuts Hit Science Research Partnerships at Arizona Universities," February 8, 2009.

Measuring the Cluster Payoff

Several symposium participants noted that a key strategy for sustaining support is to provide data showing such investments benefit taxpayers, private investors, and universities. "Once a state and a region see the payback to the economy, there is positive reinforcement and things start to move forward," said Kristina Johnson.

However, producing compelling data proving direct links between public spending on science parks, industrial investment incentives, and research consortia and positive economic outcomes, remains a challenge.[58] In part, this is because Regional Innovation Cluster initiatives are relatively new and do not yet have a record that can be empirically validated.

Another problem is that "a wide swath of America" does not see how innovation clusters will improve their lives, Mr. Fernandez observed. "We need to work on our metrics in a way that gets down and makes this stuff relevant, so that it's not just about Ph.D.s." Mr. Fernandez said the EDA is looking for partners to develop "relevant, real-world metrics." Otherwise, political support could disappear with a change in Administration and changing economic circumstances.

Some state development agencies are working on developing methods to better demonstrate the economic payoff of investments in innovation clusters. NorTech, for example, is building a database to measure the performance of each of its cluster initiatives in northern Ohio. Ms. Bagley said she would like to identify how many companies were introduced to potential customers, how many negotiated deals, how many jobs were created, and how much investment was generated. "If you could start to put paths like that together with your clusters, you can start to show how some of this very difficult to measure activity actually ends in some result," she said.

Impacts on Jobs and Growth

At the end of the day, job growth is what matters most to Americans, Secretary Locke said. And the best way to create jobs, Mr. Locke said, is to create new businesses. That means there is an "urgent need to move great ideas more quickly from university labs into the market place." Developing more regional innovation zones, "where entrepreneurs, scientists, product developers, and venture capitalists are clustered together and can work together," can accomplish that. Mr. Locke said regional innovation clusters, therefore, should be a key part of the nation's long-term strategy for growth. "It is to lay a new foundation for sustainable long-term economic growth," he said.

[58]For an overview of the rationale and methods of evaluating research parks, see presentation by Albert N. Link of the University of North Carolina at Greensboro in National Research Council, *Understanding Research, Science and Technology Parks: Global Best Practices—Summary of a Symposium*, op. cit.

Sustaining a Policy Consensus?

Despite the many initiatives taken in recent years, the fundamental challenge faced by U.S. regional innovation cluster initiatives is the lack of policy consensus regarding their benefits at the state and especially the federal levels with the attendant risk that the necessary continuity of policy and funding will not be maintained. This comes at a time when America's competitors are mounting sustained efforts and great policy continuity to enhance their innovation capabilities and national competitiveness.

II

PROCEEDINGS

Welcome

Charles Wessner
The National Academies

Dr. Wessner welcomed the participants, noting that some had travelled to wintery Washington, DC, from as far away as Brazil and Hong Kong. This symposium, he noted, is part of an ongoing study of State and Regional Innovation Policies by the National Academies' Board on Science, Technology, and Economic Policy (STEP).[1]

STEP is not only assessing how well the states and regions in the United States is doing, Dr. Wessner explained, but also it seeks to understand the strategies of other nations. "The time when we had no need to look outside our borders to understand best practices in innovation has long since passed," he said. For this reason, STEP is also undertaking a study of Comparative National Innovation Policies.

STEP has been particularly interested in the topic of innovation clusters. Here, the methods and experiences of various U.S. states as well as that of other nations offer valuable lessons on how to convert the $150 billion the federal government invests annually in research into new products and processes for U.S. and global markets.

[1]The STEP Board is conducting a series of symposia and workshops as part of a study called "Competing in the 21st Century: Best Practice in State and Regional Innovation Initiatives." The goal of this study is to identify best practices of private and public programs to strengthen industries, advance new technologies, and meet critical national needs. For summaries of some previous symposia, see National Research Council, *Innovation Policies for the 21st Century: Report of a Symposium,* Charles W. Wessner, ed., Washington, DC: The National Academies Press, 2007, and National Research Council, *Understanding Research, Science and Technology Parks: Global Best Practices—Summary of a Symposium*, Charles W. Wessner, ed., Washington, DC: The National Academies Press, 2009.

Dr. Wessner thanked the National Academies' partners in the regional innovation initiative for their contributions. Without the "inspiration and encouragement" of colleagues at the Association of University Research Parks, the meeting could not have been held, he said. He also thanked the Department of Energy, the National Institute of Standards and Technology, the Economic Development Administration of the Department of Commerce, as well as the Heinz Foundation, IBM, and Dow Corning for their sponsorship.

Introduction

Mary Good
University of Arkansas at Little Rock
and STEP Board

Dr. Good welcomed the participants on behalf of the STEP Board and explained that the whole issue of state and regional initiatives has been of ongoing interest of the board. "We have done a lot of work looking at innovation centers around the world, and now we are looking at our own," she said. "It really has been an extraordinary experience."

This particular initiative also has been very rewarding because the partners have been able to move much faster than the normal pace, Dr. Good said. "That has been an advantage in my view because we need to move innovation policy quickly."

The successes of U.S. clusters such as Silicon Valley, Boston's Route 128, and Research Triangle Park in creating industries and economic development have generated global interest in clusters, Dr. Good noted. Now other governments are promoting synergies between business, government, and research organizations in their regions. Dr. Good said she finds it both interesting and problematic that the rest of the world "is replicating our successes better than we are."

There are national cluster-development programs under way in Japan, South Korea, and all of the nations of the European Union. Also, emerging economies such as Brazil are quickening their pace of building clusters. Dr. Good noted that China has a least 54 research parks, many of a very large scale.[2]

In the United States, a number of state and local governments have sought to stimulate economic development through regional clusters. The symposium, therefore, will discuss what some of the states are doing. Such state and local

[2]See the presentation by Zhu Shen of BioForesight in National Research Council, *Understanding Research, Science and Technology Parks: Global Best Practices*, op. cit.

efforts are important, Dr. Good said. Different parts of the country will have different kinds of clusters. "But we've got to have them all over," Dr. Good said. "We can't just have them in special places."

The nanotechnology center being developed in Albany, New York, looks like it will succeed, she said, and should be studied more closely. But in many cases, the state and local entities don't have critical mass and don't have the sustained policy support to move clusters forward. Term limits for local politicians also make it difficult to achieve continuity for cluster-development efforts from administration to administration. "One of them starts something and it dies in the next round," she observed. Our observations indicate sustained innovation is a marathon, not a sprint.

Most successful innovation clusters in the United States have drawn heavily on nearby national laboratories and universities. Many state governors today have decided their state universities will have to be part of the engines of innovation. "So for those of us in universities, whether we like it or not, that is something that is going to take a little getting used to," Dr. Good said. "I don't think we will be able to get out from under that necessity."

Many people forget Silicon Valley's innovation cluster was a product of multiple private industries interacting with major universities, Dr. Good said. "If you were to take out the impact of Stanford and UC-Berkeley, Silicon Valley would not exist. It is almost that simple." It also is important to remember that, as a private university, Stanford could do what it wanted. "They didn't have to ask permission," she said. "So we need to turn the state universities loose a little bit to make this work."

Two panels in the symposium, Dr. Good noted, will discuss what universities and leading national laboratories are doing to commercialize their research. If one studies the record of national laboratories as a whole so far, "it has not been a big success story," she said. "So how can we improve that over time?"

Dr. Good also noted that although the United States has had a strong record of developing innovation clusters, "we have had no legislatively authorized program to specifically, comprehensively support clusters. We have become hung up on words. Everybody says that is industrial policy, we don't do that, and therefore the initiatives die. Let's call it something else. I don't care. But let's get it moving in one way or another."

There is evidence, however, that things are about to change, Dr. Good said. "I believe the Obama Administration has undertaken a number of important initiatives focused on the development of clusters."

Panel I

Clustering for Growth

Moderator:
Michael Borrus
X/Seed Capital Management

Mr. Borrus thanked the participants for showing up from around the country despite the East Coast's third blizzard of 2010.

Referring to Dr. Good's comments on the rest of the world replicating U.S. innovation cluster models, Mr. Borrus noted that Americans often are accused of ignoring history. "As Mary implies, it is a bit hard to ignore your own history when it is coming right back at you," he said.

The whole subject of clusters has a long and venerable history, Mr. Borrus observed. The classic analysis of modern regional clusters is Alfred Marshall's study of the 19th century cutlery industry in England.[3] More recently, scholars and policymakers have been fascinated with Silicon Valley, Mr. Borrus noted, which is "often studied but often misunderstood." In addition to the connections between private industry and universities, "Silicon Valley would not exist were it not for gobs and gobs of federal money and federal attention" dating back to the emergence of the radio tube industry in the early 20th century.

While it is nice to "repurpose old historical ideas to meet critical modern needs," Mr. Borrus said, anybody who has tried to replicate Silicon Valley knows that is very hard to do. "It does imply a very strong role for federal policy." Mr. Borrus said he is eager to learn from the first panel what the U.S. federal government has in store in this critical area.

[3]Alfred Marshall (1842-1924) discussed the origins of British industries such as cutlery, ceramics, and textiles in Book Four, Chapter 10 of his book *Principles of Economics*, London: MacMillan & Company, 1890.

REGIONAL INNOVATION CLUSTERS

Ginger Lew
National Economic Council

Washington's growing interest in innovation clusters is illustrated by the fact that this symposium is the second on the subject conducted by the National Academies in a year, said Ms. Lew, a senior advisor to the White House and Small Business Administration on small-business issues.

In the Obama Administration, she noted that Energy Under Secretary Kristina Johnson and John Fernandez of the Economic Development Agency lead efforts to move forward on the recently announced Energy Innovation Cluster. "Without their leadership, this project could not have taken place," she said. NIST played an integral role in the inter-agency team that created the initiative.

Ms. Lew said she would start by explaining what the Obama Administration is doing to promote regional innovation clusters—and why. "Our motivation is important, because it provides the context for the Energy Innovation Cluster as well as other projects the Administration will move forward with in 2010," she said.

Over the past decade, Ms. Lew noted, there has been a growing emphasis on regionalism as whole and the need for communities without regard to boundaries to come together and develop and implement regional plans. In essence, Washington, DC, is a regional economic cluster, she said. "The industry we are all associated with in some form or another is the federal government. But workers do not respect political boundaries. We live in Virginia, Maryland, and DC. So the cluster activity has a regional impact." Increasingly, businesses look not only for local resources but also regional resources. They want supply-chain vendors and service providers that can support them and allow them to scale.

Besides the familiar examples, such as Silicon Valley and Research Triangle, numerous regional clusters have emerged in the United States. Ms. Lew cited the Sonoma Valley wine cluster as an example. The University of California-Davis has been integral to that cluster. There have been pockets of cluster developments in Austin, Texas; Corning; New York, Seattle, Washington; and Kansas. "All of this occurring on an ad-hoc basis without a formal U.S. policy," she noted.

Ms. Lew presented a map of the United States featuring a few regional innovation clusters. Denver, for example, has clusters in leather and sporting goods, oil and gas, and aerospace vehicles. Clusters around Chicago include communications equipment, processed food, and heavy machinery, while Boston's regional clusters include analytical equipment, education, and communications equipment.

Not all clusters are related to high technology. Ms. Lew recalled that she recently met with representatives of an organization called Sustainable Northwest. The group manages forest and timber assets in a 300- to 400-mile area of Washington and Oregon. It is looking to convert those assets, which used to generate

timber and lumber jobs, into new industries and products such as bio-fuel pellets that can regenerate the region.

The aviation industry in Kansas also illustrates the economic benefits of clusters, she said. The industry employs 17.8 percent of all Kansas manufacturing workers. People employed in the aviation cluster earned annual average wages of $63,000 in 2006, more than 50 percent above the average of all industries in the United States. "They are generating jobs at a formidable rate," Ms. Lew noted. The cluster is expected to add 4,450 net employees from 2004 to 2014 and 10,000 new jobs when retirement and turnover is factored in.[4] Most jobs require advanced education. State incentives reward companies for creating high-skill jobs, whether they require technical training at a community college or bachelor's degrees.

Such activities around the United States stimulated discussion in the Obama Administration about policies that promote regional innovation clusters, Ms. Lew said. Thought leaders such as Michael Porter and the Center for American Progress[5] urged the federal government to be more active in regional efforts. Ms. Lew also noted that Karen Mills had written about the federal role in regional innovation strategies before she was appointed SBA administrator.[6] "All of this activity generated an 'ah ha' moment for the Obama Administration," she said. "But another key motivation, quite frankly, was the huge economic challenges the Obama Administration inherited when it came to office."

As an illustration of how difficult it can be to wade through federal bureaucracy, Ms. Lew recalled a meeting in 2009 with a group of business, academic, and community leaders from the Pacific Northwest. They discussed efforts to pursue energy-efficiency grant money. "They showed a mindboggling diagram of 23 program offices they had to apply to, respond to, coordinate with, and manage," Ms. Lew said. "They talked about how they were in the second year of this particular journey to get access to federal dollars, all related to this particular topic and this same issue." The challenge for Washington, she said, is to make the process less cumbersome and to coordinate federal and state funding.

The new Energy Regional Innovation Cluster led by the DoE is an important experiment in a regional approach, Ms. Lew said. It aims to identify and align federal programs that can work together. "By linking these federal programs, we hope we can have a more impactful outcome, and support a regional ecosystem that leverages not only federal dollars, but also state, regional, and private dollars," Ms. Lew said.

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[4]Data from "Kansas Aviation Manufacturing," Center for Economic Development and Business Research, W. Frank Barton School of Business, Wichita State University, September 2008.

[5]Jonathan Sallet, Ed Paisley, and R. Masterman, "The Geography of Innovation," *Science Progress*, September 1, 2009.

[6]Karen G. Mills, Elisabeth B. Reynolds, and Andrew Reamer, *Clusters and Competitiveness: A New Federal Role for Stimulating Regional Economies,* Washington, DC: The Brookings Institution Metropolitan Policy Program, April 2008.

Getting seven different agencies to change the way they operate is a real challenge, Ms. Lew conceded. Each agency has its own program requirements that often are defined by statute. "It was difficult to get seven agencies to overcome some established mindsets and to collaborate," she said. "But at the end, we believe, it was worth it."

What does the Administration hope to do with the "grand experiment" in regional innovation clusters? One desired outcome, Ms. Lew said, is to better "link, leverage, and align" resources of federal agencies' regional partners. This also will help ensure that the supply of resources is linked to demand, she added. The President's budget proposal for Fiscal Year 2011 calls for more than $300 million to support regional innovation cluster activities by the EDA, SBA, Department of Labor, and the USDA.

The Administration also would like to develop a replicable, joint-funding template that could be used for other projects in 2010, Ms. Lew said. "As we learn from these various pilot projects, we hope this template can be refined and streamlined."

To show how the federal cluster initiatives are organized, Ms. Lew presented a diagram that she calls a "doughnut."

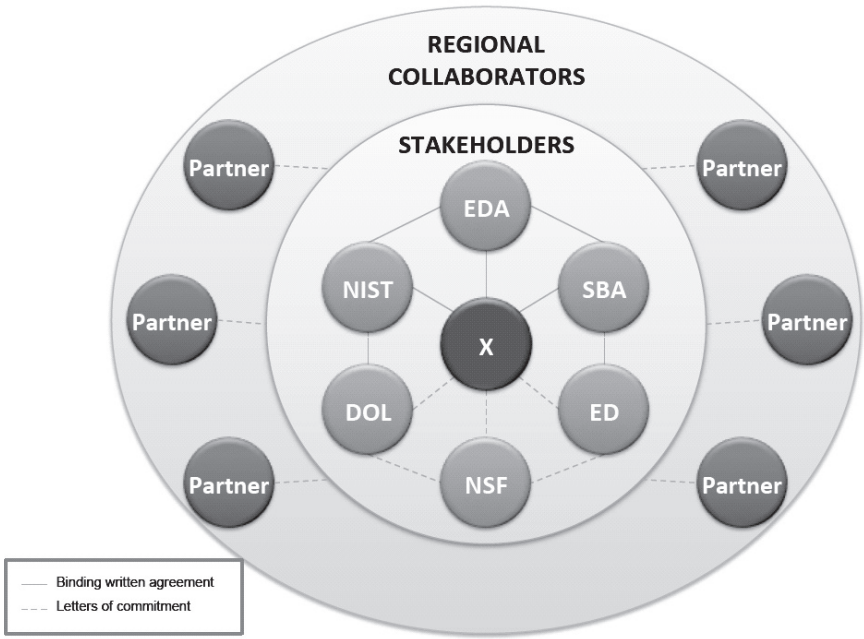


FIGURE 1 RIC operations.
SOURCE: Ginger Lew, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

The diagram depicts seven federal agencies that are involved with the Energy Regional Innovation Cluster initiative. In the center is Agency X, in this case the DoE. Six other agencies are in a circle around the DoE. They are the SBA, NIST, the Department of Labor, the National Science Foundation, and the Department of Education. On an outer ring of the circle are various "regional partners" working with the federal agencies to advance their cluster. They could include community colleges, workforce investment boards, private companies, nongovernment organizations, and regional development agencies at the local, state, and regional level.

With the E-RIC, for example, Ms. Lew said she would like to get community colleges to support the clusters by offering curricula to train workers for the jobs that will be created. The SBA, meanwhile, will tailor its technical assistance to the needs of small businesses that spin out of the energy cluster. "All of these partnerships, we hope, will lead to a more robust kind of regional economy," Ms. Lew said.

The regional model also can be applied to urban and rural initiatives. "The phrase 'innovation' is a term that not only is about technology," she said. "It is a new way of doing business." The USDA, for instance, is launching a $130 million pilot project to help five to seven communities coordinate cluster efforts. "I think this model has legs," Ms. Lew said.

BUILDING A CLEAN ENERGY ECONOMY THROUGH ACCELERATED INNOVATION

Kristina M. Johnson
Department of Energy

Dr. Johnson, the Under Secretary for Energy, thanked Dr. Wessner and Dr. Good for "their passion, their commitment, and their focus on the innovation imperative." She also said it was a great pleasure to work with Ginger Lew, John Fernandez of the Economic Development Agency, and Marc Stanley of NIST on regional innovation initiatives.

The Administration's goals for the DoE, Dr. Johnson explained, range from simply stated missions, such as "grow the green energy economy" and "secure our energy future," to the highly specific, such as reduce greenhouse gas emissions by 83 percent by 2050. The Administration also wants the United States to regain science and engineering leadership. That requires a great global workforce. "We can have all the hubs and research funding in the world, but it is people that will drive this industry," she said.

As an engineer would say, the challenge is "design under constraint," Dr. Johnson said. "We have a lot of problems to engineer, and our constraints are threefold: cost, time, and scale." The DoE's research budget for science and technology is $10 billion a year. The department could spend this entire sum to build

one supercollider for basic science. Or, on the applied end, the DoE could spend up to $8 billion on a new nuclear reactor. "Neither of those by themselves will get us to where we want to go," she said. "It's going to take trillions of dollars in investment, and it can't be something the federal government does on its own. It has to be a collaborative, cooperative partnership, which is why I am so happy to be involved in the RIC partnership."

In addition to having a finite budget, the United States also has a finite amount of time. Other countries are learning from what the United States has done. "As my professor at Stanford told me, 'There are only two ways: You can do it first or you can do it best,'" Dr. Johnson said. "I hope we do both."

To get a sense of the scale of challenges facing the United States, Dr. Johnson noted the nation has a decades-old electrical grid. The United States has doubled its dependence on oil in the past 30 years. The United States has seen manufacturing decline from around a 30 percent contribution to GDP after World War II to around 15 percent today. The energy workforce is aging. Over the next decade, more than half of American energy workers will be of retirement age. This comes at a time when only 18 percent of U.S. high school students can pass an international proficiency test, and only 1 percent excel. "So we have a lot of problems to address," she said.

The DoE's fiscal year 2011 budget of $28.4 billion shows how the agency is assigning priorities. Of that, $10.4 billion will go for energy and environmental programs and $4.2 billion, about 22 percent, would be spent on research and development of clean energy. She showed a slide depicting where those funds would go. The United States is increasing investment in solar, wind, geothermal, and nuclear energy. The DoE recently approved $8.3 billion to guarantee that two new reactors will be built in Georgia. These expenditures come on top of the $3.4 billion the DoE is dispersing under the American Recovery and Reinvestment Act for carbon-capture sequestration, $4.5 billion for smart-grid technologies, $12 billion for energy efficiency, and $2.4 billion for production of electric-vehicle batteries and components.

To attain these goals with finite resources, federal agencies must team up. "I have to say a signature accomplishment of the past year under the Obama Administration has been that the collaboration across agencies is phenomenal," she said. "Things are happening that are very hard to do, and it is because we know that we will be stronger by working together."

To put the Regional Innovation Cluster strategy into perspective, Dr. Johnson discussed the evolution of U.S. science and technology policy. She displayed a graphic with the photos of figures such as Vannevar Bush, Niels Bohr, Thomas Edison, and Madame Curie. The "linear"[7] or "feed-forward" model was

[7]The "linear model" refers to the process of turning scientific research into commercial products. The steps are basic science, applied science, technology investment, investment in assets, and finally to market.

championed by Bush,[8] science advisor to President Franklin Roosevelt. Under this model, the federal government funds basic research, passes it to the private sector and universities to develop into applied technology, and then relies on entrepreneurs and investors to bring technology to the marketplace. "It was always a relay race, and every time you handed over the baton it had to be perfect," Dr. Johnson explained. "And that is just difficult to do."

This process has evolved since the 1950s. The transistor was invented, she noted, leading to the computer revolution and software. "It gave us the analytical tools and quantitative approaches to do concurrent design," she explained. "We could take a problem, develop and design the applied technology in parallel," she noted, a breakthrough that was highlighted in the book *Pasteur's Quadrant*.[9]

Dr. Johnson displayed a diagram explaining the quadrant. On one axis is fundamental research, as typified by Niels Bohr's discovery of the atom. On another axis is strictly applied research, such as that of Thomas Edison. She said her favorite Edison quote is that "his goal in life is to make wood and plastic talk."

In the upper right corner of the chart, where research is both fundamental and applied, is Pasteur's Quadrant, so named because Louis Pasteur both discovered the causes and preventions of germ-based disease and developed a vaccine. Dr. Johnson noted that Madame Curie also operated in this quadrant. She discovered the field of radioactivity and pioneered the application of radiation to treat cancer. Others who did both fundamental and applied research include computer scientist Alan Turing[10] and Claude Shannon.[11]

The United States needs to engage in use-based research, Dr. Johnson said. "We need breakthroughs in clean-energy storage, carbon capture, nuclear energy, and renewables to solve our problems in energy security," she said. "If we invest, we have to be strategic, we have to be focused, and we have to follow through."

One way in which the federal government is acting strategically is by bringing seven agencies together to work on clusters, she said. These agencies also are investing strategically to support science and energy innovation.

With funding through the American Recovery and Reinvestment Act, the DoE is supporting 46 engineering frontier research centers for $140 million. In the fiscal year 2011 budget, the department will ask for base funding to continue

[8]Vannevar Bush (1880-1974) was director of the Office of Scientific Research and Development during World War II and is regarded as the architect of post-war U.S. science and technology policy. Dr. Bush maintained that the federal government should invest in basic scientific research, but that converting science into technology and commercial products was the role of private industry.

[9]Donald E. Stokes, *Pasteur's Quadrant: Basic Science and Technological Innovation*, Washington, DC: Brookings Institution Press, 1997.

[10]Alan M. Turing (1912-1954), an English mathematician, is regarded as a father of computer science and with helping create the first modern computer.

[11]Claude E. Shannon (1916-2001), a Princeton mathematician and electrician, is regarded as the father of information theory.

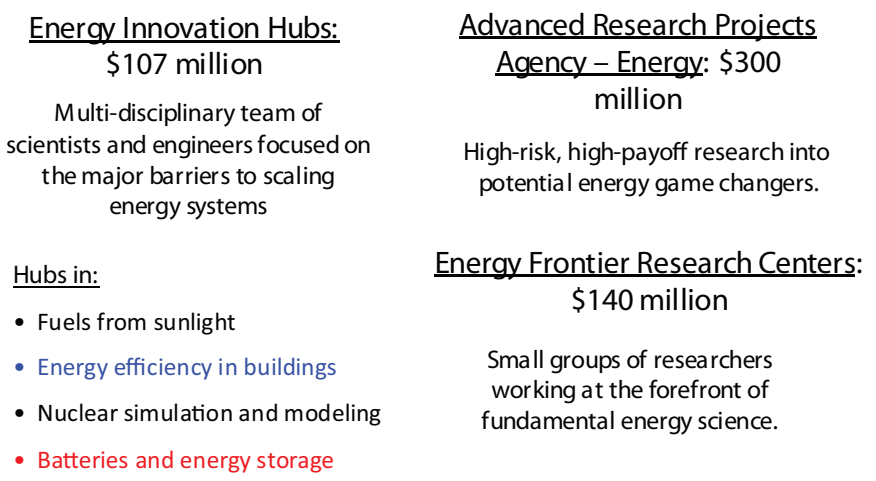


FIGURE 2 FY11: Supporting science and energy innovation.
SOURCE: Kristina M. Johnson, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

these centers, which focus on fundamental breakthroughs in basic science disciplines, Dr. Johnson explained.

The Advanced Research Projects Agency, which was funded with $400 million in the Recovery Act, looks at "technology breakthroughs that can accelerate our advances from fundamental sciences and engineering into the marketplace," she explained. "They are game-changers, things we expect to pay off soon. The plan is to fund such projects for two to three years. "If they run down a dark alley, we will end them and run down another alley where we can shine light," she said.

The DoE also is developing "energy-innovation hubs." These are multi-disciplinary teams coming together to tackle the problems of deploying "at-scale energy systems that can solve our energy-security problems, grow our clean economy, and reduce our greenhouse gas emissions," Dr. Johnson said. There are hubs in fuel for sunlight, energy-efficiency in buildings, nuclear simulation and modeling, and batteries and energy storage. The idea is to take hubs and build other programs around them to get workforces and businesses engaged and to create start-ups. "We are talking about job application here," she said. "In addition to investing in what it takes to build one job, we are investing in people who can then create multiple jobs."

One hub is devoted to fuels from sunlight hub. The Energy Frontier Research Center is investigating fundamental processes of electron transfer, the interaction of light at the bio-molecular level, inspired by bio-synthesis. At the hub, the aim is to go from experiments "in light interaction with a beaker to pilot-scale

processing, so that we can generate fuel economically at scale to meet the goal of 20 billion gallons a year by 2022," she explained.

By contrast, the Advanced Research Projects Agency for energy, known as ARPA-E, is dedicated to technology projects that are not directly addressed by hubs or the Energy Frontier Research Centers. For example, researchers are looking at the symbiotic relationship between light harvesting and algae, the breaking down of cellulose, converting it from sugars into oil, and large-scale, economic production of fuels. In other words, Dr. Johnson explained, ARPA-E is addressing cost barriers, the hubs are addressing scale barriers, and the research centers are addressing the barriers of fundamental knowledge of processes.

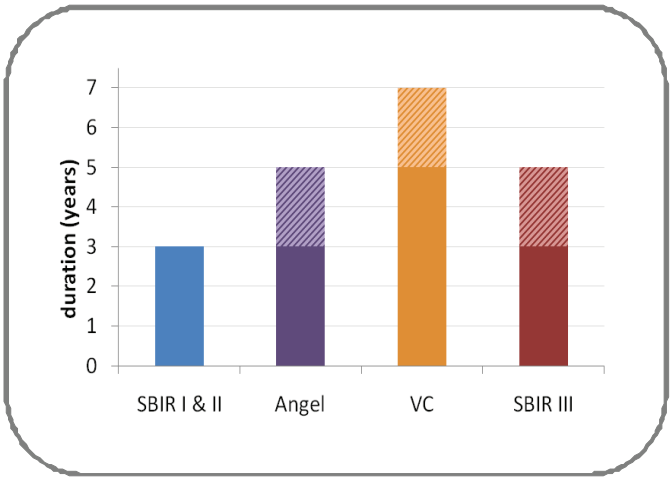
Another hub is for energy-efficient building technologies. Buildings consume 40 percent of U.S. energy, 70 percent of electricity, and 55 percent of natural gas. "When we looked at energy systems, it just seemed to be a natural, because it involves the appliance industry and the building industry, which accounts for 9.5 percent of U.S. GDP and employs nearly 10 million people," Dr. Johnson said. "It has everything." The departments of Labor and Commerce, the SBA, NIST, the NSF, and other agencies all can have something to contribute.

The DoE is working with Ginger Lew and her team at the National Economic Council to try to build the energy-efficient buildings hub because it believes it is the best place to start a regional energy innovation cluster program, Dr. Johnson said. In addition to science and technology, the initiative also involves behavior, policy, economics, and design. "We don't get there by technology alone and by policy alone," she said.

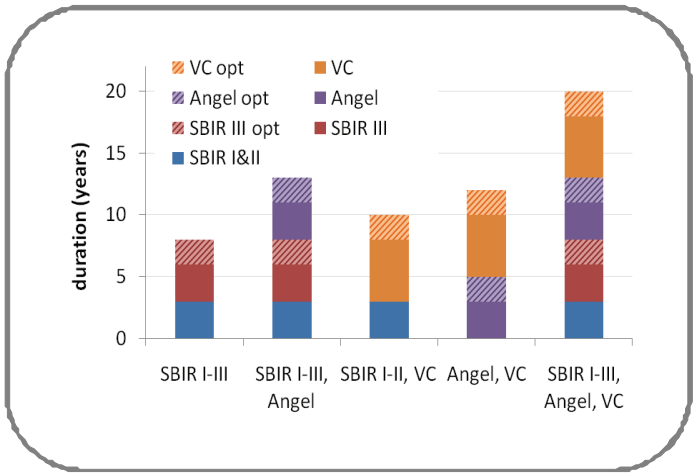
Looking at systems is important in order to reach energy goals, she said. For example, it is known that if every household in America replaced one frequently used incandescent bulb with a compact fluorescent light (CFL), the United States would save enough electricity to power 3 million homes. However, one must look at the entire system. One reason incandescent bulbs are inefficient is that they give off heat. As a result, they heat rooms. Dr. Johnson noted that United Technologies did a study showing that unless the source of heat also is understood and optimized, CFLs may not reduce greenhouse gas emissions. Therefore, it is very important to look at the system and bring in policy that can get people to change their behavior, she said. For the holidays, Dr. Johnson said she gave all of her friends and families CFLs. "Unfortunately, they are probably the kind of people who already had CFLs," she said.

To get such projects to scale, partners must amplify what they are doing. "Just like one photon can give off many photons in a laser reaction, we have to make sure that when we invest in a job, it has the potential to grow more jobs," Dr. Johnson said. "It is a probability game."

An example of how the Administration is trying to get more impact is the way it is looking at federal programs to help small businesses survive the Valley of Death. To take a technology from the fundamental breakthrough to the market can take 7 to 12 years, Dr. Johnson pointed out. The current small-business



Durations of various innovation financing mechanisms.



Combinations of financing types possibly applicable to companies pursuing fundamental innovation.

FIGURE 3 Sustaining small businesses.
SOURCE: Kristina M. Johnson, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

innovative research program funds new or existing companies developing a particular product for one to three years, or through the first three or four funding rounds. The hope is that companies by then will be able to find angel investors, who work on a three- to five-year horizon. There can be a time gap, however, before companies are able to raise funding from venture capital investors, who have a five- to seven-year timeline.

Funding only a few phases of a company's development, therefore, "may not get you staying power," Dr. Johnson said. Expanding the Small Business Innovation Research (SBIR) program could be a solution. The NSF and DoD offer SBIR Phase III programs that provide funding for another three to five years. Combined with angel funding and venture capital, that could give companies the resources they need to stay in business long enough to reach the market, she said.

Dr. Johnson said that she learned from her experience as an entrepreneur that "the most important thing was to stay long enough to figure out what your customers wanted and be smart enough to respond to it," she said. Dr. Johnson co-founded ColorLink[12] in 1995. Twelve years later, the founders sold ColorLink to RealD, a company that supplies 3-D technology used in movies such as *Avatar*.

The only reason ColorLink was able to survive long enough is that it received a $2 million, three-year grant from NIST's Advanced Technology Program to develop the process to make the 3-D glasses worn in theaters. "Without that staying power, we would have died in the Valley of Death," Dr. Johnson said, adding that she hopes regional innovation clusters will provide staying power to small businesses so they can create the jobs "to put America back to work."

ENHANCING COMPETITIVENESS AND SPEEDING INNOVATION: DESIGN AND INITIAL RESULTS OF THE NIST RAPID INNOVATION AND COMPETITIVENESS INITIATIVE

Marc G. Stanley
National Institute of Standards and Technology

Mr. Stanley noted that he has been involved with cluster development since the time he ran the Advanced Technology Program (ATP)[13] from 2003 through late 2009. Now he is working on clusters as Acting Deputy Director of NIST. For all of his years in government service as a congressional aide and in the policy circles, "I have never seen an Administration so coordinated, so open

[12]Dr. Johnson co-founded of ColorLink Inc., based in Boulder, CO. It is a photonics company that develops and manufactures polarization applications for consumer polarization consumer electronics, medical diagnostics, avionics, photography, and other products. In 2007, the company was acquired by digital 3-D technology firm RealD.

[13]The Advanced Technology Program under NIST supported early-state research by industry. It was terminated in 2007 and succeeded by the NIST Technology Innovation Program.

and transparent, and with the ability to talk to all political appointees about the concerted efforts we are discussing today," he said. "It is absolutely incredible."

Mr. Stanley discussed a new model of policy collaboration that he had worked on while at the ATP under former NIST director Dr. William Jeffrey in the George W. Bush Administration. First, however, he presented evidence of a number of "disturbing trends" that highlight the concerns many have about U.S. competitiveness in science and technology. One area where the United States is slipping is in R&D intensity.

By most measures, U.S. spending on R&D has remained flat or has been falling since long before the current recession, Mr. Stanley noted. The United States spends 2.5 percent of GDP annually on R&D. That is behind Israel (which leads with 4.5 percent of GDP) and nations such as Sweden, Finland, Japan, and South Korea. The United States remains just slightly ahead of Taiwan, Germany, and Singapore.[14] While industry spending on product development has risen sharply in the past two decades, according to National Science Foundation data, industry investment in applied research has risen slowly. Spending on basic research has remained essentially flat. Mr. Stanley also cited NSF data showing that industry's share of university R&D funding has declined since the mid-1990s. Federal government funding has dropped steadily as a share of GDP, although the new Administration is trying to change that.

NIST is part of the Administration effort to get the federal government, states, universities, and industry to work more closely together, Mr. Stanley explained. Instead of operating in silos, there should be collaboration among the many parties engaged in economic development on regional policy, economic and industry policy, education policy, and science and technology policy.

For its part, NIST is leveraging all of its programs to aid regional innovation clusters. It is a member of the E-RIC initiative, for example. In 2007, the agency launched the Rapid Innovation and Competitiveness Initiative, which is a public-private partnership for R&D investments. The goal of this initiative, Mr. Stanley explained, is to increase the nation's return on its scientific investment, collapse the time scale of technological innovation, and stimulate the economy and enhance America's competitiveness.

NIST believes such initiatives must be led by industry. If there is one thing he has learned after 17 years managing federal technology programs, Mr. Stanley said, "it is that industry knows where to go." But there is a role for government as a partner that shares costs and has "skin in the game." NIST also wants to focus on areas of national concern that it believes are under-funded.

For its first rapid-innovation initiative, NIST chose the search for technology to replace CMOS[15] as the dominant semiconductor technology. Scientists are

[14]Source: OECD Main Science and Technology Indicators.

[15]CMOS, patented by Frank Wanlass in 1967, stands for complementary metal-oxide semiconductor. CMOS is a technology for constructing integrated circuits that is used in devices such as microprocessors, static random-access memories, and image sensors.

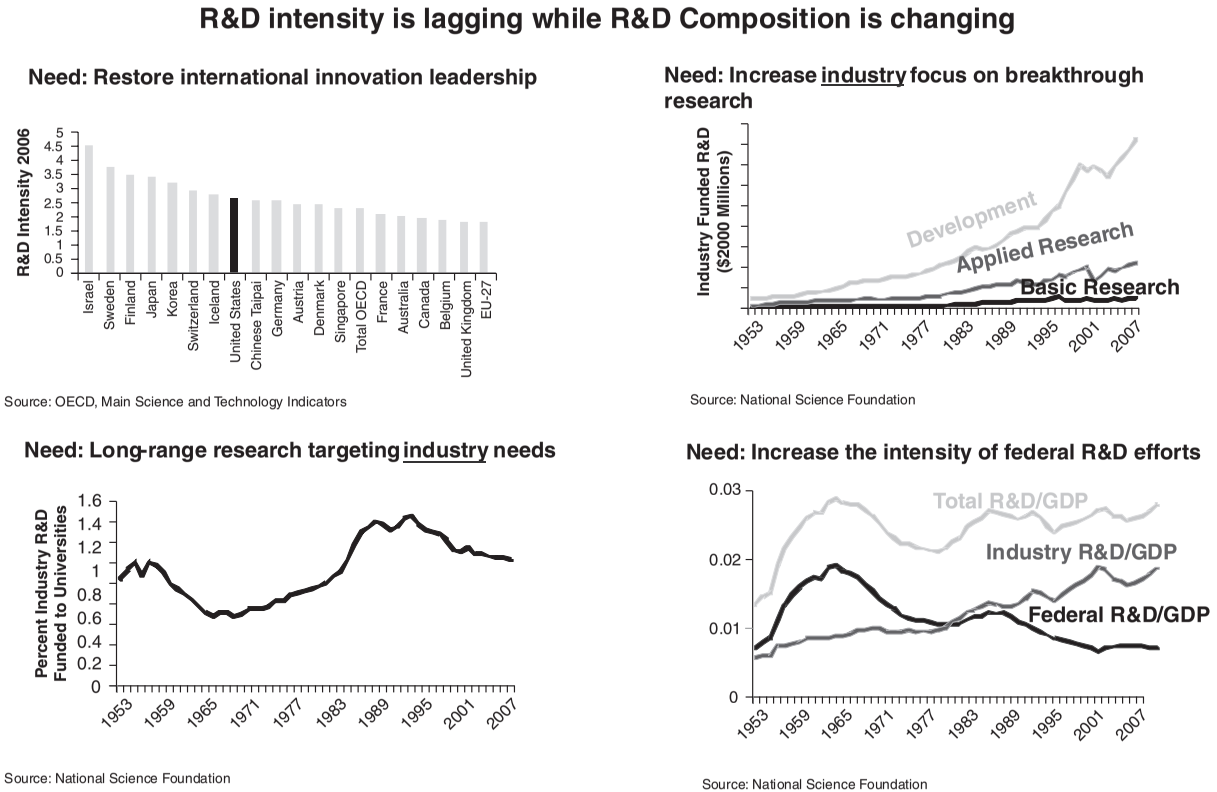


FIGURE 4 Problem: There are disturbing trends in R&D investment.
SOURCE: Marc G. Stanley, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

trying to solve the riddle of what happens when Moore's Law[16] finally reaches its endpoint, Mr. Stanley said. NIST believed this effort was of critical importance to the country, but was under-funded. In 2007, NIST backed launched a pilot program to back the Nanoelectronics Research Initiative (NRI),[17] a collaborative effort between industry, government, and academia aimed at accelerating research and innovation in nanotechnologies.

In terms of measurement metrics, Mr. Stanley said an increase in post-doctoral researchers and fellowships is one good benchmark of how well the nanotech initiative is working. Another is start-ups. "We can't let the little company go away," he said. "We have to nurture that little concept until its gets sufficient capital to go to the marketplace."

The nanotechnology initiative illustrates NIST's approach to collaboration. The pilot program began with a technology roadmap furnished by the Semiconductor Industry Association's International Technology Roadmap for Semiconductors. "We found that was an incredible place to get the kind of information we want," Mr. Stanley said. Corporate research partners include Advanced Micro Devices, Freescale, IBM, Intel, Texas Instruments, and Micron Technology.

The initiative also involves 35 universities and 4 research centers in different parts of the country. They are Index, a consortium of 11 universities that is headquartered at the University of New York-Albany, New York; SWAN, based at the University of Texas-Austin; WIN, based at the University of California-Los Angeles; and MIND, based at Notre Dame University. Cooperative agreements last for five years.

Total funding for the nanotech initiative will be in excess of $200 million, Mr. Stanley said. To finance the university-based research at each center, NIST is contributing $2.75 million annually, industry partners are contributing $5 million per year, and states are contributing $15 million. The state contributions tend to come in the form of grants and tax incentives, Mr. Stanley explained. NIST played a role in getting all of the partners to sign up and is monitoring the process.

So far, the nanotech initiative has generated 13 patents. The program is supporting the work of 128 graduate students and 24 post-docs at the four regional centers. The project also has generated 239 publications as of October 1, 2009. This shows that such an initiative can produce results and that government agencies can collaborate with universities and states, which he said "is the benchmark of where we have to go."

In terms of industry support, Mr. Stanley cited comments by Jim Kelly, IBM's senior vice-president and director of research. Mr. Kelly said that for

[16]Moore's Law, proposed by Gordon Moore in 1965, states that the number of transistors and resistors on a chip doubles every 18 months.

[17]The Nanoelectronics Research Initiative (NRI) is led by Semiconductor Research Corporation, a global consortium of companies and universities to develop novel computing devices capable of replacing the CMOS transistor as a logic switch by 2020.

America to win the global nanotechnology race, "it will take radical collaboration between government, higher education, and industry." Mr. Kelly called the NRI "the best example of this type of collaboration." Such praise, Mr. Stanley said, means "industry is recognizing that we can be a partner along with the various organizations and make something successful."

Mr. Stanley then discussed the vision of NIST Director Dr. Patrick Gallagher of where the agency is going. NIST already is world-class in measurements and scientific research. "There is a sense now in our organization that we can play a really important role in the innovation area," Mr. Stanley said. The agency is getting involved in meeting critical national needs with the Technology Innovation Program. It also offers the Industrial Technology Fellowship program, the manufacturing extension program, and the Construction Grant Program, which funds universities to expand their laboratories to match NIST priorities and Administration guidelines.

In summary, Dr. Stanley said, "We see NIST engaging even more through its extension programs and through its RICs to help in this process of making the country more innovative."

DISCUSSION

William Harris, president of Science Foundation Arizona, began by calling Ginger Lew's "doughnut" diagram depicting collaboration by federal agencies "very impressive." However, he added, he is concerned that many states do not have programs matching those of the federal government. As a result, "we often talk about these things, we end up spending money, but we fail because things are not sustainable," Dr. Harris said. "I think we need to mirror at the state level some of the federal entities. That is against all the political rhetoric. But until we get these things matching up, I think we fail as a society and as a system."

Under Secretary Johnson said the comment "is well taken." She observed, though, that when one looks at the most robust regional clusters around the country, "there has been a very, very tight partnership" both among regional organizations and state agencies. "I think the challenge, as any bureaucracy has, is how you keep that collaboration going forward and alive," Dr. Johnson said. "But I think once a state and a region sees the payback to the economy, there is positive reinforcement and things start to move forward." In California, Massachusetts, and Kansas, for example, "you do have that level of collaboration at the state level. Could it be better? Absolutely."

Dr. Johnson agreed that sustainability is a serious problem, especially with states under extreme budget distress. She noted that when she was in Colorado, ColorLink benefited from a program offered by the state technology institute. "That program died," however, when a new governor assumed office.

Mr. Stanley of NIST said he is more optimistic, "maybe because I have been around this game for so long." He said he could mention at least 10 "very

smart" state economic development organizations that "are putting together the right kinds of programs and are coming to the right kind of people in the federal government and the Administration." Mr. Stanley agreed that not every state has good economic-development programs. However, many people in the Administration "are looking for new avenues to explore and are trying to change the paradigm from just infrastructure investment to expansion to other ways in which we can help."

Mr. Stanley re-iterated that states must take the initiative, however. He also agreed with the point that "you can't rely on VC [venture capital] money any more. That has been drying up significantly because of the economic woes." He noted that one company in Texas had received an Advanced Technology Program[18] grant, but had trouble raising an additional $20 million locally it needed to finish its second stage of clinical trials. It turned to out-of-state venture capitalists. "We have a serious problem in this country, and we have to put all the best minds together and make it happen," Mr. Stanley said.

Mr. Borrus of X/Seed Capital noted that one of his solar-energy companies is working closely with several states that offer incentive packages to attract solar production. The package of incentives, which includes tax credits and loan guarantees, could be worth up to $50 million and "could be essential to build the first full-scale commercial production facility," he said. "So there are positive things happening in the states."

An audience member said his company had been hired by state governments to bring in clean-technology manufacturing. "I see states putting money into clusters, and some are actually pretty sophisticated and focused," he said. But federal programs often don't respond to those state efforts because they operate on their own track. "How do you make the federal support more agile," he asked, "so that they are not just leading but also buying into something on a track that may be faster in driving business, economic development, and links to research?"

U.S. Assistant Secretary of Commerce for Economic Development John Fernandez offered his perspective as "the new guy" in Washington and as former mayor of Bloomington, Indiana. "I think what is happening now is kind of typical in Washington," Mr. Fernandez said. "State and local leaders tend to be ahead of the curve." He noted that during his time as mayor, Bloomington already had a long track record of advancing cluster development. "What is new and what is important is that this Administration is acknowledging the notion of aligning resources and integrating programs in a smarter way so that we can amplify these investments," he said.

As to the question of "how do you drive somebody else's train," Mr. Fernandez said "that part of it is to get out of the way and let them tell you what they need." Regional innovation clusters cannot be legislated, he said. "They are organic.

[18]The Advanced Technology Program under NIST was replaced with the Technology Innovation Program under the America COMPETES Act of 2007.

You have to have champions at the local, private-sector, and state levels," he said. "What we can do is work with those folks as true partners and customize the deployment of federal resources to amplify and accelerate that particular cluster."

Dr. Johnson noted that hubs target particular areas and applications. She said the SBIR program is trying to make its solicitations broader to put greater focus on commercializing clean energy and creating jobs. Over the past 20 years, she pointed out, 94 percent of the new jobs generated in the United States came from small businesses. "The target really is about getting everyone to come together and create those spin-offs," she said.

Panel II

Clustering for Growth (Continued)

Moderator:
William Harris
Science Foundation Arizona

Mr. Harris, president of Science Foundation Arizona, welcomed the speakers and noted that one topic that is not discussed enough is new business. "We have a definition of small business that sometimes actually is big business," he observed. "It is the energy that comes from businesses that grow into big businesses that we hope to inspire today." Mr. Harris then introduced Karen Mills, administrator of the Small Business Administration.

BUILDING REGIONAL INNOVATION CLUSTERS

Karen Mills
Small Business Administration

SBA Administrator Mills noted she has been at the National Academy of Sciences (NAS) a half-dozen times over her career. "At the start of it, we were all new to clusters," she said. "So to see everybody come together at this point is enormously exciting."

Ms. Mills thanked the previous speakers for explaining the Energy Regional Innovation Cluster, which she described as "an incredibly exciting coming together of ideas we've all been working on for years. We are very proud to be a collaborator on that." She also thanked Under Secretary Johnson for supporting the Small Business Innovation Research grant program, which is managed by the SBA. She noted that about 25 percent of *R&D Magazine*'s top 100 annual innovations can be traced to companies that had an SBIR

grant.[19] "That is a very powerful program, and we are investing very heavily in it," she said.

Ms. Mills explained that she first became involved in cluster strategy in 2005, when the Brunswick Naval Air Station, close to where she lived in Maine, landed on the base closure list. "We knew we were going to lose some jobs," she said. Ms. Mills recalled that she received a call from Maine's governor, who said, "Karen, you know about small innovative businesses. You better get some here."

At the time, the U.S. Department of Labor had just come out with WIRED grants[20] for worker re-training, Ms. Mills said. A team looked around for industries where Maine had unique strengths. It identified boat-building, an industry in which the state had a 400-year-old tradition. "We have all of these independent small-business people building boats in Maine. Who would think they would ever cluster together?" Ms. Mills said. Another asset is the University of Maine's cutting-edge research in wood composite materials. These composites were being used to build hulls for boats that were some of the lightest and fastest in the world.

With the help of the $15 million workforce grant, the state created the North Star Alliance, a group that leverages the expertise of local craftsmen and the new technology being developed in the area. The state built a training center for composite technologies. Composites are applied in layers and infused with resins, so they require strong technical labor. "We have a lot of excellent folks going to community and vocational school in Maine who never thought of manufacturing careers in composite technologies," Ms. Mills said. Only one-third of Maine high school students go to college, she noted. Many go into fishing and construction industries. In mid-January 2010, she added, she spoke at three high schools to persuade students to go to the composite material training center.

Five years later, the cluster is showing important progress. Maine-built boats "are selling as far away as Shanghai," she said. At the Brunswick industrial park, there now is a cluster of companies that is supporting not only builders of boats, but also other businesses using composites.

Five to 10 of these clusters could replace the jobs lost in the textile, shoe, and pulp industries of Maine, Ms. Mills said. An initiative to establish a food cluster drew 120 people at its first meeting. "I was off and running clusters as the base for economic development," she said.

Maine established a fund to promote cluster development. Ms. Mills asked

[19]See Fred Block and Mathew R. Keller, *Where Do Innovations Come From? Transformations in the U.S. National Innovation System, 1970-2006,* Washington, DC: The Informational Technology & Innovation Foundation, July 2008, <*http://www.itif.org/files/Where_do_innovations_come_from.pdf*>.

[20]Workforce Innovation in Regional Economic Development (WIRED) grants are offered by the U.S. Department of Labor's Employment and Training Administration. A WIRED grant was awarded to train 1,800 workers in Maine to build boats using advanced technologies and materials.

how many audience members came from states with cluster funds. Only a few hands went up, but Ms. Mills says she knows there are more because she had catalogued 32 such state funds.

The next step was to figure out the federal role in regional economic clusters. She addressed these issues in a white paper on the topic for the Brookings Institution that was co-authored with Elizabeth Reynolds and Andrew Reamer.[21]

Later, Ms. Mills was appointed by President Obama to the transition team for the SBA. "Now I have the good fortune to have the best job in the world," she said. "Now we are in a good position to do something we have been talking about for years, which is to have the federal government play a meaningful role in regional economic development clusters."

The SBA is involved in other cluster initiatives besides the Energy Regional Innovation Cluster program, Ms. Mills said. Soon after joining the SBA in 2009, the agency began to focus on Michigan's robotics industry, where a cluster had been forming among companies that had supplied the auto industry. Oakland University in Rochester, Michigan, also has a Center for Robotics and Advanced Automation. This expertise was in demand by the Department of Defense. Sensors that monitor car engines, for example, are very valuable in applications such as unmanned probes to detect roadside bombs.

Recent studies, such one by the Computing Community Consortium titled "From Internet to Robotics"[22] also piqued the SBA's interest. The study said that "robotics technology clearly represents one of the few technologies capable in the near term of building new companies and creating new jobs."

The SBA helped organize a two-day summit that brought together DoD procurement officers and Detroit-area robotics manufactures and suppliers. "We got 200 small businesses in the room, with the university and the Department of Defense, and kicked off a cluster there which right now is flourishing," she said. In January, the Michigan Economic Development Corporation received the first clustering proposals from teams of private- and public-sector partners.

The SBA recently replicated the Michigan approach in Hampton Roads, Virginia, where similar technologies exist. They include robotics, unmanned systems, port security, sensors, modeling, and simulation. Another program is in Hawai'i, where there is a lot of unexploded ordinance that can be detonated by unmanned probes.

Ms. Mills said the SBA has funding in its 2010 budget for at least three more robotics clusters. There are five to seven more clusters, as well as pilot projects, that the agency may fund at some point.

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[21]Karen G. Mills, Elizabeth B. Reynolds, and Andrew Reamer, Andrew, *Clusters and Competitiveness: A New Federal Role for Stimulating Regional Economies,* op. cit.

[22]See "From Internet to Robotics: A Roadmap for U.S. Robotics," Computer Community Consortium final report to Congress, May 21, 2009, (<*http://www.us-robotics.us/reports/CCC%20Report.pdf*>).

The Obama Administration has come forth with a number of models for supporting clusters, Ms. Mills said. The ones mentioned by Under Secretary Johnson and Ginger Lew are competitive models with very large scales. In Maine, she said, "I feel like we had a traditional, organic approach to clustering." The robotics clusters in Michigan, Virginia, and Hawaii are of a much smaller scale with smaller funding and tend to involve a single customer from the federal government to create demand. "We are going to look at these models and others and think about best practices," she said. The SBA has another $10 million in the proposed fiscal year 2011 budget for clustering activities. The funds will be used to help develop public-private partnerships, launch training initiatives, and incentivize cluster creation, she said. "It is pretty substantial when you know, as we do, that a little money can go a long way in clustering."

Regardless of the clustering approach that is used, said Ms. Mills, "the SBA brings a lot to the table." The agency has a $90 million loan portfolio, and staff members know local lenders. That is important because many companies in clusters will need capital. The SBA is responsible for ensuring that 23 percent of all federal contracts go to small businesses.

The SBA also has a "very strong bone structure in the field," she explained. It can tap 68 field offices, 900 Small Business Development Centers, more than 100 Women's Business Centers, and more than 350 chapters of SCORE, a small-business mentoring program affiliated with the SBA. That means 14,000 SBA-affiliated counselors are available, many of them on-line. "If your business has a problem, you very often can get a retired executive with similar issues who can counsel you," Ms. Mills said. With the Energy Regional Innovation Cluster, meanwhile, the SBA has special funding to add experts to its small-business development centers.

The SBA also leverages its relationships with each federal agency, Ms. Mills added. Putting together the robotics clusters, which are driven by one large federal buyer, "was a pretty natural place for us to drive a cluster," she said. SBA staff on the ground, meanwhile, often act as catalysts between state and federal programs. "This bone structure on the ground is a very important operational piece of clusters, whether we initiate them or whether they come from some other process."

Ms. Mills concluded by saying the SBA is looking forward to pushing ahead with clusters. "It is a top priority for me, and it is a top priority for the President," she said. "We know that we need to drive jobs, and that jobs are going to come from high-growth, high-impact companies, some new, some old." Some of those will be "100-year-old companies repositioning themselves with innovation to compete in this next century."

REGIONAL INNOVATION STRATEGIES INITIATIVE

John Fernandez
Economic Development Administration

Referring to his background as former mayor of Bloomington, Indiana, Assistant Secretary of Commerce for Economic Development John Fernandez said that his "bias very much is for boots on the ground and a bottom-up, grass roots perspective."

Mr. Fernandez said that he would start by being the "Secretary of Obvious" and point out that "the last several years have been very brutal for all of us involved in economic development." But he added that the challenges also "in many ways have been an opportunity for a bit of a wake-up call across the board, not only for the federal government but also for the private sector and public agencies across the country."

The National Innovation Policy is at the cornerstone of the Obama Administration's economic strategy. This policy is presented as the first White House-led "national economic development framework." Mr. Fernandez highlighted the Obama Administration's Energy Regional Innovation Cluster Initiative and the $129.7 million competition to establish an Energy Innovation Hub and commercialize new energy-efficient building technologies.[23]

The innovation policy was partly in response to the deep recession, Mr. Fernandez said. "The Administration has obviously been very focused on rescuing the economy, restoring it, and rebuilding it," he said. But while addressing the immediate crisis, "the President has not lost sight of the vital importance of making smart investments that are going to be foundational for sustainable economic growth. A lot of the work we are talking about today fits into that foundation."

Economic clusters aren't really new, Mr. Fernandez pointed out. "Many of us in the room have been engaged in the concept of clustering for a long time." EDA also has been conducting research and offering assistance to clusters for years, he added.[24]

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[23]The task force is comprised of staff from the Department of Energy, that National Institute of Standards and Technology, the Economic Development Administration, the Small Business Administration, the Department of Labor, the Department of Education, and the National Science Foundation. Its Funding Opportunity Announcement for fiscal year 2010 can be found at <*http://www.energy.gov/hubs/documents/ERIC_FOA.pdf*>.

[24]Examples of past Economic Development Administration research reports on clusters can be found on the EDA's Web site. They include "Crossing the Next Regional Frontier: Information and Analytics Linking Regional Competitiveness to Investment in a Knowledge-Based Economy," October 2009, <*http://www.eda.gov/PDF/Crossing_Regional_Frontier%20Report_Oct%202009.pdf*>, "Governor's Guide to Cluster-based Economic Development Universities and the Development of Industry Clusters," 2002, and "Measuring Regional Innovation: A Guidebook for Conducting Rural Innovation Assessments Unlocking Rural Competitiveness," <*http://www.compete.org/images/uploads/File/PDF%20Files/Regional_Innovation_Guidebook.pdf*>.

What is new, Mr. Fernandez said, "is that you are seeing the federal government shining a light on this as a policy." He agreed with Mary Good's comments earlier that Americans do not like to talk about industrial policy. The federal initiative on innovation clusters is "a framework that gets close to a policy," he said. "I can't remember any time when the White House has made this level of commitment to the development of regional innovation clusters." He said he also can't think of a time when the Secretary of Commerce has embraced regional innovation clusters as a deliberate strategy. "I think those are really encouraging signs that this Administration gets this and understands that clusters can be a critical part of how we amplify investment and how we accelerate the innovation and entrepreneurship our country needs," Mr. Fernandez said.

Of the $150 million in Recovery Act funding EDA received, $50 million is being invested in regional innovation clusters around the country, Mr. Fernandez said. Previously, the agency lacked a central framework for investment priorities, he said. Under this Administration, they revolve around regionalism, collaboration, and clusters. "We are trying to get an alignment of our investments in a very smart way."

Mr. Fernandez noted that the process is "incredibly difficult." He acknowledged the significant leadership of people, like Senior Advisor to the White House National Economic Council Ginger Lew, who are driving these initiatives. "It is heavy lifting," he said. "It is new and it is difficult, but we are learning as we go, and I think it will produce great results."

The framework for EDA's development programs is called the Regional Innovation Strategies Initiative.[25] Among its priorities:

- Develop data-rich, geospatial representation of cluster activities across the United States to aid decisionmaking by businesses and policymakers.
- Develop a new tier of metrics and measurement standards to evaluate regional innovation clusters.
- Promote and facilitate trans-regional innovation clusters to spread best practices, cooperation, and problem-solving.

EDA also has partnered with research organizations to develop and produce instructional tools for economic development practitioners. For example, the agency collaborated with the National Association of Development Organizations to produce an online, self-paced curriculum called "Know Your Region" that explains the benefits of regional planning, tools to formulate regional strategies, and best practices. One tool enables planners to find data on employees and

[25]See Department of Commerce, Economic Development Administration, FY 2011 Congressional Budget Request, <*http://www.osec.doc.gov/bmi/budget/11CJ/EDA%20FY%202011%20Congressional%20v5.pdf*>.

businesses in their own regions[26] to help them "get into the weeds of nascent cluster activities they can build upon," Mr. Fernandez said.

EDA is working with federal partners and stakeholders to strengthen performance measurements. Mr. Fernandez said he appreciated the example cited by Karen Mills of the difficulties Pacific Northwest planners face procuring federal funds. There is "a wide swath of America" that does not see how innovation clusters will improve their lives, he observed. "If someone who lost a factory job hears officials talk about innovation clusters and high-tech, the person says, 'That sounds cool, but where am I in that?' We need to work on our metrics in a way that gets down and makes this stuff relevant, so people can see it's not just about Ph.D.s. It's about everyone in the entire spectrum of a cluster."

Metrics can show a cluster's impact on manufacturing, service sectors, and communities. "It is going to be essential to have relevant, real-world metrics to build the kind of sustainable political support needed to drive these kinds of policies," he added. Otherwise, the initiative could go away with a change in Administration.

EDA is realigning its programming to better support regional innovation strategies, Mr. Fernandez said. It is expanding its Public Works and Infrastructure program to include critical infrastructure of the 21st century, expanding access to capital, and bolstering activities to support research parks and incubators. It also is supporting proof-of-concept and training centers. Not all support facilities need to be labs, he said. Some are places where workforce organizations and education groups can come together and offer training for industry. "There is a whole spectrum of places where our programs can be aligned to support these kinds of initiatives," he said.

As the only government agency with economic development as its sole mission, EDA plays an important role in the effort to enhance America's long-term competitiveness. Some investments may be only $1.5 million. But one advantage EDA enjoys is "an incredible amount of discretion and flexibility in terms of how we use funding," Mr. Fernandez said. EDA's flexible programs leverage private/public investments, support "bottom-up" strategies and build 21st century innovation infrastructure. Its approach prevents a "race to the bottom" in which cities, counties, and states, undercut each other in order to attract short-term growth. By bringing together business leaders, government officials, universities, and nonprofits to work together— EDA helps regions capitalize on shared strengths, multiplying their economic power and creating jobs.

These activities do not mean the federal government is now assuming leadership of regional innovation cluster initiatives, Mr. Fernandez said. "We can't legislate this stuff, but we can support it," he said. "What is very encouraging about the Obama Administration is that we are shining a light at the federal level on these regional innovation clusters in a very smart way to build sustainable

[26]Economic data down to the county level are available at <*http://www.statsamerica.org*>.

economic development for the 21st century. That is new, that is important, and I hope we can stay focused on that."

Mr. Fernandez said federal agencies can play a powerful role in stimulating regional development. The way to move forward, he said in summary, is for agencies to align their resources, shine a light on meaningful and impactful initiatives, find smart ways to do their work, and customize the way they invest federal resources "to support this bottom-up growth of strong, organic clusters."

In terms of EDA itself, Mr. Fernandez said the aim is to modernize the agency. "We are not trying to blow it up or re-invent it," he said. "We are trying to fine-tune it." He urged people to pay attention to the agency's regional cluster initiatives to "make sure our programs are fine-tuned in a way to really support the 21st century infrastructure we need to grow our economy."

Panel III

Building 21st Century Clusters—The Role of State and Regional Governments

Moderator:
Dan Berglund
State Science and Technology Institute

Mr. Berglund said he found it interesting that only three people in the room said their states had regional innovation cluster programs when asked by SBA Administrator Karen Mills—compared to 32 to that she counted. "Actually, I think the difference is entirely a definitional one," he said. "That is a large part of what needs to be clarified as we move forward in the coming weeks and months on clusters."

He explained that this featured three states with very explicit, targeted cluster development initiatives. Other states, he said, would say they are providing support for elements that would contribute to developing robust clusters.

Mr. Berglund noted that the first speaker, Doug Parks of the Michigan Economic Development Corp., the state's investment promotion agency, heads "really one of the most creative economic development organizations in the country." The presentation by the next speaker, University of Texas at Dallas President David Daniel, is "particularly appropriate and important at a time when higher education is being cut in so many states around the country," he said. The final speaker, Rebecca Bagley, works at the development agency for northeast Ohio. Prior to that, she had responsibility for development in Pennsylvania.

BUILDING ON THE BATTERY INITIATIVE IN MICHIGAN

Doug Parks
Michigan Economic Development Corporation

Three years ago, recalled Mr. Parks, senior vice-president of business development for the Michigan Economic Development Corp., he was asked by

Michigan Governor Jennifer Granholm to help identify opportunities to diversify the state's economy. "Earlier today, Under Secretary Johnson talked about the mantra for engineering being design under constraints," Mr. Parks noted. "Well my job was design under crisis." Michigan had the nation's highest unemployment rate, losing close to 1 million manufacturing jobs. It is seven times more reliant on the auto industry than any other state.

The state decided to look for opportunities both external and internal to the auto industry, Mr. Parks explained. State officials spent a lot of time studying industrial acceleration and clustering models around the world, Mr. Parks said. They were especially intrigued by Sweden's success with a model known as the "triple helix."[27] After identifying opportunities, teams were formed for each sector and Governor Granholm mentioned the strategy in her 2008 State of the State address.

To develop their cluster strategy, state officials began by identifying Michigan's strengths and areas "where we can compete and win," Mr. Parks explained. One core asset is manufacturing, thanks to the auto industry. "We are very good at manufacturing across most sectors," he said. Michigan also has R&D to support manufacturing. Eighty percent of R&D in autos in the United States is within 50 miles of the Renaissance Center in downtown Detroit. Michigan also has natural resources and the Great Lakes.

Michigan has targeted six industrial clusters, Mr. Parks explained. They are advanced energy storage, solar power, wind turbine manufacturing, bioenergy, advanced materials and manufacturing, and defense. Each leverages state strengths. While Michigan doesn't have as much sunlight as Western states for solar power, advantages include its immense manufacturing expertise and local materials companies such as Saginaw-based Hemlock Semiconductor, the world's leading supplier of polycrystalline silicon. Wind projects envisioned for the Great Lakes give Michigan an added edge in wind-turbine manufacturing. The auto industry makes Michigan a logical place to make lithium-ion batteries.

After deciding on clusters, the MEDC formed cross-functional teams to develop roadmaps in each sector. Teams included people from universities, industry, venture capital, and other fields to help identify market opportunities and necessary value chains.

The MEDC also created some tools, Mr. Parks said. For example, Michigan has a $1 billion incentive program to catalyze a new industry in batteries. The MEDC used companies in which it invested to help recruit suppliers and support industries needed for a complete cluster. As it goes along, the state is monitoring

[27]Triple Helix in the study of knowledge-based innovation systems refers to interaction among universities, industry, and government. The Triple Helix concept has been championed by Henry Etzowitz. See *Triple Helix: A New Model of Innovation*, Stockholm: SNS Press, 2005 (in Swedish), and *The Triple Helix: University-Industry-Government Innovation in Action*, London: Routledge, 2008.

clusters efforts to see which should be expanded and which should be discontinued because they aren't bearing fruit.

Michigan is continuing its aggressive investments even though the state's budget deficit has surpassed $1 billion, Mr. Parks noted. The MEDC needed metrics and "discernible return-on-investment numbers that would help us convince legislators that this was a valuable and viable investment," he said.

The state's investment incentives include:

- Centers of Energy Excellence. The state has awarded $43 million so far to two centers, for advanced batteries and for bio-fuels. The funds are matched by the private sector, universities, and national laboratories. Among the criteria for centers are that they have the potential for high economic impact and can draw significant federal dollars. Partners include A123, Mascoma, Volvo, Mistra, and Smurfit Kappa.[28]
- Anchor Tax Credits. These tax credits are aimed at encouraging high-technology supply chains in Michigan. Anchor companies get rebates based on personal income tax generated by employees and investments, as long as they are within 10 minutes of the company or an existing industrial site nearby.
- Advanced Battery Credits. These total $1 billion. Portions of business taxes are refunded to companies manufacturing battery cells, battery backs, and advanced batter engineering.
- Photovoltaic Tax Credit. Companies investing in manufacturing facilities related to photovoltaic technology, systems, or energy can get a credit equal to 25 percent of the investment.
- Technology Collaboration Tax Credit. This credit encourages strategic innovation partnerships with emerging-technology companies. Companies get tax credits by investing in smaller companies that employ 50 people or fewer and under $10 million in revenue. Companies investing at least $350,000 can get 30 percent back.

To receive grant money for centers of excellence, companies must partner with a Michigan university or a federal laboratory. In February, the state authorized new funds for a center of excellence for low-cost carbon-fiber materials involving Dow Corning and Oak Ridge National Laboratories.

Michigan's "centers of excellence" are modeled after those in Sweden, Mr. Parks said. Such centers have an anchor company supported by universities and the Swedish government. Mr. Parks said state officials were impressed by a collaborative effort at a pulp and paper mill located north of the Arctic Circle that converts a chemical waste known as "black liquor" into bio-fuels. "What we

[28]An additional $30 million was authorized by PA 144, signed November 13, 2009, for new centers of energy excellence. To get funding, centers must get 50 percent of funds matched by the federal government and be affiliated with a national laboratory or institution of higher learning.

thought was compelling was that they brought together federal agencies, the end users, and the value chain," he recalled. "All of those resources were focused on solving that problem, which the Swedes thought could provide 10 to 15 percent of their bio-fuel requirements."

Through this research, the state "got the idea that if we invest in the private sector, and have the private sector pose the problem, that might be the best way for us to catalyze some of these new industries," he said.

Tax credits have proven to be powerful tools. The anchor credits "are literally cash to the companies," Mr. Parks explained. This cash offsets investment requirements, whether they are for factories, capital equipment, or processes. The $1 billion in refundable tax credits for batteries were competitively bid out. For companies establishing Michigan plants, the credits come on top of federal dollars made available through the Recovery Act for electric vehicle batteries. The Recovery Act required companies to cover 50 percent of project costs. Tax credits for the solar industry, meanwhile, have generated investments by companies like Dow, Hemlock, and United Solar, who have used the credits for investments.

The advanced battery initiative is by far the biggest, drawing $5.2 billion in private investment. Among the companies taking advantage of federal and state incentives to build battery plants are A123, General Motors, Johnson Controls/Saft, LG Chem, and XTreme Power.

The investment came to Michigan "not because we needed it," Mr. Parks said. "We won, we think, because we made the right business case" and because next-generation power trains for electric vehicles are being developed by carmakers in Detroit. Most of these battery activities started happening six months

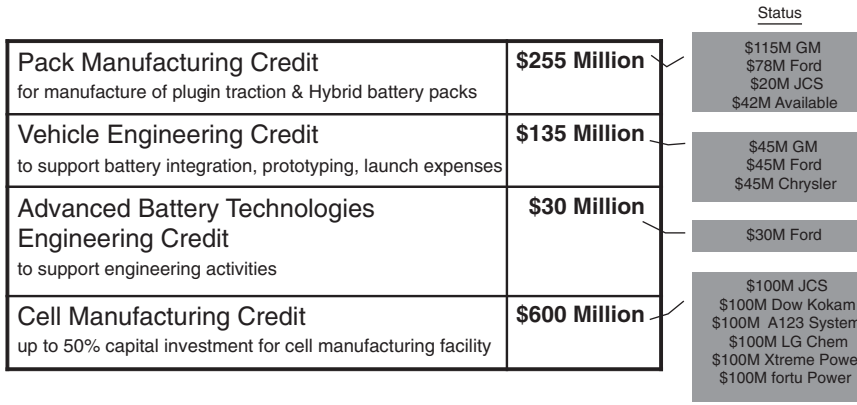

FIGURE 5 Michigan Advanced Battery Credits: Over $1 billion in refundable credits. SOURCE: Doug Parks, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

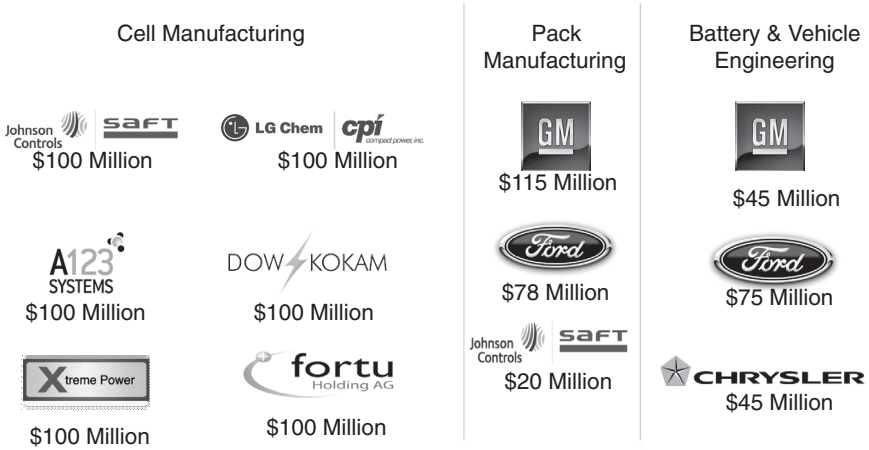

FIGURE 6 Michigan's stimulus for advanced batteries: $1 billion program.
SOURCE: Doug Parks, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

before the federal government released its investment incentives, Mr. Parks said, "so our companies were ready."

To build its supply chain, Michigan also is recruiting partners from outside Michigan. For example, Mr. Parks noted, the MEDC helped arrange a joint-venture between Dow Chemical and the Missouri affiliate of South Korean lithium-ion battery maker Kokam Co.[29] All told, the energy-storage industry is expected to create at least 8,000 direct jobs, and according to economic impact studies, will create 20 to 40,000 jobs over the next five years."

Mr. Parks says such results have enabled him to demonstrate to state legislators the "return on investment" for the battery program. He also noted that Michigan has been successful in convincing a number of other Asian companies who have dominated the lithium-ion battery industry for consumer electronics to invest in the state. "They are moving here because they see Michigan and the Midwest as the place where batteries are going to happen," he said. Also helping reinforce political support is that most of the groundbreakings on the new plants will occur this year. "It will be week-by-week groundbreakings as the new companies open up and start to hire folks," he said.

The next steps are to continue to recruit the value chain and Michigan

[29]A joint venture between Dow Chemical Co. and Townsend Kokam LLC received a $161 million DoE grant to develop and make a new generation of batteries for electric vehicles in Midland, Michigan. Kokam America is the U.S. affiliate of South Korean lithium-ion battery maker Kokam Co. Ltd. Townsend Ventures LLC has a financial stake in Kokam.

manufacturers to other manufacturing opportunities. In the car battery industry, for example, there is talk about overcapacity. But that is true for batteries for electric cars, Mr. Parks said. Much of that capacity can be used to supply growing demand for advanced energy-storage systems by utilities and the military. The state has just approved a new credit to the Dow Kokam facility, for example, which already expects to sell out its capacity by the end of the year.

The MEDC also is trying to gear its new clusters to address "critical national needs." Mr. Parks said Michigan officials were introduced to that concept three years ago when they met with Marc Stanley of NIST. At the time, MEDC was putting together its cluster-development program under the "design under crisis" concept. "We thought, wouldn't it be good if we identified Michigan strengths that also helped resolve critical national needs?" he said.

Advanced storage, lightweight materials, and bio-products all fall into this critical national need category. The approach is helping traditional Michigan auto suppliers find opportunities in industries such as defense, aerospace, and equipment for renewable energy such as solar and wind.[30] For example, the MEDC is introducing Michigan suppliers to TACOM,[31] the U.S. Army's weapons depot in the Detroit area. The state also is developing a relationship with Oak Ridge National Laboratory, which now has an office in Michigan to help companies gain access to lab resources and understand military opportunities.

MAKING THE BIG STATE BIGGER: CURRENT TEXAS UNIVERSITY INITIATIVES

David Daniel
University of Texas at Dallas

Dr. Daniel, the president of the University of Texas at Dallas, told the story of how he had helped convince the Texas legislature to pump $500 million into research universities in the state. "You don't move $500 million into resources for universities without setting a firm basis for the value proposition," he explained.

The spark plug was a white paper Dr. Daniel released in May 2008.[32] The paper elicited favorable editorials in the *Dallas Morning News* and other newspapers. "Senators got behind it, ideas bubbled up, and this got to be the top priority of the Dallas Chamber of Commerce," he said.

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[30]For detailed information on activities in non-auto manufacturing industries, see the Michigan Economic Development Corporation Web site, called "Michigan Advantage," <*http://www.michiganadvantage.org*>.

[31]The U.S. Army TACOM Life Cycle Management Command, headquartered in Warren, Michigan, is "one of the Army's largest weapon systems research, development, and sustainment organizations." See <*http://www.tacom.army.mil/main/index.html*>.

[32]David E. Daniel, "Thoughts on Creating More Tier One Universities in Texas," White Paper, May 30, 2008, <*http://www.utdallas.edu/president/documents/thoughts-on-creating.pdf*>.

Texas's economy was strong when he first proposed the plan, Dr. Daniel said, so one of the first questions he addressed was why the state needed to spend more money on research universities when the state was doing fine without them. He explained why the state had to think out its future.

To illustrate his point, he showed a slide of the nation's most populous cities in 1920. While New York and Chicago remain high on today's list, the others in the top six do not: Philadelphia, Detroit, Cleveland, and St. Louis. What changed? In the 1920s, a city's most important economic assets included good ports, rail hubs, and natural resources for manufacturing, Dr. Daniel observed. In the 21st century, the keys to prosperity are to be places where creativity, discovery, and entrepreneurship converge. Contrary to Thomas Friedman's argument that "the world is flat,"[33] Dr. Daniel says he subscribes to the Richard Florida thesis that "the world is spiky,"[34] in other words that place matters.

There are a few places in the world where a disproportionate amount of discovery occurs. He displayed a map showing that scientific citations and patents are highly concentrated in a few cities on the east and west coasts of the United States, in Western Europe, and in Japan. "One finds pretty quickly the convergence between great universities and great business sectors," he said.

Dr. Daniel pointed to data from the Association of American Universities (AAU), which represents 60 of America's most productive research universities. While they represent just 1.5 percent of the nation's more than 4,000 colleges and universities, Dr. Daniel noted, they garner 57 percent of all federal R&D dollars for universities. They are home to 81 percent of scholars who are National Academies members, and since 1901, 70 percent of U.S. Nobel Prize winners were affiliated with AAU institutions. While they have only 6 percent of U.S. undergraduates, 63 percent of National Merit Scholars "go to this club of exceptional universities."

Dr. Daniel then showed charts indicating how Texas compares to other populous states. "The Texas legislators were especially galled by the fact that California has three times more AAU universities than did Texas, and in fact we underperform relative to the rest of the nation," Dr. Daniel said.

With a population of 24.3 million, Texas is the second-largest state, behind only California. But it has only three major research universities—the University of Texas at Austin, Rice, and Texas A&M. That compares to nine in California, seven in New York, and four in Pennsylvania, America's sixth most populous state. Texas has 1.2 research universities per 10 million people, ranking ahead of only Florida. That is half the national average, and one-third the ratio for New York and Pennsylvania.

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[33]Thomas L. Friedman, *The World is Flat: A Brief History of the 21st Century*, New York: Farrar, Straus and Giroux, 2005.

[34]See Richard Florida, "The World is Spiky," *Atlantic Monthly*, October 2004. See also Richard Florida, *The Rise of the Creative Class*, New York: Basic Books, 2002.

Rank[1]	City	Number of AAU Universities	AAU Universities
1	New York City	4	Columbia, NYU, Rutgers, Stony Brook
2	Los Angeles	4	USC, UCLA, Caltech, UC Irvine
3	Chicago	2	Northwestern, U. of Chicago
4	Washington DC	2	Johns Hopkins, U. of Maryland
5	Dallas-Fort Worth	0	
6	Philadelphia	1	U. Pennsylvania
7	Houston	1	Rice
8	San Francisco	2	Stanford, UC Berkeley
9	Boston	3	Brandeis, Harvard, MIT
10	Atlanta	1	Emory
	Average (Excluding Texas)	2.4	

[1]Based on economic productivity of metro. Statistical areas in 2005.
Source: www.bea.gov/newsrealeases/regional/gdp_metro/2007/.

FIGURE 7 How many top research universities should Texas' two largest cities have? SOURCE: David Daniel, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

Major research universities near the state's most dynamic cities would be great economic engines, Dr. Daniel contended. "Imagine what Texas would be if we had three more powerhouse universities—particularly if you co-locate them in the right places, such as Dallas-Ft. Worth and Houston," he remarked. These are two of the six most economically productive cities in America.

He pointed out that Dallas-Ft. Worth is the only one of America's 10 most economically productive cities without an AAU-member university. New York City and Los Angeles both have four. Boston has three, and Chicago, San Francisco, and Washington, D.C., have two each. "This got the blood pressure going with the many leaders in Dallas, and frankly it worked," he said.

To illustrate the impact a major research university can have on a city, Dr. Daniel cited a Bank of Boston economic study of the Massachusetts Institute of Technology. In 2004 alone, MIT produced 133 patents, launched 20 companies, spent $1.2 billion in sponsored research, and had operating expenditures of $2 billion.[35] But the real impact came from entrepreneurs. Dr. Daniel cited 1994 data showing MIT alumni by then had "founded more than 4,000 companies employing 1.1 million people and generating $232 billion in sales worldwide."[36]

[35]Source: MIT Web site (2004 data).
[36]Source: "MIT: The Impact of Innovation," Boston: Bank of Boston, 1997.

Those sales, Dr. Daniel noted, were roughly equivalent to the $85 billion in gross economic output of the Dallas-Ft. Worth metropolitan area in 2005. "In other words, one great research university can have the economic impact of one great city," he said.

A similar impact can be seen in Austin, home of UT-Austin, a top research university. "Austin used to be a nice, sleepy, hippy capital of Texas when I went to school there," Dr. Daniel recalled. "It went from 90,000 people to over 1 million people now." Austin now is one of the most interesting places in the nation in terms of creativity and innovation, he added. A similar transformation has occurred in Pittsburgh, home to AAU members Carnegie Mellon and the University of Pittsburgh. In 2008, *BusinessWeek* magazine included Pittsburgh among "The Best Cities for Riding out a Recession." That is because it "made the transition from manufacturing to a center of creativity," he said.

With its oil tycoons, Texas does not lack for start-up capital, Dr. Daniel said. Yet it far underperforms other major population centers in venture-capital investments in new-technology companies, which account for 21 percent of U.S. GDP and job growth that is eight times greater than the U.S. economy as a whole. "These are the fuel for growth," he noted. "To create wealth we used to build factories and smokestacks. But today we invest in brains." Texas, with 8 percent of the U.S. population, gets only 4.5 percent of venture capital investment, he noted.

- ~$30 B per year of VC investment in the U.S. – just 0.2% of GDP
- 11% of all U.S. jobs are at VC backed companies (and growing!)
- 21% of GDP comes from VC backed companies (and growing!)
- From 2006-2008, job growth in VC backed companies was 8 times greater than the U.S. economy as a whole
- Examples : Amazon, Apple, AOL, Dell, eBay, Facebook, Google, Intel, Medtronic, Microsoft, Qualcomm, YouTube

State	Population	Federal R&D	NAS Members	Venture Capital
California	12%	18%	30%	50%
Massachusetts	2%	5%	15%	11%
Texas	8%	5%	3%	4.5%

Source: NVCA & NAS

FIGURE 8 Venture capital.
SOURCE: David Daniel, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

Massachusetts, with 2 percent of the population, gets 11 percent, and California gets 50 percent with 12 percent of the population.

An examination of where venture capital goes in Texas again highlights the importance of research universities. Austin, with 7 percent of the Texas population, gets 51 percent of venture capital investment. That is more than Dallas-Ft. Worth, Houston, and San Antonio combined. Dallas-Ft. Worth and Houston alone account for two-thirds of the state's population, and each would rank among the world's 20 biggest economies if they were countries, Dr. Daniel said. What's more, he said, Dallas-Ft. Worth is second only to Silicon Valley in technology workers, due to the presence of Texas Instruments, major telecom companies, and the defense-related industries. "There is a massive technology-delivery machinery in Texas, but not a massive technology innovation center," he said.

The shortage of great opportunities in dynamic technology clusters is leading to an exodus of some of the state's brightest young talent, Dr. Daniels warned. While 3,700 U.S. high school students went to Texas to study at doctorate-granting universities in the fall of 2007, some 11,500 Texas high school graduates went to such universities in other states. That adds up to a "brain drain" of 7,800 high school students. "We are packing up and sending off the equivalent of the freshman class of UT-Austin to other states, including Michigan," Dr. Daniel said. "Name one organization that wants to ship its best and brightest young people somewhere else." He said his own daughter studied at UC-Berkeley. "Guess where she lives now? San Francisco," he said. "Losing talent to other states is clearly not a good thing for Texas. It's because we have only two large, AAU-level universities."

In sum, Dr. Daniel said, the shortage of elite research universities is costing the state. Texas is missing out on jobs that could be generated through venture capital. "Texas is exporting tax dollars to other states to fuel research at their universities. As a result, they are getting the federal R&D and venture capital," he said. "And on top of that, they are taking our best and brightest young people."

This argument succeeded in persuading legislators. In June 2009, the governor signed Texas House Bill 51. The bill established the Texas Research Incentive Program, which allocates $50 million in matching gifts for endowed faculty chairs, graduate student fellowships, and research support. "The idea is not to anoint any one university to receive this money, but to allow them to compete for this money," Dr. Daniel said. UT-Dallas received $17.3 million in private gifts and another $15 million in state matching funds.

The bill also established the National Research University Fund. It provides a $500 million endowment to support emerging research universities that meet certain criteria, such as quality students and faculty, research productivity, and infrastructure investment. The endowment was set up because leaders "realized that legislatures come and go," he said. The goal is to grow that endowment over the next 10 or 15 years, then use the income it generates as recurring money.

In terms of next steps, Dr. Daniel said two priorities are to hold onto the

university's gains and to sustain the matching gifts program. The university is now aggressively recruiting faculty to fill new chairs. As a result, master's level student applications for next year are up 45 percent and doctoral applications are up 70 percent. Research at UT-Dallas, publications, and spin-offs are rising sharply, he said. And more companies are interested in locating close to campus.

The best sign that the initiative has staying power, Dr. Daniel said, is that in a recent legislative hearing, the chairman of the education committee showed the same slides Dr. Daniel used in his presentation and said, "We have to stick with this."

GROWING NORTHEAST OHIO'S HIGH-TECH ECONOMY

Rebecca Bagley
NorTech

One of her goals as President and Chief Executive Officer of NorTech, Ms. Bagley said, is to restore the Northeast Ohio area to the 1920 ranking, mentioned in Dr. Daniel's presentation, as one of the nation's five most vibrant regions.

"NorTech is a nonprofit Technology-Based Economic Development (TBED) organization serving 21 counties in Northeast Ohio. As a catalyst for growing Northeast Ohio's emerging technology industries, NorTech is leading efforts to develop regional innovation clusters that create jobs, attract capital, and have a long-term, positive economic impact."[37] NorTech's regional footprint contains 42 percent of Ohio's population and covers a diversity of urban and rural areas.

NorTech is funded by regional foundations and chambers of commerce in Northeast Ohio, "so the business community as well as the foundation community has a large investment in TBED," Ms. Bagley said. In addition, NorTech receives federal funding from the Small Business Administration and Economic Development Administration for specific cluster building initiatives in advanced energy and flexible electronics.

The State of Ohio provides funding to support the growth of emerging technology industries via the Ohio Third Frontier program, which has become for the cornerstone of the state's TBED strategy. The state is in the process of investing $1.6 billion over 10 years in cluster-building initiatives. In May 2010, citizens will vote on a proposal to authorize $700 million for four more years.[38]

NorTech also collaborates with partners such as JumpStart Inc., a venture development organization that provides assistance and investments to entrepreneurs and early-stage businesses, and the Manufacturing Advocacy and Growth Network (MAGNET), which helps manufacturers adopt best practices and new technologies.

[37]See the Nortech Web site, <*http://www.northech.org*>.

[38]This proposal to extend Ohio's Third Frontier was passed in May 2010 with 62 percent of the vote.

Ms. Bagley joined NorTech in July 2009 after managing various technology investment programs for the Commonwealth of Pennsylvania. "We are institutionalizing some of those methodologies that were used in Pennsylvania and applying them in Ohio," she said.

When developing regional clusters, it is important that different partners have a common strategy, Ms. Bagley said. Developing roadmaps for selected sectors is one way to achieve that common strategy. NorTech's strategy is to "engage the full community in the roadmap process," she explained. In order to identify promising clusters, NorTech first assesses Northeast Ohio's assets and competitive strengths in the global market. It also identifies the strategic steps needed to build a cluster, and who is responsible for achieving the action items. "Sometimes it is NorTech's responsibility, but other times it will be the responsibility of industry, universities, or other economic development organizations," she said. Above all, she said, "there must be a clear vision and somebody to 'quarterback' or lead that regional vision."

Government engagement is also critical to NorTech's cluster building efforts. Ohio has been investing in clusters for the past seven years in areas like advanced energy, bioscience, and electronics. Now, the region must become more competitive by attracting federal funding to accelerate growth of innovation and technology, Ms. Bagley said. NorTech hired a consulting firm to do "deep dive" assessment of federal funding opportunities for advanced energy, innovation and entrepreneurship, business incubators, and regional manufacturers in transition. Ms. Bagley described these areas as "critically important" issues in the Great Lakes region. From the assessment, NorTech has developed a coordinated regional federal funding strategy and action plan among partner organizations in Northeast Ohio to be more proactive in attracting federal funding to the region.

Currently, NorTech is focused on two industries in Northeast Ohio—advanced energy and flexible electronics.

For the advanced energy industry, NorTech is developing road maps in four sectors: energy storage, smart grid, transportation electrification, and biomass/waste-to-energy. This is perhaps the biggest effort in the NorTech Energy Enterprise advanced energy initiative, Ms. Bagley said. NorTech's role is to act as a "center of gravity" in Northeast Ohio, defining the vision and regional strategy, hosting educational events, convening cluster organizations, tracking performance, and connecting companies with funding opportunities. NorTech also manages several advanced energy projects. They include attracting resources and talent, recruiting collaborators, producing market research, and grant writing. Such tasks "involve multiple collaborators and could not get done without somebody facilitating them," she said.

One project is an advanced energy incubator in Warren, Ohio, "an auto-distressed area where the local economy lost tons of jobs," she said. "They really need something to help transform that economy." With the help of Congressman Tim Ryan (D-OH), the state raised capital to launch an advanced energy

incubator, called the TechBelt Energy Innovation Center. Community partners are helping to develop the business plan and required technologies. "It is a community process being led by NorTech," Ms. Bagley said. "Once it is developed and launched, our role will be complete, and the community will manage and facilitate the incubator."

Northeast Ohio has over 400 companies in the advanced-energy industry, she noted, and there are 10 energy sectors in which the region believes it has strengths. A lot of the companies are able to utilize the region's supply chain and manufacturing capacity. One of her jobs in Pennsylvania, Ms. Bagley noted, was to manage the manufacturing strategy for the state. "So I understand the importance of connecting innovation to manufacturing and how those two areas work together."

NorTech is developing its database to create stronger metrics to measure cluster performance. Ms. Bagley said that the goal is to show how many companies were introduced to potential customers, how many deals were negotiated, and how many jobs were created as a result of NorTech's work. "If you can start to put connections like that together with clusters, you can show how this very difficult-to-measure activity results in real impact," she said.

NorTech also is focused on developing an emerging flexible electronics cluster in Northeast Ohio. The term refers to electronic devices such as displays, solar cells, batteries, and sensors that bend and fold. The initiative is called *FlexMatters*^{SM}. Ms. Bagley noted that Northeast Ohio has a unique capability in liquid crystal displays and electronics that can be printed on flexible polymers. The University of Akron has expertise in polymers, and Kent State University has the Liquid Crystal Institute, which developed the first LCD wristwatch in the 1970s.

NorTech's *FlexMatters* program will soon complete a roadmap for Northeast Ohio's flexible electronics industry. The roadmap will access the global markets and applications for flexible electronics combined with Northeast Ohio's industry strengths. "This will help us establish a vision for what the region can achieve in this industry," said Ms. Bagley. She continued, "The roadmap will provide specific action items for building the cluster, which include continuing to grow our industry and research capacity, as well as retaining the manufacturing processes that make sense for Northeast Ohio."

In the past, Ms. Bagley noted, Kent State University produced the first liquid crystal technology breakthroughs, but the resulting manufacturing activity migrated elsewhere in the world. "The region cannot make that same mistake again" she noted. "Our goal is to keep the manufacturing of flexible electronics devices in Northeast Ohio to create jobs and economic impact for our region."

Panel IV

Lessons from Abroad—Clusters, Parks, & Poles in Global Innovation Strategies

Moderator:
Stephen Lehrman
Office of U.S. Senator Mark Pryor (D-AR)

Mr. Lehrman expressed the appreciation of Senator Pryor to the National Academies, Dr. Mary Good, and Dr. Charles Wessner for leading the effort to look at innovation, research parks, and innovation clusters. Mr. Lehrman noted this panel built on work Dr. Good and Dr. Wessner did in 2009 that led to the book *Understanding Science and Technology Parks*.[39]

Senator Pryor also is very thankful, he said, to the Association of University Research Parks, National Academies members, and Senator Olympia Snowe (R-ME), his partner in legislation to stimulate funding for research parks, technopoles, and science parks in the United States.[40] He added that the Senator is hopeful it will pass this year.

Many nations view science and research parks as "catalysts of the development of innovation and innovative clusters that support rapid economic growth and attract a talented and education workforce," Mr. Lehrman said. "The rest of the world has caught up with the United States over the last 40 years, and in many cases has surpassed us in the way they are developing their research and science parks," he said. "Now it is up to us to learn from their lessons in how to modernize our systems here in the United States."

Many of these nations are making substantial investments in parks and

[39]National Research Council, *Understanding Research, Science and Technology Parks: Global Best Practices—Report of a Symposium,* op. cit.

[40]The Building a Stronger America Act was passed by the Senate Commerce, Science, and Transportation Committee on December 17, 2009. It allows the "Secretary of Commerce to guarantee up to 80 percent of loans exceeding $10 million for construction of science parks and would provide grants for feasibility studies and construction plans for new parks or expansions." The National Academy of Sciences is mandated to evaluate the program.

clusters that create regional and national centers of economic development and that facilitate new technology, Mr. Lehrman observed. "Eventually, that is the goal of all of us," he said, "which is economic development, the development of new products, and commercialization of technology."

Mr. Lehrman said the panel is fortunate to have four experts on clusters, science parks, and technopoles, and how they contribute to the innovation systems of their nations and regions.

AN INTEGRATED APPROACH: BRAZIL'S MINAS GERAIS STRATEGY

Alberto Duque Portugal
Minas Gerais Secretariat for Science, Technology, and Higher Education, Brazil

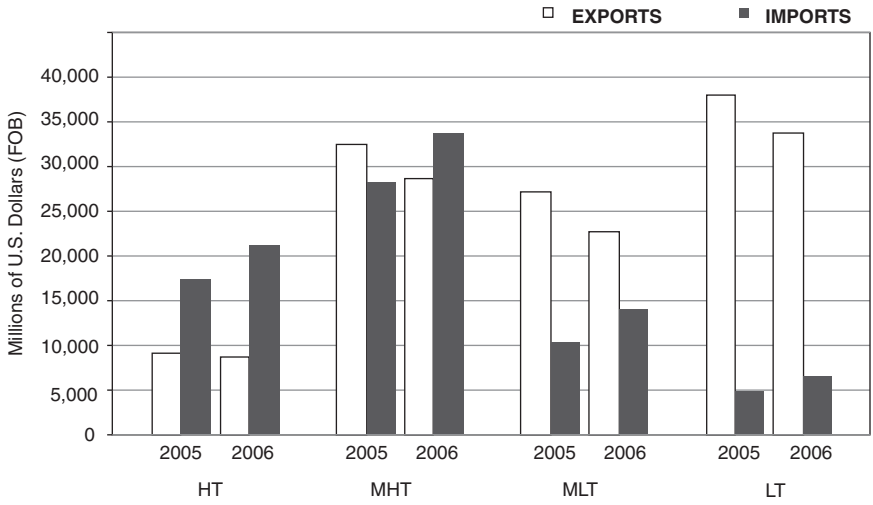
State Secretary Duque Portugal began with a few facts about Minas Gerais. The state is located west of Rio de Janeiro, Brasilia, and Sao Paulo, has a population of 20 million, and covers a territory about the size of France.

The state's economy has been growing "reasonably well," Dr. Portugal said. It has a GDP of $122 billion and the nation's second-largest industrial park. The state is a leader in mining, metallurgy, coffee, biotechnology, and other industries. For Brazil, Minas Gerais has roads, railways, airports, and other infrastructure, and is responsible for 18.5 percent of the nation's energy generation.

By many measures, Brazil has been making good strides in terms of scientific output, he noted. The number of Brazilian articles published in scientific journals has grown from less than 5,000 a year in the early 1990s to more than 30,000 in 2008, and its global share of such papers has risen from about 0.5 percent to 2.6 percent. Master's degrees awarded annually have surged from around 5,000 in 1993 to 33,360 in 2008. Ph.D degrees have risen sharply, to 10,711. That is a good output for a Latin American country and emerging nations, he said.

The big challenge "is how to transfer this science and technology into production, productivity, quality, competitiveness, and better employment," Dr. Portugal said. He displayed a slide that shows the "technology intensity" of foreign trade in Brazil. In 2006, Brazil imported more than twice as many "high-technology" goods, valued at around $21 billion, than it exported. Brazil also imported more "medium high-technology" goods than it exported that year. The country enjoys a large surplus in "medium-low technology" and "low technology" products. He noted that these data are a bit out of date. While there is improvement, however, the balance isn't substantially different.

Brazil exports a lot of agricultural goods and raw materials, such as iron and soybeans, which require technology. Such products, however, don't have a lot of aggregate value, he said. "So the big challenge we have is how to provide more value to the economy through innovation."



HT: High Technology
MHT: Medium High Technology
MLT: Medium Low Technology
LT: Low Technology

Source: (GOMES; LOURENÇO, 2007) – Funed Medicamentos: estudo da cadeia de valor – v. 2 – Base de Dados: MDIC/SECEX, 2007.

FIGURE 9 Technology intensity in foreign trade in Brazil.
SOURCE: Alberto Duque Portugal, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

Minas Gerais has a substantial research base, Dr. Portugal said. It has federal universities and four state universities with 91,322 students. Universities in the state awarded 2,850 master's degrees and 904 doctorates in 2008. The state also has 283 private institutions conducting more than 8,500 research projects and employing 15,842 researchers. Universities spend $1.3 billion annually on R&D.

The state has invested more than $300 million in the past four years to build its innovation system, Dr. Portugal said. Its science and technology education master plan has four main goals:

- To transform knowledge into business to raise productivity and competitiveness, contributing to economic development.
- To make Minas Gerais a leader in the knowledge economy.
- To consolidate in society the perception that science, technology, and innovation are strategic areas.
- To align the actions and indictors of the science, technology, and higher-education systems.

To advance this agenda, Dr. Portugal said, the state created Sistema Mineiro De Inovação, better known as SIMI. This organization is an operational platform to promote innovation. It has a forum chaired by the governor, a higher-education observatory, and a Web 2.0 Internet portal enabling researchers, entrepreneurs, and others to talk to each other. SIMI also has a "technological innovation network" that provides skills training, an outreach program to transfer technology to businesses across the state, a committee of entrepreneurs to support and stimulate innovation, and international partnerships.

All of these activities concentrate on some basic points. They focus on speed, achieving scale "in order to reach as many actors as possible" with finite resources, and improving "social technology," Dr. Portugal said. An overarching goal is to "improve collaboration, coordination, and strategic alliances to create an environment and stimulate an attitude for a culture for innovation."

To build an "innovation environment," SIMI is promoting technology parks, incubators, R&D centers, and a program called Innovate in Minas. SIMI also is hosting a technology fair in October.

There are a variety of programs designed to bring technology to business. They include an innovation incentive program for businesses, technology innovation units, programs to promote basic industrial technology, a design center, and assistance in coordinating venture capital. To promote "innovation in society," Dr. Portugal explained, SIMI supports several entrepreneurship training programs, including master's level courses. It also supports a network of 1,800 centers that work with higher education to train professionals needed by emerging clusters. For example, there is a program to meet projected workforce needs in aerospace, a rising industry in Brazil.

SIMI is aligning these programs to advance the development of four regional clusters that Minas Gerais has targeted because they have the potential to make a high economic impact. A micro-electronics and telecom cluster is based in the southwest of the state. Growing software and biotechnology clusters are concentrated in central Minas Gerais. A bio-energy cluster, which includes charcoal, bio-fuels, and solar power, is expanding in the north. Among other things, SIMI is developing programs to support entrepreneurs, train management, and promote exports in these industries.

In addition to innovation clusters, the state is working to develop what it calls "poles of excellence." These are establishing industries in which communities in Minas Gerais already have expertise and leadership. They include metallurgy, telecommunications, cattle genetics, forestry, dairy, environmental management, and coffee. The state government is trying to develop certain cities into national hubs for these industries. It is encouraging private companies and public agencies to consolidate their people, laboratories, and management in these hubs. The goal, Dr. Portugal explained, is to enable the hubs to attain critical mass and become magnets for new investment and R&D.

One problem is that most of the clusters and poles of excellence are located

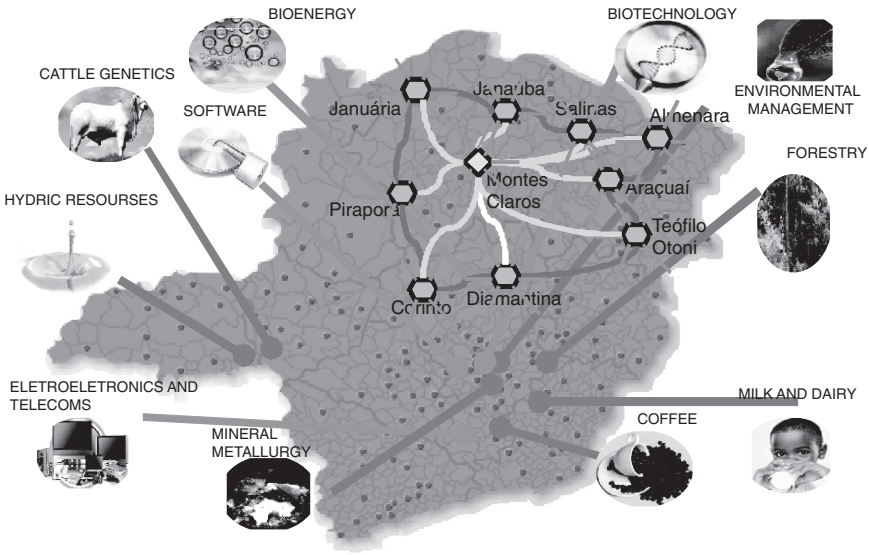


FIGURE 10 Poles and clusters of Minas Gerais.
SOURCE: Alberto Duque Portugal, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

in the southern half of Minas Gerais. The north is poorer and less densely populated. The government is investing a lot in roads, education, health, and other infrastructure in the north to spread development, Dr. Portugal said.

Meanwhile, SIMI is developing what Dr. Portugal described as a "network of pools of innovation," or linkages between cities across the nation to create channels to disseminate best practices. To make such an innovation platform work, he added, "we also have to invest in human resources." SIMI began working with two towns that have universities to create a pool of highly skilled people, including Ph.Ds.

SIMI also is forging international partnerships to advance its innovation strategy. Currently, it is working with Italy's Piedmont region in energy, mobility, and automotive technology; the German state of Saarland in nanotechnology; the Australian state of Queensland in mining, water, and sustainable management, and France's Brittany region in dairy and Web. 2.0 technologies. SIMI is working to internationalize its organization.

Dr. Portugal invited the audience to attend the 2010 INOVATEC fair, which stands for Technology and Innovation Fair and Congress. INOVATEC is an opportunity for researchers, private industry, government agencies, and R&D centers to interact and exchange ideas, he said. In 2008, INOVATEC's main partner

was Italy. In 2009, the focus was on France. In 2010, the invited country is the United States. Among the priorities are to foster cooperation in solar energy. The state hopes to attract participants from U.S. government agencies, R&D, institutes, and companies.

BRAZIL'S NEW INNOVATION STRATEGY

Francelino Grando
Ministry of Development, Industry, and Foreign Trade, Brazil

Dr. Grando, Brazil's Secretary of Innovation, said he could sum up his goal in a single word: "system." He added a second word: "articulation." By this, Dr. Grando said, "I mean that within a government, a federal government, we see that different parties of the same body do not speak in the same language, do not address each other, and do not even know what the others are talking about. So we see system and articulation within the government as the keys to what we call Brazil's new innovation strategy."

Articulation is needed at the federal, state, and local levels, he said. But it is possible to speak the same language. He noted that within Brazil's Ministry of Science and Technology, a number of top officials have been local secretaries of science and technology. "So, of course, we bring to national government the same purpose," he said. He also noted that the national forum of local secretaries of science and technology is represented on the national board of science and technology, which advises the President.

As a university professor, Dr. Grando said he agrees with Dr. Daniel of the University of Texas at Dallas on the central role of universities. This has been Brazil's focus for more than a half century with public federal and state money, he said.

Brazil has made particularly impressive progress in the first decade of the 21st century toward increasing its knowledge base. Between 2000 and 2008, he noted, the number of master's degrees awarded annually has doubled, to 36,014, and the number of doctorates also has doubled, to 10,711. "This is a huge output, and this is the result of permanent, dedicated investment for decades and through several different governments," he said.

Recently, Brazil has put greater emphasis on science and technology education, Dr. Grando said. It took more than 100 years to establish 140 technology schools. From 2002 to 2010 alone, that number has swelled to 366. Government investment of $550 million in these schools has created 500,000 new student positions. This intermediate level of training, he said, "creates a strong base for knowledge production." These schools also are spread across Brazil, even in the Amazon rain forest, which accounts for half of the nation's territory.

Dr. Grando pointed to other indicators of scientific output. Brazilian scientists have sharply increased published papers. Public and private R&D investment, meanwhile, soared from $8.7 billion in 2000 to $24.4 billion in 2008.

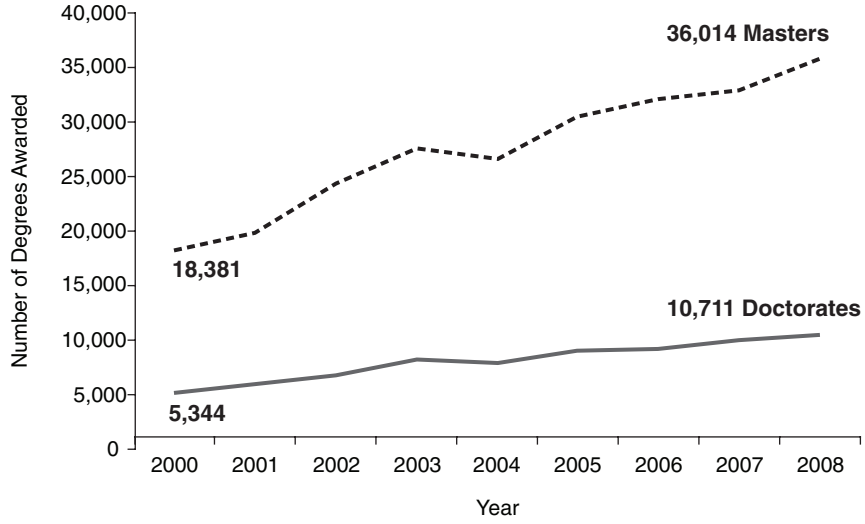


FIGURE 11 Increasing knowledge.
SOURCE: Francelino Grando, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

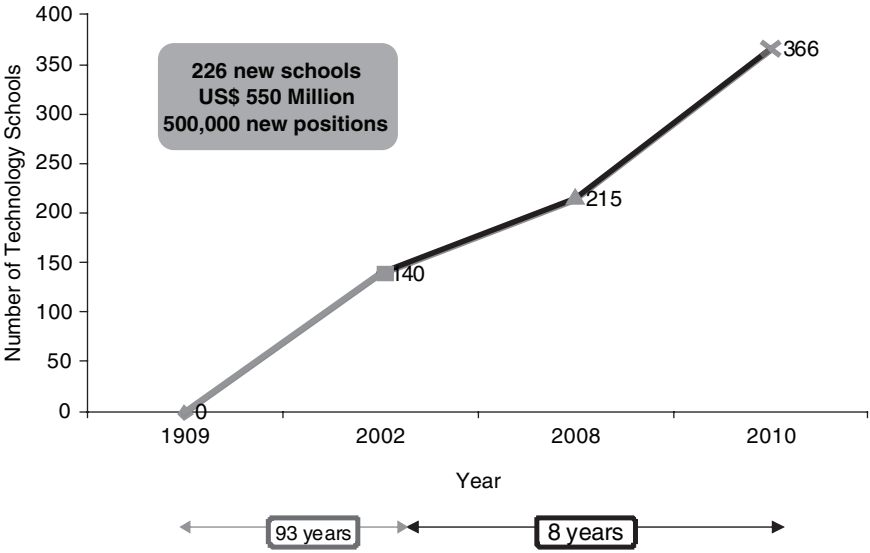


FIGURE 12 Technology schools.
SOURCE: Francelino Grando, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

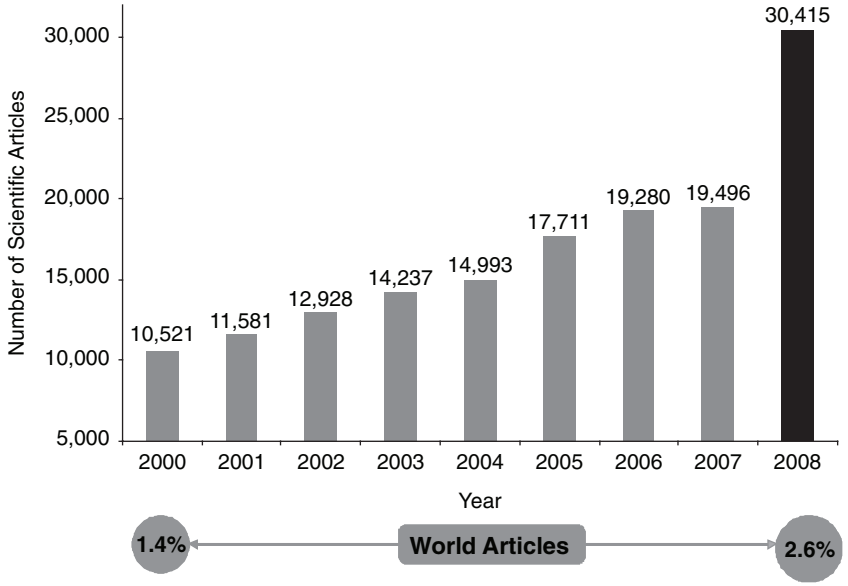


FIGURE 13 Scientific articles.
SOURCE: Francelino Grando, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

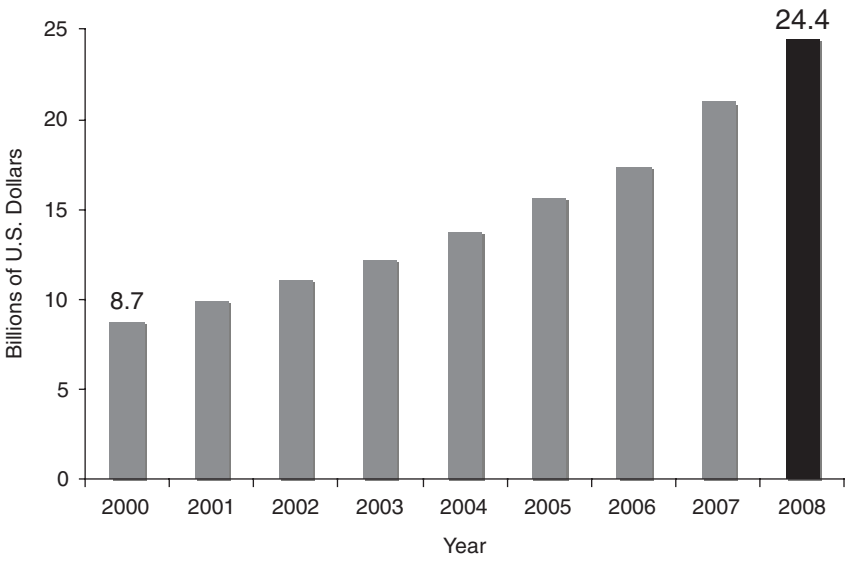
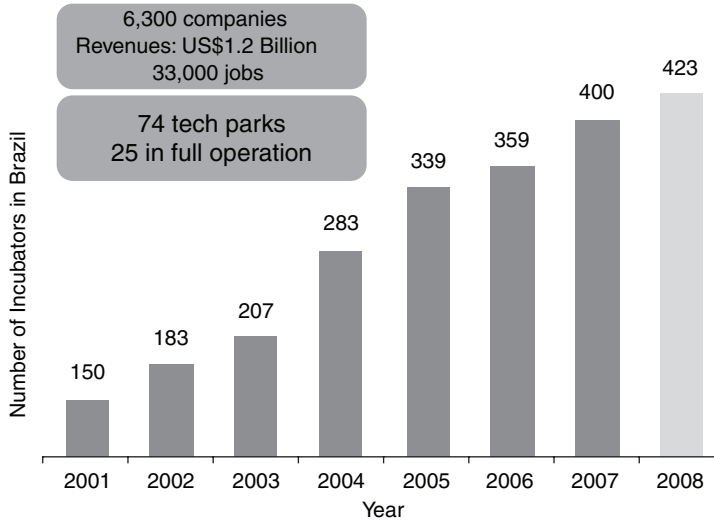


FIGURE 14 R&D expenditure in Brazil.
SOURCE: Francelino Grando, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."



Source: ANPROTEC.

FIGURE 15 Incubators: science + entrepreneurship.
SOURCE: Francelino Grando, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

Brazil has made equally impressive strides in promoting technology entrepreneurship, Dr. Grando said. The number of small-business incubators in Brazil surged from 150 in 2001 to 423 in 2008. These incubators have helped 6,300 companies. This is the result of policies that help companies "that are getting into the market, not just scattering money on very, very good ideas that are not fit for one reason or another to generate innovative products."

In addition to the 33,000 jobs created by these new companies, Dr. Grando said, these incubators have been a smart investment. State and national tax dollars generated by these new businesses are three times the amount the government has spent on incubators, he said. "Those are good metrics," he said.

Infrastructure is important, he said. Even after improving the capacity for knowledge generation and making entrepreneurs more sensitive to innovation, Dr. Grando said, "there still is something that public money has to do." Brazil set up the equivalent of the U.S. National Institute of Standards and Technology. The agency is called INMETRO, which stands for the National Institute of Metrology, Standardization and Industrial Quality.

INMETRO has sharply increased the number of qualified technicians that are civil servants. The number of master's degree holders at the agency rose from 27 to 201 since 2000, and the number of doctorates grew from 8 to 152. The number of INMETRO labs has grown from 18 to 53 over that period.

Brazil's new focus on innovation is present in what Dr. Grando described as two "systemic policies." One, led by the Minister of Development, is the Productive Development Policy. It entails investment of $150 billion. Of that, $3 billion is devoted to promoting "innovation in a strict sense," he said. Another $20 billion, managed by the Ministry of Science and Technology, is earmarked for a "science and technology action plan."

The Ministry of Development is responsible for deciding where to invest the money. Managers in the Ministry of Technology lead teams in specific targeted areas, such as information and communications technology, biotechnology, and nuclear energy. All of these programs "are articulated around a nexus of innovation," Dr. Grando said.

The ultimate goal of all of these efforts is to attain sustainable growth. "We long for the time when 'sustainable' will no longer be an adjective, when development will no longer be qualified as 'sustainable development,'" he said. "We long for the time when development means only 'development that is sustainable,' just as 'democracy' does not need a clarification."

The Secretariat of Innovation, which is part of the Ministry of Development, Industry and Foreign Trade and the Secretariat of Innovation, coordinates the national innovation system, Dr. Grando explained. It collaborates with the National Development Bank (BNDES), INMETRO, the National Institute of Intellectual Property (INPI), the Industrial Development Agency (ABDI), and the Export Promotion Agency (APEX). These agencies also communicate with other federal ministries. To help the entire federal bureaucracy to stay in touch, the Secretariat of Innovation is setting up a Web 2.0 portal. "We need innovation in the public administration as well as in the private sector," Dr. Gordo noted.

Investments in the innovation system have made Brazil more globally competitive, Mr. Grando said. The nation now is self-sufficient in oil production, "a very, very good example of Brazil's technological development and focus on innovation." Petrobras is now the world's fourth-largest energy firm. Brazil also is a leader in production of sustainable energy, he added. "We won't talk about ethanol here," he said jokingly, referring to the trade dispute with the United States, which has curbed imports of Brazilian ethanol made from sugar. Brazil also is home to Embraer, the world's third-largest aircraft manufacturer. Brazil is the world's fifth-largest personal computer market and is ranked as the fifth-best location for the offshore outsourcing of information technology. Brazilian banks are leaders in Internet bank. There are 175 million users of mobile phones. And 44 out of 50 global major companies operate in the country.

The progress so far "is just the beginning," Dr. Grando predicted. Given all of the investment, creativity, and systemically articulated programs at all levels of the private and public sectors in Brazil, "there are some quite fascinating experiences ahead of us."

HONG KONG SCIENCE PARK—OPTIMISING SYNERGIES

Nicholas Brooke
Hong Kong Science and Technology Parks Corporation

Hong Kong has been a "great fan and big believer" in clustering for some time, noted Mr. Brooke, chairman of the corporation that operates the Hong Kong Science Park.

The decision to launch the science park in 2001 was heavily influenced by Hong Kong's experience in the Asia financial crisis of 1997. The territory's economy experienced 54 months of deflation, "a pain we are not used to," Mr. Brooke said. While the crisis was painful, it forced the Special Administrative Region's leadership to focus on the structure of its economy.

The government realized Hong Kong had to broaden its base beyond industries such as financial services, tourism, and trade, Mr. Brooke said. It concluded that Hong Kong should serve "as a platform for innovation and technology, capitalizing in particular on our location close to the mainland of China," he said. The park is located 20 minutes from the mainland border, 20 minutes from Hong Kong's Central district, and 40 minutes from Hong Kong's airport.

The park was established with public funds, "but it is no holiday," Mr. Brooke said. "The park basically must operate according to commercial principles." The Hong Kong Science and Technology Parks Corporation is responsible for operating the park. Even though the Hong Kong government provided all of the money and is the sole shareholder, only 1 of the 16 board members is a government official. Rather, membership comes from a range of industries and from academia.

The government's role in the park is interesting, Mr. Brooke explained. The government decided it should provide the infrastructure, or the platform for innovation and technology. It has invested $1.5 billion in land and funding for "hard and soft infrastructure" for Phases I and II, he said. In mid-February 2010, the Hong Kong Financial Secretary signed off on $500 million for a third phase. Once the government has made that investment, "the corporation is essentially on its own," he said. The park must support itself financially.

Hong Kong leaders understood the best way to build a knowledge-based economy was to build on what it already had, Mr. Brooke said. The park's vision is to position the SAR as a regional platform in innovation and technology. Hong Kong's geographic location gives it unparalleled access to the mainland market.

Facilities include a major design center, small-business incubators, and industrial estates. These enterprise zones are reserved for companies making high-value products using technologies developed in the park. It is assumed companies making low-value products can manufacture in China, Mr. Brooke said.

What differentiates the Hong Kong science park from many of those in China is the "soft infrastructure," as opposed to only the "hard infrastructure," he said. While the scale of Chinese parks is impressive, "many, many of them in fact are

real estate plays," he added. "They brand themselves as technological parks. But often the technology content, if you like, is actually quite minimal."

The entire thrust of the Hong Kong Science Park, by contrast, is to foster innovation and technology, Mr. Brookes said. It provides support for selected technologies, incubates new businesses, and promotes collaboration among industry, academia, and researchers.

The park now has state-of-the-art facilities in 20 buildings and will eventually extend to 330,000 square meters. The first phase was finished in 2004. The second opened in 2008, and ground will be broken on Phase III in the fall of 2010, Mr. Brooke said.

The park already has 250 companies. They include R&D operations of major multinationals such as Philips and DuPont, as well as many small and mid-sized companies. There are 30 U.S. companies and others from China, Japan, Taiwan, France, the Netherlands, and other nations. All are referred to as "partner companies," Mr. Brook said. "It is not a landlord-tenant relationship. We deliberately describe them as partnerships."

The most iconic structure in the park is known as the "golden egg." It is a large oval, gold-colored auditorium seating 300 people. It is named after Charles K. Kau, the Nobel Prize-winning fiber optics pioneer.[41] The "golden egg" serves as the anchor for everything that happens in the park, he said.

The government also leaves it up to the science park corporation to pick which industrial clusters to focus on. "The government of Hong Kong is not inclined to choose or pick winners because governments usually get it quite wrong," he said. The corporation has identified clusters where it believes Hong Kong has an advantage and that warrant special attention. It selected electronics, green technology, information and communication technology, precision engineering, and biotechnology. The laboratories support technologies specific to those clusters. "We cannot be all things to all people," he said.

It is not enough to focus on these broad areas, however. "We decided that if we were to create world-class niche technologies, we had to move to subsets," Mr. Brooke said. The park selected areas where Hong Kong already is strong, such as RFID, smart cards, and design of integrated circuits for mobile devices. He noted that many telecom chips inside Blackberry devices were designed in Hong Kong. Another Hong Kong cluster focuses on light-emitting diodes for lighting.

The Phase III facilities will focus on new clusters. They are thin-film photovoltaic panels, environmental engineering, and energy management for buildings. "Here we see ourselves as aggregators, as integrators, of technologies that already exist around the world," he said. Companies in Hong Kong can adapt these technologies so that they are applicable to China and other Asian countries.

[41]Charles Kuen Kao, born in Shanghai in 1933, shared the 2009 Nobel Prize for his work on the use of fiber optics in telecommunications. He was vice-chancellor of Chinese University of Hong Kong.

The breakdown of partner companies and start-ups in the park illustrates the early focus on information technology (IT), Mr. Brooke noted. Thirty-nine percent focus on IT and telecom and 29 percent on electronics. Life sciences and green-technology companies account for 8 percent each and precision engineering for 12 percent, but the importance of these sectors is expected to grow.

The park has 130 companies in the incubation phase, or "babies as I call them," Mr. Brooke said. The park offers accommodation, technical support, business plans, marketing help, and other things start-ups often lack. The park also helps raise funds, facilitates networking, and offers mentoring, he added. "It's not just about incubation, but about success as well," Mr. Brooke said. So far, 213 companies have graduated from incubators and moved into the industrial park. Four are publicly listed. Two of those companies were started with three employees, he added.

The park also offers companies access to a wide local talent pool. At any one time, its Web site advertises 1,000 jobs and information on 5,000 people looking for work. Mr. Brooke said that the park helps place 3,000 people every year in the technology area. In terms of funding, the park has raised 584 million Hong Kong dollars (US$75 million) since 2003 in venture and angel financing.

The park has technology-support laboratories for integrated-circuit design and development, reliability, materials analysis, biotechnology, RFID, photovoltaic testing, wireless communication, and solid-state lighting. Companies are charged just for the cost of lab labor, not rent. "They can either use our people if they want or their people, depending on how sensitive they feel things are," he said. In addition, the park has an intellectual property service center.

Eighty-eight percent of incubates are from Hong Kong. But among partner companies, 42 percent are foreign-based. The companies produced combined revenues of 62 billion Hong Kong dollars ($8 billion) in 2009, he said. Seven thousand people work in the park, 4,000 of them engaged in R&D. When Phase III is completed, Mr. Brooke said, the park expects to have 450 companies and employ 15,000 people.

Phase III will focus on clean energy technologies. The park plans to commission a study to identify three to four green-tech clusters that would "best position Hong Kong and most benefit the mainland," he explained.

One of the park's biggest challenges is low R&D investment by Hong Kong companies, Mr. Brooke said, as well as limited venture capital support for start-ups. He noted that Hong Kong spends less than 1 percent of GDP on R&D, well behind other industrial nations and even less than China.

Still, the park has achieved considerable success. The number of R&D personnel in Hong Kong grew nearly five-fold, to 12,700, between 1998 and 2007, he noted.[42] Private industry spending on R&D rose nearly four-fold over that same period, to 6.1 billion Hong Kong dollars ($79 million).

[42]Source: Census and Statistics Department, Hong Kong Special Administrative Region.

Many foreign companies perform R&D in Hong Kong and manufacture in nearby Shenzhen, China. Mr. Brooke predicted more companies would adopt this "Hong Kong-Shenzhen business model."

DuPont Apollo Ltd.[43] is a good example of this model. The unit of DuPont will manufacture thin-film solar modules in a new plant in Shenzhen. But R&D and intellectual property will remain in Hong Kong, where the company feels more comfortable, Mr. Brooke said. DuPont is discussing further collaboration with the Nano and Advanced Materials Institution in Hong Kong. Other corporations using the Hong Kong-Shenzhen business model include Philips, Freescale, Xilinx, and Nvidia.

The next step for Hong Kong is to "widen the menu further," Mr. Brooke said. The park is exploring new clusters in areas where Hong Kong is well-positioned, such as medical services, creative industries, and educational services.

INNOVATION AND CLUSTERS: WHY THEY ARE BACK ON THE OECD POLICY AGENDA

Mario Pezzini
Organisation for Economic Co-operation and Development

Mr. Pezzini, who heads OECD activities that promote regional competitiveness, began by saying he must disagree with those who contend that other countries are trying to copy the United States. "The situation is much more complex," he said. "A lot of things we are discussing here are not at all new."

Mr. Pezzini recalled that when he was a manager in the regional government of Emilia-Romagna in Italy prior to joining the OECD in 1995, a series of Americans—including then-Arkansas governor Bill Clinton—visited to study the region's success at producing clusters with many small and midsized companies. The phenomenon of "many firms relating to each other and being competitive did not happen first in Silicon Valley," Mr. Pezzini said. "It happened in many other places."

What is interesting in the policy debate is that "we are now dealing with different units of analysis and intervention," he said. "This is crucial for what we do." Mr. Pezzini said policymakers need to move beyond merely inventing new subsidies for firms and understand what really makes clusters competitive.

What is really new, he added, is that many countries are looking at subnational entities differently, whether they are regions, states, counties, or whatever. Many places had regional economic strategies, but they were mainly regarded as mechanisms to redistribute resources to compensate for disparities. Governments gave subsidies to individual firms belonging to certain sectors. The "big actors,"

[43]DuPont Apollo Ltd. is a fully owned subsidiary of DuPont that will make silicon-based thin-film photovoltaic modules on glass.

federal governments, "acted like Robin Hood to take from the rich and give to the poor," he said. Northern Brazil, southern Italy, Japan, and northern European countries all used this model.

Regional redistribution strategies failed. "In reality, these disparities are still there," Mr. Pezzini said. "Using these approaches does not help to exploit the potential of regions. Sometimes they exaggerate the disparities between regions." Giving subsidies to small entrepreneurs in southern Italy, say, "more or less meant reproducing the same machinery that was already there." If producers lack economies of scale, the capacity to compete will not grow. "A central government that tries to do everything very often tends to produce cathedrals in the desert," he said, "investments that do not produce multiplicative effects."

Now there appears to be a paradigm in regional thinking. "That's the new thing, not the clusters," Mr. Pezzini said. "Rather than compensating disparity, many governments are trying to get every region to identify their comparative advantages and to exploit those advantages in a global arena in which you are no longer protected by your national borders." Then governments try to position regions as "athletes in the Olympic Games of globalization."

The message that has come through in this symposium, Mr. Pezzini observed, is that governments should not pursue sectoral approaches. "There should be multi-sectoral intervention, where investments are coordinated in order to exploit comparative advantage." The tools are not subsidies, he added. They are investments to build public goods for communities. There is a growing realization that it is hard for companies to compete when they are alone and isolated, he said. They also need infrastructure to be competitive.

Governments are also adapting to new approaches to innovation, Mr. Pezzini said. They are taking into account that innovation is increasingly open. It requires interaction between different specialties.

To illustrate his point, Mr. Pezzini held out his cellular phone. The product is a collaboration by experts in different technologies, such as radio engineers who are experts in signals and telephone engineers who make sure those signals go to the right numbers. "Cocktail partners were required to put together the people in places where they could discuss with and see each other, to stop them when they want to kill each other again, and then to put them together again and launch a new discussion, after which you get an innovation."

Not all government interventions promote such cross-fertilization. Mr. Pezzini noted that 80 percent of R&D tax credits in Mexico go to eight firms that specialize in the auto industry. Are such policies really needed to promote and diffuse innovation? "I don't think so," he said.

Another important new idea in promoting clusters, he said, is to combine different public investments in innovation and technology. If a region wants to create science centers and technopoles, then it should plan and design them with different actors that must come together. This requires new kinds of governance, Mr. Pezzini said.

He said he was impressed that in the United States seven federal agencies now sit at the same table to make sure policies succeed. A decade ago, most governments kept agencies separate and finance ministries decided which to support. Now, governments realize that investments in areas like infrastructure will be extremely unproductive if not coordinated with investments in areas like human capital.

New strategies also go beyond the old focus on creating macro-economic environments conducive to growth. Mr. Pezzini recalled that recently the U.S. government asked the OECD for advice on how to reduce unemployment in America. Researchers concluded that the biggest factors influencing employment were regulatory reform, flexibility and mobility of the labor market, and sound macro-economic policies. But the United States already ranked as best in the OECD in all of these areas. "Therefore, traditional answers cannot be used to address the problems of today," Mr. Pezzini said. Other policies are needed that complement the macro environment.

How to carry out public governance of innovation strategies raises a number of questions, he noted. One is how to align the different actors. Should federal agencies give money to the states, or give them part of the money if they put in the other 50 percent? Should the parties set up performance indicators and then sit down three years later to discuss progress? And should money be removed if the efforts aren't working? Should the process be transparent?

"This debate for me is new, is extremely important indeed, and I thank you for inviting me here," Mr. Pezzini concluded.

Luncheon Address

Gary Locke
Secretary of Commerce

Introduction:
Ralph J. Cicerone
National Academy of Sciences

Dr. Cicerone, president of the NAS, noted that before he was confirmed as Commerce Secretary, Gary Locke had been a "very popular, respected, admired, effective, and dynamic" governor of the state of Washington. Prior to that, he had been an elected state representative.

Secretary Locke came to Washington "to be one of the champions of innovation and entrepreneurship and the jobs and growth they bring," Dr. Cicerone said. He noted that President Obama has described Secretary Locke as "a tireless advocate for economic competitiveness and an influential ambassador of American industry." Secretary Locke, Dr. Cicerone said, "recognizes that innovation and entrepreneurship are proven paths to more and better jobs, to economic growth, and to national competitiveness."

Underscoring this commitment, Dr. Cicerone noted, Secretary Locke opened the new Office of Entrepreneurship and Innovation within the Department of Commerce and launched the National Advisory Council on Innovation and Entrepreneurship. The secretary also was at the NAS building the previous day, February 24, 2010, participating in a lively group discussion about research universities and their role in the innovation economy. When President Obama addressed the NAS annual meeting in April 2009, Secretary Locke was with him.

Gary Locke
Secretary of Commerce

Mr. Locke thanked the National Academy of Sciences and added, "It's great to see you again." The previous day, Mr. Locke explained, he was at the NAS "talking with a group of businesses and university leaders about the urgent need to move great ideas more quickly from university labs into the market place." He said that the group also discussed how "government, business and academia can better collaborate and take steps to make the country's innovation ecosystem more focused and efficient."

We all know "that America is not lacking for groundbreaking ideas in this country," Mr. Locke said. "Nor are we short on smart entrepreneurs willing to take risks. What we need to do is get better at connecting the great ideas to the great company builders." That is why this symposium is so important, he added.

"Regional innovation clusters have a proven track record of getting good ideas more quickly into the marketplace," Mr. Locke said. "When businesses, government, academia and nonprofits are situated in one place pulling towards similar goals, good things happen." He cited Silicon Valley, Boston's Route 128 corridor, and North Carolina's Research Triangle as striking examples of innovation clusters done right. "The burning question then comes: 'How do we create more of them?'" he said.

Mr. Locke said the answer to this question isn't just important to him or those at the symposium. "It's important to the millions of Americans who—even before this recession began—were falling behind," he said. Since 2000, he said, most families have seen their wages stagnate or decline, while the costs of necessities such as health care and tuition have skyrocketed. The prime culprit of America's economic problems has been "the decline in the type of good, skilled, well-paying jobs that once helped America build the strongest middle class in the history of the world," Mr. Locke said. "America's challenge, therefore, isn't just to emerge from recession. It is to lay a new foundation for sustainable long-term economic growth," he said.

Mr. Locke said that the place to start is by promoting the creation of new businesses. America has always celebrated "those pioneers who were willing to mortgage their houses, work 100-hour weeks, and throw caution to the wind in the pursuit of an idea," he said. "That story is at the very heart of America's economic success." Over the years, however, "we fell in love with another type of risk that extolled short-term thinking and speculation," Mr. Locke said. "Instead of working to engineer a breakthrough technology or build a great company, too many of our brightest minds were busy engineering credit-default swaps. America can't afford to inflate another bubble that enriches a select few while putting everyone else in peril."

The United States no longer can count on Wall Street's version of innovation to drive its economy. "We know how that story ends," he said. "Instead,

we need to encourage the right kind of risk-taking—the type of risk-taking that allows successful entrepreneurs to build companies and discover breakthrough technologies that allow people around the world to live wealthier, healthier, and more productive lives."

Companies that have solid foundations and a lot of growth potential are known as "gazelles," Mr. Locke noted. "Gazelles" can thrive in science and technology parks, laboratories, and business incubators. These are "places where entrepreneurs, scientists, product developers, and venture capitalists are clustered together and can work together." They are places where innovations are developed and brought to market, and where new businesses have a chance to grow. They are places, he said, "where entrepreneurs—even the ones who at first don't succeed—have a chance to try, try, and try again." They also are places where workers have the security of knowing that if one employer closes its doors, another will emerge to take its place.

These dynamics already are at work not only in well-known innovation clusters such as Silicon Valley and Research Triangle. Despite the difficult job picture, Mr. Locke said, these approaches also are working in places like the New Mexico Technology Corridor, the Arizona Bioscience Park in Tucson, Virginia Tech University's Institute for Advanced Learning and Research in Danville, and many other places around the United States. "For all the missed opportunities of the past decade, and for all the challenges of the present moment, there are great American success stories to tell," he said. "And every one of these success stories has a common theme: place matters."

Innovation clusters yield results because entrepreneurs, researchers, and innovators want to be around each other, Mr. Locke said. "They want to feed off the shared creative energy. They want access to a shared talent pool. They want to build relationships." If a local community can create the climate for innovation and build critical mass, then private investment will follow, he said. So will innovation and jobs.

Mr. Locke said there are numerous examples of innovation hotbeds, such as Rochester, New York; Dubuque, Iowa; Saginaw, Michigan; and San Jose, California. But clusters should not only be seen as belonging to a single city. Iconic zones like Research Triangle and Silicon Valley are regions, he noted. That is why Harvard Business School's Michael Porter began calling them "regional innovation clusters." In such regions, he noted, groups of companies, educational institutions, municipalities, and even state agencies work together to create the best possible business climate. "They work together because they are stronger that way," he said.

One problem is that most of the United States remains outside the borders of clusters. If one took a map of the United States and colored in all the established regional clusters, Mr. Locke observed, the clusters would be dispersed across the nation. But most of the U.S. map would remain white space. "These regional clusters aren't quite exceptions," Mr. Locke said. "But they're certainly not the rule."

To change this map so that innovative clusters spring up in new regions, there must first be consensus that the growth of such clusters are a national priority, Mr. Locke said. There also must be a commitment that regions be "dedicated to creating ecosystems where universities, venture capital, entrepreneurs and skilled workers are all amplifying each other's talents," he added.

At the federal level, "President Obama is doing just that," Mr. Locke said. At the Commerce Department, the Economic Development Agency is taking the lead. He noted that the President's 2011 budget includes $75 million for the EDA to implement a federal clusters strategy. "Region by region, EDA is helping to speed the transition to a more entrepreneurial, innovation-driven society," he said.

To fulfill this mission, the EDA is "fostering regional innovation that builds on an area's competitive advantages." The agency is "encouraging business exports and competitiveness in a way that leverages private investment."

Despite these federal efforts, Mr. Locke stressed that local governments must take the initiative in any cluster strategy. "Let me underscore how critical it is that regions take a leadership role in this process," he said. "The federal government can facilitate and encourage stakeholders to work together. But regions will know where their unique strengths and abilities lay." While the federal government can "shine a spotlight on the importance of clusters," he said, "it can't replace a region's knowledge of what it does best."

He cited New Orleans and New Mexico as examples of "how the federal government can support regional initiatives." The EDA "helped fund the New Orleans Regional Planning Commission's plan to link new medical research centers and a new bioscience district with medical centers at Tulane and Louisiana State University. New Orleans is not merely re-building from Katrina," Mr. Locke said. "It's redeveloping a large portion of the city into a world-class medical corridor."

In New Mexico, he added, the EDA is "working with a regional council to help create more robust alternative-energy production, grow artisanal manufacturing, and fund new micro and nano-engineering centers." "The genius of regional innovation clusters," Mr. Locke said, "is that different parts of the country can leverage their regional strengths to accomplish a common goal: creating well-paying, sustainable jobs and growing the country's economy."

"And at the end of the day, job growth is the metric that is most important to most Americans," Mr. Locke said. "It's the metric that is most important to the Obama Administration." He called regional innovation clusters a key part of the nation's long-term strategy for economic growth. Mr. Locke thanked the audience and said he looks forward to working with the symposium's participants in the years to come.

Panel V

Clustering Around the Lab—Best Practices in Federal Laboratory Commercialization

Moderator:
Jonathan Epstein
Office of U.S. Senator Jeff Bingaman (D-NM)

SANDIA NATIONAL LABORATORIES AS A CATALYST FOR REGIONAL GROWH

J. Stephen Rottler
Sandia National Laboratories

Over the past five years, Sandia National Laboratories in Albuquerque, New Mexico, has expanded its mission well beyond national security, said Dr. Rottler, Sandia's Chief Technology Officer and Vice President of Science and Technology. "We have built into that mission a significant leadership role in moving technologies from inside the laboratory into the economy," he said. Sandia has invested considerable time and effort to build partnerships well beyond its traditional relationships with the government and others involved in national security.

Dr. Rottler explained that Sandia began as a spinoff of Los Alamos National Laboratory in the late 1940s. It was then called the "Z Division." The lab began as a designer of nuclear weapons that went into the nation's stockpile. In the ensuing 60 years, Sandia's mission has evolved. Now it is a pre-eminent national security research and development institution with nuclear weapons as a core, defining mission. Its job is to take R&D and translate it into service for the country.

A decade ago, three-quarters of Sandia's $2.5 billion in annual revenue was devoted to nuclear weapons, Dr. Rottler said. Today, 50-60 percent of revenue is from what Rottler described as the "broader national security enterprise" in the United States. That mainly means developing technology and systems for the Department of Energy, Department of Defense, the intelligence community, and the Department of Homeland Security. "Energy security" is a particular focus.

The nuclear weapons program accounts for the other 40-50 percent of revenue and is the largest customer, Dr. Rottler said. It also continues to be the *raison d'être* of the lab, and "the reason why we are able to make broader contributions to national security."

Sandia has three overarching "strategic" or "corporate" capabilities in science and engineering, Dr. Rottler explained. They are high-performance computing and simulation, nanotechnologies and micro systems, and extreme environments. The government, and especially DoE/NNSA, has invested heavily in people and state-of-the-art facilities, some of which are unique to the Labs; These capabilities "cut across all mission elements at our laboratory," he said.

Below these capabilities, Sandia has six core "research foundations" that stem from investments over the years in a very broad and deep science and engineering base. Some date from the early days of the laboratory, while others are new:

- Computer science.
- Materials.
- Engineering sciences.
- Micro systems.
- Bioscience.
- Pulsed Power.

Sandia's entry into bioscience over the past five to seven years may seem a little far afield for an engineering laboratory, Dr. Rottler noted. But bio-fuels and bio-defense relate to its broader national security mission.

Twenty years ago, Sandia began to transfer technology from the lab to the economy, Dr. Rottler explained. Corporate partnerships have been a key part of that strategy. Among the companies with which Sandia has substantive relationships are Hewlett-Packard, Procter & Gamble, IBM, Corning, Intel, Lockheed Martin, ExxonMobil, and Goodyear. They began around 15 years ago as "technical exchanges," in which the federal government and companies both put in money.

The partnership with Goodyear has been one of the most durable. Sandia and Goodyear collaborated on computational simulation technology that Goodyear wanted in order to improve its tire design and its design and manufacturing processes. After six or seven years, "when Sandia proved it could add value to Goodyear," the relationship grew, Dr. Rottler explained. Goodyear uses Sandia simulation tools to design a wide range of tires.[44] Goodyear now fully funds the program and has invested $40 million over 15 years in research at Sandia.

[44]To read about the Sandia-Goodyear relationship, see Pete Engardio, "Los Alamos and Sandia: R&D Treasures," *BusinessWeek*, September 11, 2008, <*http://www.businessweek.com/magazine/content/08_38/b4100062751339.htm*>.

"Goodyear talks very openly about how the use of our technology has helped its business," Dr. Rottler said.

Sandia also engages in programs to contribute to development of New Mexico's economy. They include the Sandia Science and Technology Park; a small-business assistance program in collaboration with the state of New Mexico and Los Alamos National Laboratory; an "open campus" in Livermore, California, dedicated to green energy and transportation; and a program called Entrepreneurial Separation to Transfer Technology. This program supports Sandia employees who want to leave and start a new business, but also want to be able to return should the experience not work out.

The science and technology park has enjoyed considerable success, Dr. Rottler said. The park is a public-private partnership conceived 12 years ago. It now has 30 tenants and accounts for nearly 2,000 jobs in Albuquerque. The park's tenants include companies with names like Ktech, ATA, Poly-Flow Engineering, TEAM Technologies, and Emcore, some of which are spin-offs of the lab and that still collaborate with Sandia.

The jobs in the science park, moreover, pay salaries that are twice as high as the Albuquerque average. "For a state such as New Mexico, which still tends to rank at the bottom of many national statistics, this is something that the city, the county, the state, and our laboratory are quite proud of," Dr. Rottler said. The park has a "very aggressive" goal to account for 6,000 jobs 10 years from now. Construction has been under way at the park for the past 142 months, he added.

The New Mexico Small Business Assistance Program, established 10 years ago, is made possible by state tax credits, Dr. Rottler noted. Sandia and Los Alamos, which pay taxes on gross receipts, each get $2.4 million in credits to support small New Mexico businesses. The program allows small businesses with technical problems to come to the labs for assistance from staff.

The assistance program is credited with creating and retaining 1,020 small-business jobs across the state. One study estimated that the assistance program produced a return on investment for the state of $1.34 for every $1 in tax credits. The program has been so successful that a proposal by a legislator to eliminate the credit was defeated, Dr. Rottler said, despite the state's budget crisis. "The bill died without going to the floor."

Sandia and Lawrence Livermore National Laboratory are developing another regional cluster around their campuses in California, which have historically been dedicated to nuclear weapons and other national security work. Certain facilities will remain "inside the fence" and focus on national defense, Dr. Rottler said. Other facilities are being converted into an "open campus" that is a partnership between the laboratories and the city of Livermore. It will be devoted to industry partnerships in green transportation and renewable energy.

Dr. Rottler said the two labs developed their proposal to create the Livermore Valley Open Campus several years ago. Now it has gotten "sufficient support from the Department of Energy, so we are going forward with this," he said.

In early February, Sandia and Lawrence Livermore announced a tie-up with the city of Livermore to open an innovation hub for advanced transportation excellence, called i-Gate. The state will fund this research center, which will be a public-private partnership focusing on adapting green technologies to transportation.

Sandia also promotes entrepreneurship, Dr. Rottler said. The Entrepreneurial Separation to Transfer Technology program allows scientists to apply for "entrepreneurial leave" to help expand or start up a company. If the employee wants to return to Sandia for whatever reason within two years, the laboratory promises to find a similar job to the one he or she left. Usually, he explained, employees' spouses are more worried about the safety net than the employees. "They want to know that if the wild-eyed dream of their spouse doesn't work out, they have a job to go back to," Dr. Rottler said.

Since 1994, 138 scientists and engineers have left the laboratories in New Mexico and California to enter business. As a result, 91 companies have been started up or expanded, he said. At least 300 jobs have been created in the past five years, although Dr. Rottler said that number is probably an underestimation.

Solar-equipment manufacturer Emcore "represents the integration of all of the programs I am talking about today," Dr. Rottler said. In 1996, a group of Sandia scientists took entrepreneurial leaves to found a company called MODE, which specializes in photovoltaic applications for satellites. MODE was acquired by an out-of-state firm, Emcore, which moved its headquarters to the science park in Albuquerque. Emcore continued to license technologies from Sandia. After several expansions, it now employs 350 people. The company also receives help from Sandia's small business assistance program.

Sandia's experience shows that regional innovation strategies can work, Dr. Rottler said. "But there is also much that can be done at the national level," he said. He pointed to legislation in the U.S. Congress that would provide funds for national science parks.[45] The House bill was drafted by Representative Martin Heinrich (D-N. M.) and Representative Gabrielle Giffords (D-AZ). Dr. Rottler noted that the original science park legislation was drafted by Jonathan Epstein, the panel's moderator.

[45]H.R. 4413, the Science Parks Research and Innovative New Technologies Act, was introduced on January 12, 2010. It authorizes the Department of Commerce to offer $7.5 million in competitive grants for feasibility studies for development and construction of new science parks and expansion of existing ones. It also provides construction loan guarantees of up to 80 percent, with a maximum loan of $50 million per project. The companion Senate bill, S. 583, the Building a Stronger America Act, was approved in committee and attached to the America COMPETES re-authorization act in December 2010.

EXPLORATION PARK AT THE KENNEDY SPACE CENTER

Robert Cabana
NASA Kennedy Space Center

Mr. Cabana, director of the Kennedy Space Center (KSC) and a former astronaut, said the Kennedy Space Center has substantive innovative programs under way at the center.

Kennedy Space Center is mainly known as the launch site for America's human spaceflight programs, and since 1981, it has been the home base for the processing and launch of the Space Shuttle. The end of the Space Shuttle program, however, will have a significant impact on the center and its workforce.

Several budget provisions will help Kennedy Space Center commercialize technologies. Plans are to renovate the launch complex to support NASA's future exploration programs, as well as commercial space operations. The budget also provides funding to use the International Space Station as a national laboratory for researchers and for technology development. The center has great capabilities with commercial applications, he noted. "The question is: How do we tie all of this together, to where we can bring industry in and really make this beneficial to everyone?" Mr. Cabana said.

Kennedy Space Center has a history of developing projects that commercialize technology and promote innovation. Exploration Park, located on federal land that once was orange groves, is the hub of these efforts.

Exploration Park will support the commercial space industry and spin-offs in related technologies. The park is projected to have 5,000 technicians, engineers, and administrative support staff. It will benefit from "a really high-quality workforce that will be transitioning from the end of the Space Shuttle program to the future," Mr. Cabana said. The campus also is near the University of Central Florida, the third-largest university in the United States, with a "superb" engineering school. "If we can capitalize on universities, industry, and government partnerships with the state of Florida," he said, "it is amazing what we can accomplish. I think you get innovation by bringing people with diverse backgrounds together and offering them an environment where they can converse with each other and capitalize on what each other knows."

The anchor facility, the Space Life Sciences Lab, already is open. Because it is located inside the security gates of Kennedy Space Center, however, it is difficult for civilians, especially foreign nationals, to enter. Eventually, though, it will be accessible outside the gates of the space center. The 104,000-square-feet life sciences building has 25 fully equipped scientific laboratories with administrative and office support. It was built by the state of Florida in cooperation with NASA, Mr. Cabana explained. The lab will be turned over to the state, and NASA will lease any required space. The Brevard County government is funding design of a road that will bypass the secured perimeter so people can easily get to the park.

The space center is also helping NASA use the International Space Station as a national laboratory. The Space Life Sciences Lab already conducts research for the Space Station, Mr. Cabana noted. "If we really are going capitalize on the International Space Station as a national lab, why not use a facility like this to draw in industry and researchers to do that?" he asked.

The way to accomplish this is through partnerships, Mr. Cabana says. Even though it mainly is regarded as a launch center, he said, Kennedy Space Center has excelled at applied research and commercialization of technology. "Of all the NASA Centers, KSC has the highest percentage of executed licenses compared to patents issued for the last five years," he noted.

Prominent examples of the NASA Innovative Partnerships Program are:

- Lunar Analog Field Demo of ISRU[46] Lunar Prospecting. This is a partnership with Johnson Space Center, Glenn Research Center, Carnegie Mellon University, and the Pacific International Space Center for Exploration Systems run by the University of Hawaii. The program demonstrates systems for prospecting, mining, and developing natural resources on the moon using a simulation of the lunar environment.
- Desert Research and Technology Studies, otherwise known as Desert RATS. Based in New Mexico, this partnership with Johnson Space Center, Glenn Research Center, ASRC Aerospace Corp., Caterpillar, and the Colorado School of Mines demonstrates equipment for excavating lunar regolith, or the layer of soil and broken rock on the moon's surface, and lunar communication concepts.
- Light-emitting diodes (LEDs). The Kennedy Space Center is leading studies in LED lighting technology to help plants grow in controlled environments such as space. It also is studying LEDs in different frequencies that produce color and are found to have a direct influence on human performance. Such technology could adjust lighting for certain times of a day to help people work more efficiently, Mr. Cabana said. Although developed for space environments, the technology "has applications here on Earth," he said.
- Self-healing wire. This is a partnership with ASRC Aerospace Corp. One problem with the Kapton wiring in the space shuttle was that the insulation on the wires cracked as it aged, causing electrical shorts, Mr. Cabana explained. "Through microencapsulation,[47] we can have polymers that sense a break and then release polymers that help that wire heal itself," he said.
- Corrosion control materials. Working in a salty environment on the Florida Coast can be a real problem, he said. Through a partnership with PPG Industries and University of Texas Health Science Center, Kennedy Space Center is helping develop microencapsulated materials that inhibit corrosion in paint.

[46]ISRU stands for In Situ Resource Utilization Project. Its goal is to develop ways to use resources already on the moon to establish lunar habitats and sustain human life. See <*http://microgravity.grc.nasa.gov/Advanced/Capabilities/ISRU/*>.

[47]Microencapsulation is a process in which tiny particles are surrounded by a coating.

• Autonomous Flight Safety System. A partnership with Starfighters, Inc., Florida Institute of Technology and the Defense Advanced Research Projects Agency is developing flight termination range safety systems for commercial space flights.

• Monitoring of radiation damage to DNA. One problem of traveling long distances in space is dealing with radiation, Mr. Cabana said. This project is developing on-board biological instruments to detect radiation damage to DNA during flights.

• Dust mitigation. We have developed technology to clean dust and powder off of solar arrays used in space vehicles. A partnership with Florida Solar Energy Center is studying whether such technology would improve the efficiency of solar arrays on Earth.

There are several other industry collaborations that go beyond research and development. For example, the Kennedy Space Center is teaming with Florida Power & Light to install a 10-megawatt solar array facility, with capacity to expand. "If we do this right, we hope to attract solar array technology to the Exploration Park," Mr. Cabana said.

The space center also is working with Starfighters, Inc., a company that operates a fleet of F-104 jets[48] now used for training. In addition to using the planes as trainers for companies planning to offer commercial space flights, the company is working on autonomous range-destruct systems. Currently, humans must watch and track a rocket that is fired on a range, Mr. Cabana explained.

The NASA Innovative Partnerships Program provides bridge funding so that many new companies "can get going and progress," he added.

In short, Mr. Cabana said, "We really are doing all the right things." The Kennedy Space Center is well prepared for the future, he added. Having an Exploration Park adjacent to the Kennedy Space Center draws on research that NASA is already doing and makes profitable use of excess facilities as the space center makes a transition from the Space Shuttle program to the future. "It is the right time for this to happen," he said.

DISCUSSANT

Ken Zweibel
George Washington University

Mr. Zweibel began by drawing from his experience in technology development at the National Renewable Energy Laboratory (NREL),[49] where he had

[48]The Lockheed F-104 Starfighter is a single-engine, supersonic, interceptor jet used by the U.S. Air Force from 1958 until 1967. NASA used F-104s for test flights until 1994.

[49]Mr. Zweibel was program leader of the Thin Film PV Partnership Program at the National Renewable Energy Laboratory in Golden, Colorado, until 2006.

worked from 1980 through 2006, and prior to his current post as director of the George Washington University Solar Institute. That federal laboratory has a commercial mission, he explained, in that it develops new technology and then tries to see that it is successful in the U.S. market. Therefore, NREL is organized in a way that is not traditional for a national laboratory.

NREL used a model that essentially "reversed the technology-transfer idiom," Mr. Zweibel explained. Instead of the federal laboratory transferring technology to a private company, the lab supported companies that were leading their own R&D programs. This arrangement had the effect of eliminating confusion over whether the scientists' chief job was to do research for the government or for private industry. "The scientists were clear on the mission they were hired for, which was to support this kind of commercialization," Mr. Zweibel said. "They didn't have an issue with having a different mission or different view of themselves. So we were able to harness the personnel and the equipment to help move these technologies forward."

NREL helped universities, foundations, and companies develop proofs of concept for solar cells. The lab also had contracts with companies such as Uni-Solar, First Solar, and Sun Power "that now are the difference between the United States being a follower and being a leader in the world in terms of technology in photovoltaics," he said. Without that leadership, "we would have nothing in PV module manufacturing." Currently, Chinese-made crystal silicon photovoltaic products "are wiping the slate clean worldwide because of their low-cost advantage." The only reason the United States enjoys any edge in photovoltaics is technology that NREL helped nurture, he said.

NREL can be regarded as a success story for clusters, Mr. Zweibel said. Rather than being limited to a region, however, photovoltaic products are a national cluster. While there were several Colorado-based spin-offs from NREL, "that was just as accident because it was a national program," he said.

DISCUSSION

Mr. Zweibel began the discussion by noting that national laboratories don't have great reputations for commercialization. They do have reputations for performing their national security missions. "So why should the zebra change stripes now?" he asked.

Dr. Rottler responded that while he can only speak for Sandia, he thinks that leaders of all of the other labs would agree that "what they have and what they manage for the government represents a unique asset." He noted that many national labs were founded in the past 30 to 60 years with concrete missions. Sandia started with a focus on nuclear weapons but broadened in the 1970s to the energy program. In the past 10 years, it has widened its definition of national security, as have other labs.

"Each of these institutions recognized 20 years ago that in order to survive

they had to rethink the way they contribute for the country," Dr. Rottler said. Sandia decided it should move technologies into the economy.

For Sandia, the shift toward commercialization was a natural move, he said. The lab "really sits at the interface of research and application," he explained. "If you visit us and watch us, what you will observe is a pretty deep and broad investment in science, but an investment with an end in mind." Sandia also creates intellectual property that is useful for other applications. "So for us, we saw it as a strategic contribution we can make to the country in a way that not only can further the ambition and reputation of the laboratory but also expands our ability to have a high impact," he said.

He noted that Sandia's slogan, "exceptional service in the national interest," was taken from a letter President Harry Truman wrote to the president of AT&T in the late 1940s, when that company was asked to take over management of Sandia. It is hard to work at Sandia without having that concept "pretty deeply engrained into your DNA," Dr. Rottler said. "For us, we saw this focus on moving technologies into the commercial sector as a way to further provide exceptional service in the national interest. For national laboratories to continue to have relevance, I think it is necessary that they do so."

Mr. Cabana of the Kennedy Space Center sees himself as "a steward of a critical resource for our future, and I want to make sure that it is maintained so that we have the ability to explore."

Even though the International Space Station has only been functioning as a national laboratory for a year, when three more crew members were added, it already is making social contributions. Mr. Cabana said that as a result of research conducted on the station, scientists believe they may have discovered a vaccine for salmonella. Now that the station has six crew members, there is more time for dedicated research, he added.

Mr. Cabana said he wants to improve access to the space station. He wants the Space Life Sciences Lab to help develop experiments and host researchers who can work on microgravity environments and bring payloads into orbit.

The United States has to think about its role in space, Mr. Cabana said. Other countries highly subsidize their commercial space programs. "It is not a pure commercial effort," he said. "And I think we have a role to play to ensure that our commercial companies are successful."

Mr. Zweibel observed that when he was in a national lab, directions change when administrations and policies change in Washington. Even with the best of intentions, that can lead to dislocations at the lab. There also are complexities with the way Congress thinks and develops law. He asked Dr. Rottler and Mr. Cabana if lab management, the DoE, and other federal agencies fully support commercialization, or whether they get "mixed messages."

Dr. Rottler said he thinks the current Administration is very supportive of commercialization and moving research and development to the private sector. "For me, it's important for us to capitalize on that and use it to our advantage," he

said. It doesn't matter if administrations come and go. "If what you are doing is relevant, and you deliver a quality product at a fair price, you will continue to do what you do," he said. Whatever the lab does must be relevant for the future, critical to the nation's success, and present opportunities for growth. "If you structure yourself correctly, the right things are going to happen," he said.

Mr. Cabana said changes in administrations are a reality. "We accept those cycles as a natural part of our great republic, and what we try to do is sustain an institutional commitment to this," he said. "We think about our goal of moving technologies into the economy and ensuring our labs think more about how to use relationships and partnerships with other government agencies, industry, and universities to meet national priorities."

John Epstein, an advisor to U.S. Senator Jeff Bingaman (D-NM), was asked to give his opinion from the perspective of Congress on the national labs and their mission.

Mr. Epstein replied that one problem is that the DoE's approach to commercialization at federal laboratories has been disorganized. The 2005 Energy Policy Act[50] had several provisions to promote technology transfer by national labs, including appointment of a coordinator within the DoE. Mr. Epstein says he believes that person has finally been appointed. "So we have good hope," he said. "But as Reagan said, 'Trust but verify.'"

Senator Bingaman sees technology transfer by national labs as a "two-way street," Mr. Epstein said. Research parks can be built next to federal laboratories to help create clusters. While that is good, "at the end of the day it's important to look at the reverse osmosis," he said. "Many times these spin-off companies come up with good ideas outside the fence that then go back inside the fence." From the federal government's perspective, "it's important to have pretty free thinkers outside the fence so that they can expose the lab to fresh ideas."

Brian Darmody, president of the Association of University Research Parks, noted that not all national labs have good commercialization programs. Some, like Sandia, are privately managed.[51] Others, such as the National Institutes of Health (NIH), are government-operated and tend to be less flexible. He said it would be great if NIH had an entrepreneur leadership program such as the one at Sandia. Mr. Darmody asked what can be done to spread best practices between federal laboratories so that the $25 billion they spend on R&D is used more efficiently.

Mr. Epstein said the principle issue that must be considered is conflict of interest. The dilemma is that a federal employee "is working under the taxpayer's

[50]Title X, Sections 1001, 1002, and 1003 of the Energy Policy Act of 2005 (P.L. 109-58) contained several provisions to promote technology transfer and commercialization by federal laboratories, including establishment of a technology transfer coordinator at the Department of Energy, a working group of laboratory directors, an energy commercialization fund, a technology infrastructure program, and a small-business assistance program.

[51]Sandia National Laboratories is managed by Sandia Corporation, a company owned by Lockheed Martin, under contract with the DoE.

dollar and making decisions on how taxpayer dollars are spent." Although Mr. Epstein said he thinks there is support in Congress for the idea of letting federal researchers enter private industry, the issue must be managed very carefully. "The public puts trust in that employee," he said. While there is support at the policy level for the practice, he added, "the devil is in the details."

Dr. Rottler said that Sandia has managed to build sustained support for such practices from its main customers, the DoE and the National Security Administration. Sandia also has enjoyed strong support from its congressional delegation of two Senators and three U.S. Representatives. He noted that Mr. Epstein of Senator Bingaman's office has been very supportive and authored the legislation now before the Senate and House.

It also helps to have sustained leadership within the laboratory to support creative thinking, he added. "We started with a commitment to make this a part of the lab's strategy for the future," Dr. Rottler said. "But many of the things I showed you today were not part of some grand plan, where we said 20 years from now we want this, this, and this done." Rather, these programs evolved over time. Partnerships are the key. "It's about building relationships to help you think about creative opportunities, like we did with New Mexico." "It wasn't like we walked up to our state legislature and said, 'Hey, how about a tax credit of $4.8 million for two national laboratories that are fully funded by the federal government.' They had to see this was going to provide a positive return to the state."

Audience member Mary Ann Hammond of Business Oregon, the state of Oregon's economic development agency, commented that the state would like to expand its work with the Pacific Northwest National Laboratory (PNNL). "It is a key asset for us, but because it is funded by the feds and state funds are limited, it's tough not only to explain to legislators what the value prospect is, but also what we bring to the table when we meet with PNNL." She said that discussions generate "a lot of good feelings," but defining deliverables and how the partnership will work is difficult.

Mr. Zweibel offered some advice based on his experience at NREL. The lab dealt with the state of Colorado. The lab has "collaborative research agreements" with private companies in which both parties do research in their own labs in parallel. Neither the lab nor the companies give money to each other. One way to facilitate such a partnership is for the state to give money to one of the parties. "In that way, you have an in-state company that wants to do work in an area that seems important," he said.

At Sandia, Dr. Rottler explained, it was a matter of the laboratory going to the state and federal administrations with an idea. It requires commitment on both sides.

It helps to make such proposals during the high point of an economic cycle "because you are not struggling to make ends meet when you have to take a little bit of risk," he said. Also, he said such proposals have to be about a relationship,

not just a financial transaction. The state has to see some value in having a relationship with the institution, and the other way around.

The state must help financially, Dr. Rottler added. Each national laboratory is a full-cost recovery organization. "The federal government is not going to fund us to work for businesses in the state that are not consistent with the mission of the institution," he said.

Some government funding has been critical to developing partnerships with large corporations. Goodyear, for example, likely never would have entered its relationship with Sandia had the federal government not put in some money up front, he said. The funding helped give Goodyear time to understand the relationship and see what it could get out of it.

This is especially true for small companies. One example is the work Sandia has done for health spas in New Mexico. The spas are small businesses that take advantage of the state's natural resources. One spa in northern New Mexico had trouble maintaining the right temperature, Dr. Rottler explained. "They didn't have an understanding about how to engineer their system from a thermal management perspective," he said. Sandia provided an engineer who quickly corrected the problem and helped the business.

Dr. Rottler also cited Sandia's help for a small grower and processor of green chilies, a major crop in southern New Mexico. The company had a machine for cutting the stems off chilies that kept clogging and breaking down. "From an engineering perspective, it was not a great problem but for them it meant the difference between being solvent and insolvent," he said. Sandia assigned an engineer, who solved the problem.

Such companies cannot afford to hire Sandia, whose services are quite expensive, Dr. Rottler said. "Our people are highly paid, are some of the smartest people on the face of the earth, and have capabilities that exist only in our facility," he said. "The only way this happened was for the state to put money into it through the tax credit. Financial resources are a must."

One questioner noted that labs such as Sandia have contractual agreements with their contractors to be engaged in economic development. She asked whether national labs should be required to make development part of their mandate.

Dr. Rottler was cautious. "I am always suspicious of mandates, especially if they come to us in a way that is a bit orthogonal to the mission, the thing the government pays us to do," he said. "I also am very skeptical when they come to us without funding. That always leads to a dilution of mission. It results in the institution itself generally not being too enthusiastic, and as a result it often turns out badly for all involved."

On the other hand, he said, labs like Sandia recognize that, as institutions, they are quite well off now. They have large revenue streams, and their employees are relatively highly paid. "So we are extremely sensitive to not being seen as carpetbaggers," he said, as a federally funded institution that spends a lot of public money but whose staff just lives there and move on at the end of their careers.

It is important to be a contributing member of the community. While Dr. Rottler said Sandia believes economic development should be part of the lab's commitment, "how it gets funded and the terms and conditions around how that is created is a very sensitive issue because we don't want it to end badly. We want it to be successful. So we want it to be incentivized in the right way."

Dr. Wessner asked Mr. Epstein to assess the odds of congressional passage of the bills to promote science parks. Bills have floated around Congress in various forms since 2004, Mr. Esptein observed, before adding that "the climate for this is pretty good right now. It is just a question of the initiative of elected officials," he said. Legislators are very concerned now about the recession and creating jobs. Federal labs should show them how many jobs science parks create, he said, and bills should be attached to a larger legislative package, "as long as they are not extravagant."

Panel VI

University-Based Clusters

Moderator:
Brian Darmody
Association of University Research Parks

The Association of University Research Parks has been "into clusters before clusters were cool," noted AURP President Darmody, who also serves as Associate Vice President for Research and Economic Development for the Maryland university system.

The United States developed the world's first research parks, but is now losing its global lead, Mr. Darmody contended. He noted that China now has the world's largest research parks. While the United States once had one of the best university technology-transfer policies when the Bayh-Dole Act[52] was passed in 1980, the United Kingdom now says its technology-commercialization system is more efficient. The United States used to have the highest number of business start-ups per capita. Now that title belongs to Israel. The United States also once led the world in the best tax policies for corporate research and development. Now 17 other nations offer more generous tax breaks.

To support his argument, Mr. Darmody cited Commerce Secretary Gary Locke, who recently said: "America has a broken innovation ecosystem that does not efficiently create the right incentives or allocate enough resources to generate new ideas, develop those ideas with focused research, and turn them into businesses that can create jobs."[53]

[52]The Bayh-Dole Act of 1980 (P.L. 96-517, Patent and Trademark Act Amendments of 1980), or the University and Small Business Patent Procedures Act (P.L. 96-517, Patent and Trademark Act Amendments of 1980), gave universities control over their inventions stemming from federally funded research.

[53]From January 7, 2010, remarks by Commerce Secretary Gary Locke to the President's Council of Advisors on Science and Technology, Washington, DC, <*http://www.commerce.gov/NewsRoom/SecretarySpeeches/PROD01_008778*>.

The AURP has issued a new report on the topic called the Power of Place 2.0: The Power of Innovation.[54] Among the 10 steps for creating jobs and improving technology commercialization, the AURP recommends supporting research park infrastructure and developing "communities of innovation."

To improve technology transfer, the AURP also calls for reforming the federal grant and contract funding model of the Office of Management and Budget to encourage commercialization efforts by principal investigators. "If you are a principal investigator, there are a lot of accounting rules about what you can directly charge and what you can't charge," he said. "If we are really going to create the most efficient tech-transfer system, the first Valley of Death quite often takes place at the fence level, or with the principal investigators and their sponsors' programs offices." That system needs to be tweaked.

The AURP also calls for federal financial support for proof-of-concept work. Mr. Darmody noted that President Obama's proposed budget calls for such funding. He also supported calls for reviewing U.S. export controls, which often present problems for corporate and university research relationships. "If we can get the right set of export control rules, that will improve the amount of corporate and university research," he said.

Other recommendations include expanding the corporate R&D tax credit, eliminating IRS tests related to university licensing of intellectual property to corporate research in facilities funded by taxpayer bonds, and to include entrepreneurship programs in science, technology, engineering, and math (STEM) initiatives. Essentially, the term STEM should be expanded into STEEM, in order to include the word "entrepreneurship," he said. "We need to embed entrepreneurship in all of our projects and policies."

Mr. Darmody concluded by noting that the AURP also is working for passage of federal legislation aimed at promoting science and research parks.

CURRENT TRENDS AND CHALLENGES IN UNIVERSITY COMMERCIALIZATION

Ashley J. Stevens
Boston University
and Association of University Technology Management

While explaining that he does not have all of the answers to improving university technology transfer, Dr. Stevens, president-elect of the Association of University Technology Management (AUTM), said he could highlight many of the problems with current systems.

[54]Brian Darmody, *The Power of Place 2.0: The Power of Innovation—10 Steps for Creating Jobs, Improving Technology Commercialization, and Building Communities of Innovation,* Tucson: Association of University Research Parks, March 5, 2010, <*http://www.matr.net/article-38349.html*>.

One reason it is possible to assess university technology-transfer programs in the United States, Dr. Stevens said, is that schools are extremely transparent. AUTM has abundant data going back to at least 1991. "We bear our souls," he said. "Unlike some countries, like the UK, each individual institution reveals its performance on technology transfer." One can learn how many licenses each university issued and the income it earned, for example. "You cannot go see what the University of Oxford did."

Dr. Stevens explained that AUTM, an association of university technology-transfer managers, operates "at the cultural interface between the not-for-profit educational world of universities and the for-profit world of companies that take our technologies and develop them." He joked that the technology-transfer experience reminds him of the song-writer Tom Lehrer in the 1950s, "who quite elegantly talked about sliding down the razor blade of life."[55]

To illustrate how little has really changed in the debate over U.S. competitiveness over the decades, Dr. Stevens displayed a cover story from *BusinessWeek* magazine published in April 1992 titled "Industrial Policy: Is It the Answer?"[56] The cover language said: "The very phrase rattles the teeth. It implies bureaucracy. It suggests government will pick winners and losers. If done badly, it will certainly hurt America. With the Cold War over, and the global economy taking shape, America needs to shore up its competitiveness." It was a "grim call to arms," Dr. Stevens noted. "But not something that actually happened."

Just six months later, *BusinessWeek* published another cover story called "Hot Spots: America's New Growth Regions."[57] He noted that many of the so-called "hot spots" on *BusinessWeek*'s map had names like "ceramics corridor" in New York and "laser lane" in Florida. A large map of hot spots inside the magazine did not include Boston's Route 128, Silicon Valley, or North Carolina's Research Triangle Park. This article, Mr. Stevens observed, proved to be remarkably prescient. A table in the article highlighted what were regarded at the time as some of the key ingredients of a high-tech cluster. They included:

- A major research university.
- Quality of life.
- Building on local industry.
- Cooperation between local universities, business, and government.
- Technology transfer from the university.
- Funding sources—state, venture capital, angels, and incubators.

[55]From "Bright College Days" that appeared on the 1958 album "An Evening Wasted with Tom Lehrer." Lyrics can be founded on Wikilyrics.com at <*http://wikilyrics.net/song/892258/Tom-Lehrer---Bright-College-Days-Lyrics*>.

[56]*BusinessWeek*, "Industrial Policy," April 4, 1992, pp. 70-77.

[57]Kevin Kelly, "Hot Spots," *BusinessWeek*, October 19, 1992.

Dr. Stevens said the article was the first to put university research-led clusters in the public consciousness. It also described the development process that since has been widely embraced: Start-ups emerge, divisions of major U.S. companies and foreign companies move in, and export-led growth takes off. "This was the formula and package, and I think we have only seen these predictions borne out in the subsequent 20 years," he said.

The emergence of the pharmaceutical industry in Massachusetts is one of the most stunning examples of university-led growth, he said. The Boston area has a major concentration of pharmaceutical R&D, biopharmaceutical manufacturing, and related industries. Back in 1971, the only major operation of a pharmaceutical company in the state was the U.S. headquarters offices of Astra ABA, which had very little economic impact.

Everything that followed was the result of spin-offs of the University of Massachusetts, MIT, Tufts, Harvard University, Boston University, and so forth. The other driver was the Massachusetts Biotechnology Research Park, which the city of Worcester put next to the University of Massachusetts Medical Center. The first big tenant was Germany's BASF, whose facilities were later acquired by Abbot Labs.

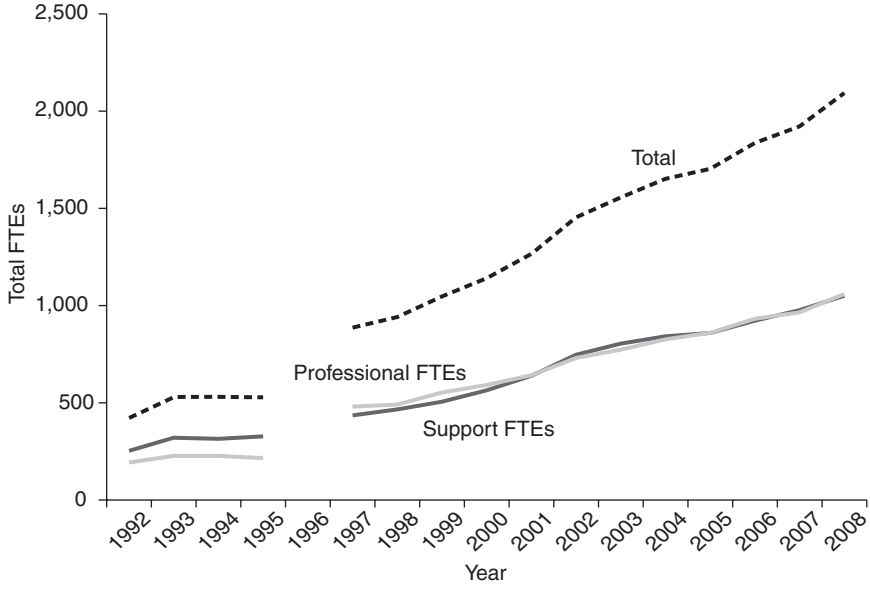


FIGURE 16 U.S. technology transfer employment.
SOURCE: Ashley J. Stevens, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

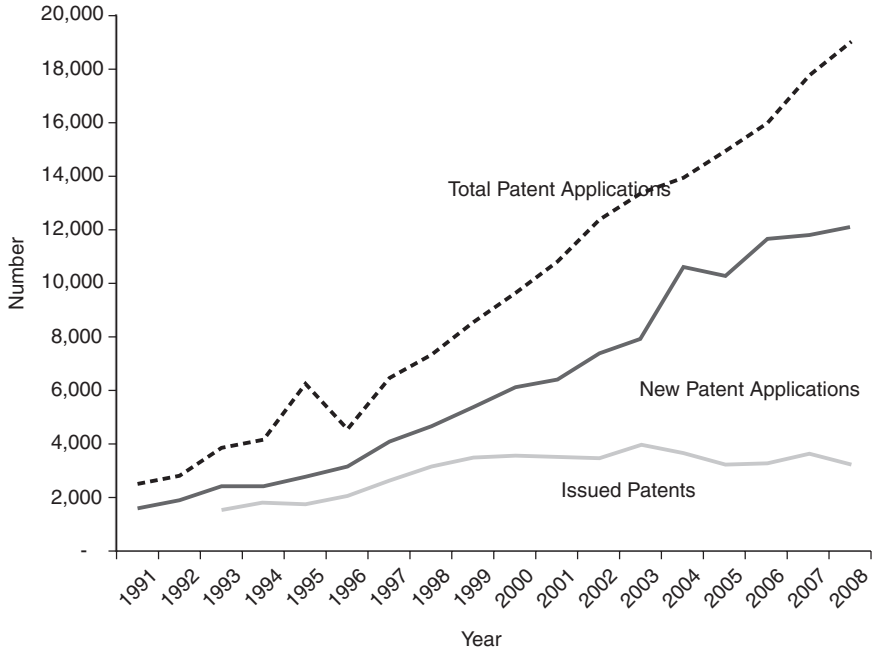


FIGURE 17 U.S. patent activity.
SOURCE: Ashley J. Stevens, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

Fast forward to 2009, and the Boston area now is home to operations of the Who's Who of the pharmaceutical world. They include Amgen, Biogen IDE, Genzyme, Astra Zeneca, and GSK. "This has been a stunning example of the power of university spin-outs coming out at the right time," Dr. Stevens said. The arrival of biotechnology tools caused dislocations in the industry, and "Massachusetts just happened to be very fortunately poised with venture capital and a highly networked city."

Dr. Stevens then turned to an analysis of technology-transfer trends at U.S. universities based on AUTM data. The analysis reveals mixed success over the past two decades.

On the positive side, Dr. Stevens noted, there have been sharp increases in technology-transfer activity. The number of inventions publicly disclosed by universities surged from 5,000 in 1991 to around 20,000 in 2008. The number of technology-transfer employees at U.S. universities has more than doubled, to around 2,000, since 1997. There also have been sharp increases in new patent applications by universities and licensing revenue. Spending by universities

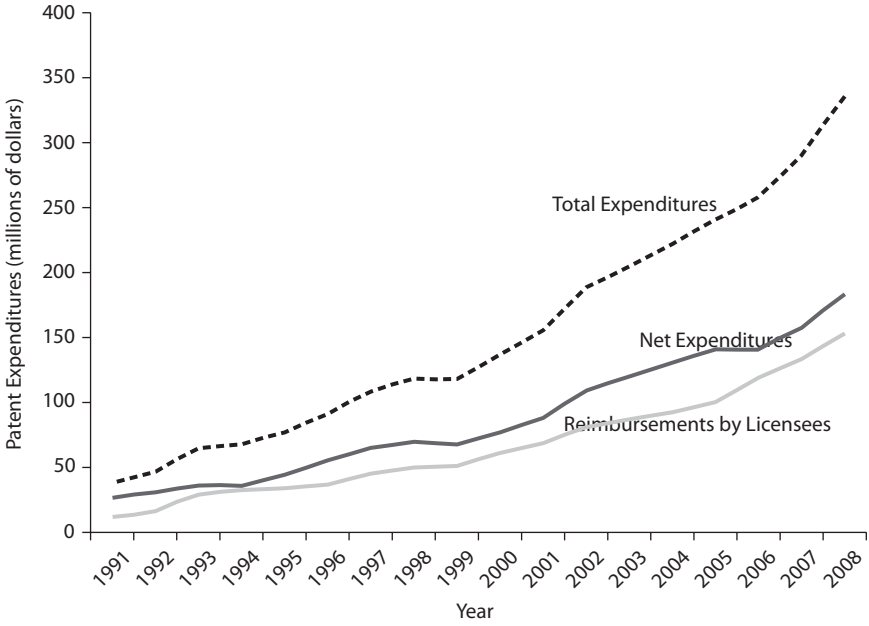


FIGURE 18 Patent expenditures.
SOURCE: Ashley J. Stevens, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

aimed at turning scientific research into intellectual property that can be licensed by corporations also has surged. Net expenditure rose from less than $50 million in 1991 to around $180 million in 2008.

When one examines actual results, however, the picture is far less impressive. The number of new patents actually awarded to universities has "distinctively flattened out" since 1998. He offered several possible reasons. One is that the U.S. Patent Office has become less liberal in awarding patents. The Supreme Court case KSR vs. Teleflex[58] also may have reduced new patents. Another factor could be limited personnel devoted to commercializing university discoveries. Even with the sharp increases in staff, there are only 1,000 full-time employees managing technology-transfer activities at all American research facilities, which Dr. Stevens described as "a very thin base."

[58]In KSR International Co. v. Teleflex Inc., 550 U.S. 398 (2007), the U.S. Supreme Court ruled that a patent by Teleflex was not enforceable on the grounds that its process was obvious to a "person having ordinary skill in the art."

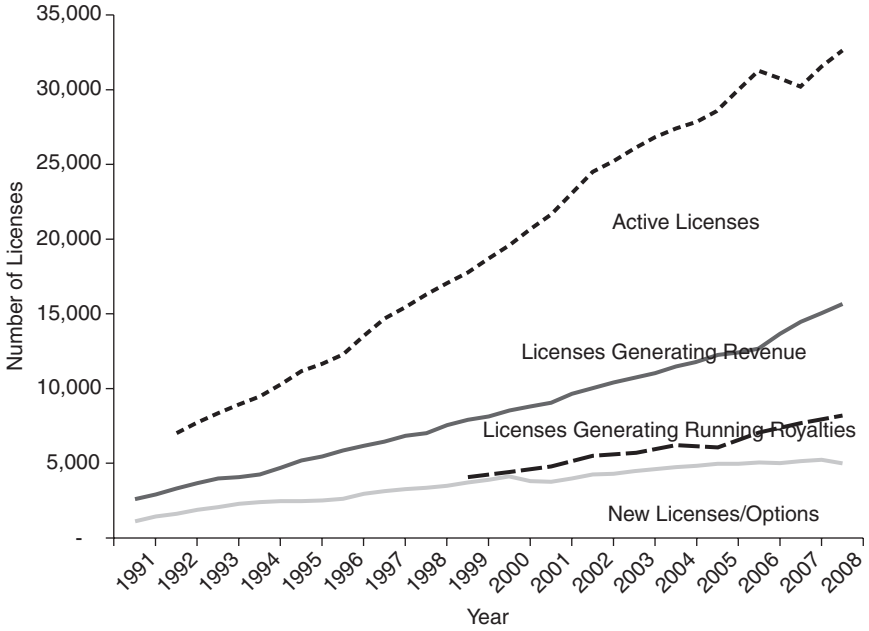


FIGURE 19 Licensing activity.
SOURCE: Ashley J. Stevens, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

The AUTM asked universities to break down their patent expenditures as a percentage of their total technology-transfer operating budgets. It found that universities spend roughly the same amount of money filing for patents as they spend on people. The survey also revealed that universities devote only 0.59 percent of their research budgets to technology-transfer activities and on protecting patents. Dr. Stevens called that proportion "amazingly low."

The AUTM also discovered interesting trends in university licensing activity. Since 1991, the number of active licenses has skyrocketed from around 7,000 to more than 30,000. Licenses that generate revenue—meaning royalties universities collect on products in the market—have more than tripled to 15,000. However, the number of new licenses has remained at around 5,000 per year for a decade.

Start-up trends also are revealing. The number of companies launched by AUTM members rose from 200 a year in 1994 to nearly 600 in 2008. However, there is much room for productivity improvement. Of the 19,554 invention disclosures by universities last year, 59 percent resulted in U.S. patent applications. That means more than 40 percent "never made it out of the lab," he observed. Just 26 percent led to signed licenses, and only 16 percent to U.S. patents issued.

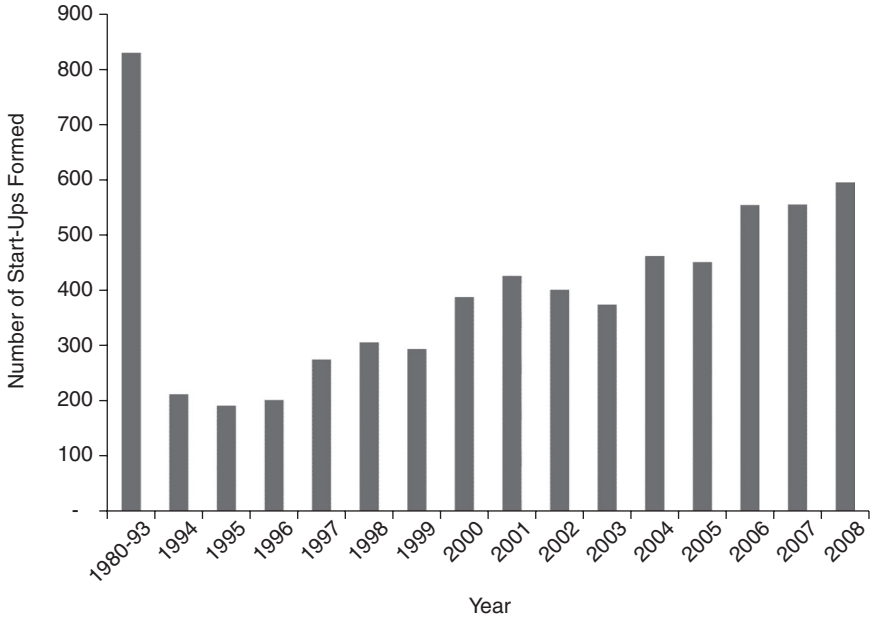


FIGURE 20 Start-ups formed.
SOURCE: Ashley J. Stevens, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

Furthermore, only 3 percent of those inventions led to the formation of companies. "You are beginning to get a sense of the Valley of Death at this point," Dr. Stevens said. "So why is it so hard? Why are so many of the babies ugly, as we say in the tech-transfer profession?"

One might think that bigger institutions with bigger research budgets have a huge advantage, he noted. But when one drills in the AUTM data, one finds performance levels are fairly consistent. The medium success rate for all institutions is 21.7 percent, Dr. Stanley noted. Those with annual research budgets of more than $200 million are only marginally more successful, at 22.9 percent. Stanford's success rate is 24.3 percent, and MIT's rate stands at only 18.8 percent.

How can this record be improved? Several strategies are being tried, again with mixed success. He noted that Research Corporation Technologies, based in Tucson, has agreements with many universities to develop their technologies. The organization accepted 228 inventions from 1991 through 2008, about 13 per year. Despite being highly selective, only 29 percent of these inventions led to licenses. "Not a whole heck of a lot better," he said.

Another idea is for universities to make inventions "less embryonic" before

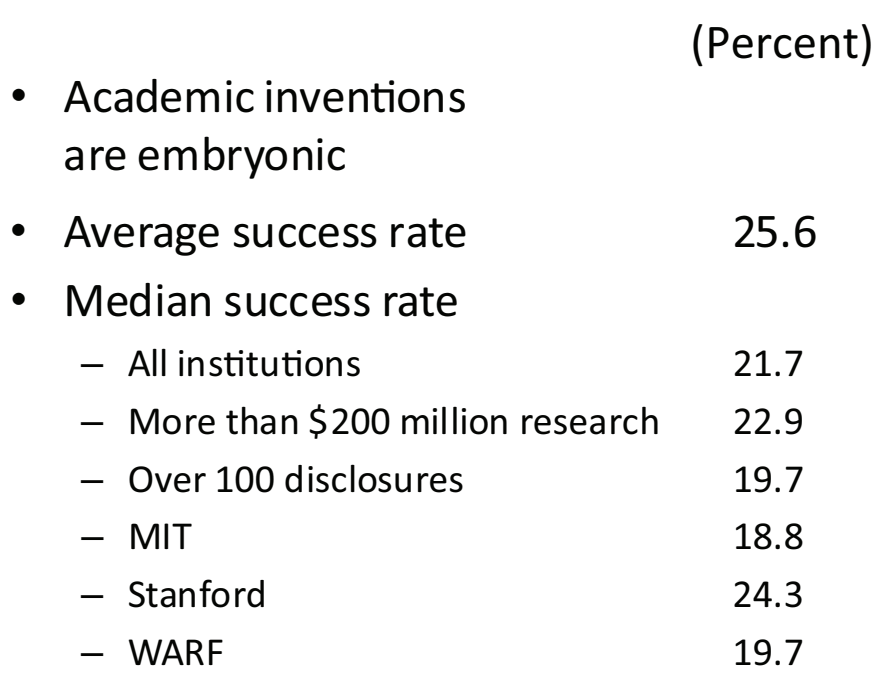


FIGURE 21 Why is this so hard?
SOURCE: Ashley J. Stevens, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

seeking capital, such as by investing more in developing proofs of concept. That is the idea behind several "translational research" centers established by foundations at big research universities. MIT's School of Engineering, for example, has the Desphande Center,[59] which has full-time staff that help fund and guide start-ups. Another is the von Leibig Center[60] at the University of California-San Diego's Jacobs School of Engineering. Both centers offer seed funding and professional advisory services.

Based on their publicly disclosed data, however, it is not clear whether these centers are more successful. A Kauffman Foundation study found that von Liebig commercializes around 24 percent of projects it takes on, Dr. Stevens noted, while the Deshpande Center commercializes 16 percent. Their combined success

[59]The Deshpande Center for Technological Innovation was founded in 2002 with a $20 million donation from Jaishree and Desh Deshpande, co-founder and chairman of Sycamore Networks Inc. Its mission is to provide a sustainable source of funding for innovative research and guidance to help MIT discoveries reach the marketplace.

[60]The William J. von Liebig Center for Entrepreneurism and Technology Advancement was founded in 2001 with a $10 million gift from the William J. von Liebig Foundation.

rate is similar to the average for all university technology-transfer programs.[61] One difference, he noted, is that some spin-offs from these centers have raised substantial investment.

Universities have been able to sharply boost the revenue they receive from inventions, the AUTM study showed. Since 1996, total income has soared by nearly seven-fold, to almost $3.5 billion a year. Running royalties have risen sharply and account for most of that. Very little comes from sales of stock, he noted, "despite all of the anguish over conflict of interest over the years."

Perhaps the most important question for universities is whether technology-transfer offices really pay off. One objective, after all, is to make university research financially self-sustaining by selling intellectual property. Dr. Stevens said he was "shocked" to find that 52 percent of the 130 technology-transfer programs studied lose money for their universities. Another 20.8 percent reported they earn a gross profit. Only half of those make a net profit. Nor do universities make much money by selling stock they hold in start-ups. Only 16.2 percent reported that their programs are financially self-sustaining, meaning they do not depend on the university operating budget to remain in operation. One big reason is that technology-transfer offices get only a portion of licensing revenue to offset their expenses. Still, "the results were a lot worse than we ever expected," he said. "This raises the question: Why?"

Part of the explanation is that tech-transfer remains a business driven by a very few "big hits," especially in the drug-research field. The U.S. Food and Drug Association approved only 153 drugs, vaccines, biologics, and *in vivo* diagnostics between 1985 and 2009, Dr. Stevens noted. Northwestern University was fortunate enough to earn $700 million by selling an interest in royalties it receives from its 50 percent interest in Lyrica, a popular drug used to control seizures and nerve pain, in December 2007. Such big hits are rare. Only 198 of 15,498 income-generating licenses in 2008 generate more than $1 million in proceeds.

Dr. Stevens raised the question of whether the Bayh-Dole Act was flawed because it was an "unfunded mandate." Originally, the act called for financing tech-transfer activities through indirect cost payments, but the funding was never appropriated. Administrative costs at university research programs, what's more, are capped at 26 percent.[62] "It certainly has turned out to be a longer timeline to sustainability than we ever expected," he said.

Dr. Stevens recommended several improvements. He endorsed the idea of having entrepreneurial post-doctoral fellowships for graduating Ph.D. students or current post-docs who want to commercialize the scientific research they work

[61]For an analysis of the Desphande and von Liebig centers, see Christine A. Gulbranson and David B. Audretsch, "Proof of Concept Centers: Accelerating the Commercialization of University Innovation," Ewing Marion Kauffman Foundation, January 2008, <*http://www.kauffman.org/uploadedFiles/POC_Centers_01242008.pdf*>.

[62]In 1991, the Office of Management and Budget directed that universities could be reimbursed for no more than 26 percent of research grants for administrative costs.

Financial Contribution	Number	Percent
Loss making	68	52.3
Gross profitable	27	20.8
Net profitable	14	10.8
Self sustaining	21	16.2
Total	130	

Source: Abrams, Leung & Stevens, 2010

FIGURE 22 Financial performance.
SOURCE: Ashley J. Stevens, Presentation at February 25, 2010, National Academies Symposium on "Clustering for 21st Century Prosperity."

on. Such fellowships could be awarded for two years through a state-wide selection process with competitive peer review. Funds would be used for proof-of-concept experiments and developing business plans. Such fellows should either be at a university that has a business school or that has a relationship with one, he said. Schools also should be required to have a business mentorship program. Dr. Stevens said the federal government should fund such a concept.

IMPROVING THE UNIVERSITY MODEL

Aris Melissaratos
Johns Hopkins University

Mr. Melissaratos, a former Westinghouse Electronics executive who now leads the technology-transfer program at Johns Hopkins University, said that "it is time to make technology transfer and innovation a national priority" in the United States. He noted that in his book, *Innovation: The Key to Prosperity*,[63] he

[63]Aris Melissaratos and N. J. Slabbert, *Innovation: The Key to Prosperity—Technology and America's Role in the 21st Century Global Economy*, Washington, DC: Montagu House, 2009.

has made the case why a national push at the presidential level in technological innovation is critical for the U.S. economy.

Mr. Melissaratos joined Johns Hopkins in 2007 after serving as secretary of economic development for the state of Maryland. During that period, he said he "learned that the current way we play economic development games among the states is about trying to steal somebody else's company and providing more funds than the next state over is willing to provide. It's kind of a lose-lose game."

The best place for states to invest economic-development dollars, he argued, is the university system, which generates new companies and leads to "strategic economic development." When he worked for Maryland, the state put almost 90 percent of its economic-development budget into universities and research programs. Most were connected to the National Institutes of Health, the Food and Drug Administration, and the military. As a result, Mr. Melissaratos said, Maryland has a diversified base of science and industries, such as biotechnology, defense, aerospace, and information technology. "Maryland itself is a research state," he said, receiving more research grant money per capita than any other.

University technology-transfer efforts in the state have lagged, however. Johns Hopkins, for instance, ranks as the nation's top research university, with a $1.6 billion annual research budget. It is the biggest recipient of grants. But Johns Hopkins "is not anywhere near the top in technology commercialization," he said. "In fact, research commercialization was an anathema among our faculty." They are interested in research and what makes nature tick. "At Stanford University, it is said anecdotally that faculty don't get tenure unless they start one or two companies and take one or two public," Mr. Melissaratos said. "At Hopkins, you are not even thought of being capable for tenure if you even thought about starting a company." Former Johns Hopkins President Bill Brody recruited Mr. Melissaratos to change that culture.

As a Johns Hopkins alumnus, Mr. Melissaratos said he had a deep understanding of the university's culture, and was determined to change its attitude toward technology transfer "while fully respecting the research excellence that had been our motto." At about the same time, Johns Hopkins had received funding to start a business school. Several times in the past, the school's trustees had rejected such offers, including a $50 million offer that Michael Bloomberg is said to have made in the 1990s. Now, the Carey Business School has been launched at Johns Hopkins. "That gives us an ingredient we didn't have before," he said. The school plans to teach entrepreneurialism to researchers.

The greater effort in commercialization is paying dividends. From 1998 to 2008, Mr. Melissaratos said, Johns Hopkins was spinning off four companies a year on average. In the past two years alone, 22 companies were launched that brought in $89.5 million in venture investment.

He said all royalties Johns Hopkins received in fiscal year 2008 were used to encourage professors to tap their contacts in the venture capital industry. Johns Hopkins has helped launch start-ups all over the country. It also has increased its

annual licensing revenue, from $9 million in 2008 to $12 million in 2009. That is still a far cry from other universities, according to data published by the *Chronicle of Higher Education*, he noted. Johns Hopkins "is still waiting for our first big hit." He said he thinks that hit will come from oncology or brain research. The National Cancer Institute recently announced it will build a 500,000-square-feet headquarters building at its Montgomery County campus.

Johns Hopkins also now has a research park. A 300,000-square-feet building on campus is nearly filled with researchers and several start-up companies. The oncology center will expand Johns Hopkins' core strength in life sciences, which consume 93 percent of research spending at the university.

The university leadership now is fully behind such university-industry collaboration. "We want every professor, every researcher, every department head, and the deans of every school to be interested in and applaud the current change in attitude," Mr. Melissaratos said. "We are open for business. We want to facilitate the process, not throw legal and bureaucratic barriers in the way of progress." He added that the university is training its researchers "in all of the ways that Silicon Valley and Route 128 have done," such as with events to match scientists up with entrepreneurs.

Mr. Melissaratos then turned his attention to national issues. He argued that the United States needs a national strategy for promoting innovation and upgrading its global competitiveness. There has been talk about science and technology education year after year. "It is time we get it done," he said. Science and technology education must improve. Standards should be implemented, and "we should forget about social promotion in our schools," he said. "Our only strength in the global economy is our innovation and research at universities," Mr. Melissaratos said. "To improve, we need to create an environment that promotes innovation."

Greater investment in infrastructure also is needed. "This country is a couple hundred years old, and it shows it," he said. "Innovators like to be involved at the latest state of the art. So we should put in new infrastructure faster than the developing countries." The United States must make broadband available everywhere, install smart grids that moves electricity from wherever it is generated to the users, and build modern transportation systems. "Our top 30 metropolitan areas need to have world-class public transit systems," he said. "It ought to be a national priority." Mr. Melissaratos called for augmenting or replacing the highway system with a North American network of Maglev[64] trains that whisk passengers "from Halifax to Miami, from Anchorage to Vancouver to Mexico City and maybe down into South America."

Other national priorities should include self-sufficiency in energy, which is also a business opportunity. Mr. Melissaratos said he believes nuclear power is the only alternative energy that can be scaled up quickly enough to meet the

[64]"Maglev" refers to magnetic levitation. Maglev trains are lifted and propelled by a system of magnets and have reached speeds of up to 361 miles per hour in Japan.

nation's needs and address climate change. The United States should license 20 new nuclear power plants instantly "to give this country a chance to build the capability to build nuclear power plants."

If the United States has a long-term commitment to infrastructure, that also will bring back a distributed, heavy manufacturing base, Mr. Melissaratos predicted. "This is something we don't have today. We are becoming a prototyping economy." America once was the world's leading manufacturing power, and served as an outsourcing location for Europe for decades.

America has a huge opportunity to move the nation forward, Mr. Melissaratos said. To achieve such an agenda, however, America needs to unleash creators of technology that are being held back by bureaucracies.

BUILDING NEW GROWTH CLUSTERS

James Clements
West Virginia University

West Virginia University (WVU) is pursuing a number of different strategies to advance innovation clusters in the state, said WVU President Clements.

The first method is what Dr. Clements described as a "single-source technology transfer model." In this model, basic research leads to applications that can be commercialized. Then, new businesses spring up and expand. In many cases, this process can begin with a single faculty member with an idea who pushes it forward. Start-ups by other faculty follow, forming a cluster. "It is typically a fairly linear process and can sometimes be quite by happenstance." He noted that an Arizona State University study characterized such an approach as "the single scientific moment that can define the beginning of an industry."[65]

A good local example of this model at work at WVU is Protea Biosciences,[66] which has developed and commercialized technologies to discover new proteins in human blood and tissue samples. After the technology was developed in WVU labs, a faculty member co-founded the company at WVU's Business Incubator. Protea then moved to its own office space in Morgantown, West Virginia. Protea is expanding its product portfolio and global network and is "getting ready to do some really, really cool things," Dr. Clements said. It continues to collaborate with researchers at WVU's nearby health care-related companies.

The success of companies such as Protea provide graduates and faculty

[65]"Universities and the Technology Intensity of the Local Workforce: Evidence from Metropolitan and Micropolitan Areas," November 2009 report from the Productivity and Prosperity Project (P3), an initiative supported by the ASU Office of the University Economist. The quote appears on page 4 of the report.

[66]Protea Biosciences Inc., based in Morgantown, West Virginia, manufactures products that help companies obtain protein mass spectrometry data from biological samples. See <*https://proteabio.com/*>.

opportunities to remain in the region, in turn helping the region move toward a more knowledge-based economy, Dr. Clements said.

A second cluster model involves taking advantage of location by leveraging local assets, needs, and companies. West Virginia is developing an innovation cluster based on its traditional endowments of natural resources such as coal, timber, and gas. "To sustain that development, innovation is absolutely critical," he noted. More than 100 faculty researchers in West Virginia work on advanced energy projects, such as liquefied coal for transportation fuel, environmentally safe access to natural gas reserves, and carbon sequestration. WVU also takes advantage of its proximity to two major research universities, Carnegie Mellon and the University of Pittsburgh, and the Department of Energy's National Energy Technology Laboratory.

One key to building a cluster is to coordinate all of these research activities, Dr. Clements said. "An ad-hoc series of projects is good, but when not properly coordinated, you don't get to leverage them." So recently, the university organized an Advanced Energy Initiative that puts a framework around that research. The program is off to a good start, and has a full-time director who is helping form partnerships with other universities, industry, and government. The initiative also has an advisory board of industry experts.

To bring all of these regional resources together, an alliance has been formed called the Regional University Alliance (RUA) program. In addition to WVU, the University of Pittsburgh, and Carnegie Mellon University, the alliance also includes Virginia Tech and Penn State. The Alliance was part of a team that recently won an approximate $435 million contract to work on energy projects with the National Energy Technology Lab (NETL).

Other assets for the cluster include the National Research Center for Coal and Energy, which facilitates research partnerships around the country and abroad and is based at WVU. The center has several coal-related partnerships in China, for example. West Virginia has also created a trust fund modeled after Kentucky's Bucks for Brains[67] program that allows WVU and Marshall University to recruit scientists that aim to commercialize their research in energy and other fields.

A third innovation cluster strategy used by WVU is "targeting and creating," Dr. Clements explained. It involves identifying a technology niche and going after it. The biometrics cluster in the Morgantown region is an example of this method. WVU has "a lot of really big stuff going on" in biometrics," Dr. Clements said.

Since the September 11, 2001, terrorist attacks, federal law-enforcement agencies have become especially interested in technologies that can be used to identify individuals through distinguishing biological traits. West Virginia has a

[67]The West Virginia Research Trust Fund, also known as Bucks for Brains, is a $50 million endowment established in 2008 by Senate Bill 287 that is to be matched by private contributions. West Virginia University and Marshall University are to use the funds to recruit research scientists that intend to commercialize their work.

history of more than 40 years in biometric identification,[68] Dr. Clements noted. Recently, WVU become the main academic partner with the Federal Bureau of Investigation's (FBI's) Biometric Center of Excellence, which is especially active in border-security technology. WVU established one of the nation's first degree-granting programs in biometrics.

WVU is also a founding and lead partner for the CITeR,[69] a National Science Foundation center for identification technology research. Twenty affiliates have operations close to the center, including Booz Allen Hamilton, Northrop Grumman, Lockheed Martin, and Raytheon.[70]

CITeR also works with agencies such as the FBI, Department of Homeland Security, the Federal Aviation Administration, and the National Security Agency. Some people regard CITeR as the most successful NSF center in the country, he said. CITeR established a second site for credibility assessment at the University of Arizona. A third is planned at Clarkson University in Potsdam, New York.

CITeR promotes cluster-building by offering "very cost-effective research," Mr. Clements said. It offers its partners access to research at a broad spectrum of research laboratories across the country, helps form inter-disciplinary faculty teams, and facilitates interaction among federal agencies.

Now that West Virginia's biometrics cluster has critical mass, "more companies are coming in, and more people want to connect with our researchers and students," Dr. Clements said. The University is working with the Department of Defense to develop algorithms to measure the iris, for example, and on biometric fusion algorithms. These programs already are generating spin-off companies, he added. Among WVU's more distant partners is Michigan State University, which is teaming up to develop automated systems to help federal agencies identify individuals on the basis of scars, marks, and tattoos.

In summary, Dr. Clements said that WVU's experience highlights three methods for building innovation clusters: Leveraging faculty discoveries, capitalizing on regional assets, and picking technological niches.

DISCUSSION

Mr. Darmody observed that many regional cluster strategies are premised on federal R&D. With the prospect of looming budget deficits, he asked whether

[68]For a concise history of the development of West Virginia's biometrics cluster, see Kim Harbour, "WV Biometrics: Fertile Ground for Innovation," on West Virginia Department of Commerce Web site, <*www.wvcommerce.org/business/industries/biometrics/fertileground.aspx*>.

[69]CITeR stands for the Center for Identification Technology Research is a Industry/University Cooperative Research Center funded by the National Science Foundation. The center was founded by West Virginia University and is the I/UCRC's lead site for biometrics research and related identification technologies.

[70]Biometrics is the use of science and technology to measure and statistically analyze biological data.

federal investments in R&D may decline and what opportunities universities have to expand their regional cluster activities in such an environment.

Actually, funding numbers remain fairly constant over the years, Dr. Stevens observed. Over 20 years, federal spending has remained at about two-thirds of total R&D spending in the United States. Industrial spending has ranged from as high as 9 percent, but has been fairly static at 7 percent for the past four or five years. "So I think we will depend on federal funding to continue to grow, and with the decline in asset values in endowments I'm not sure I can see a lot of money from philanthropy at this point," he said.

Mr. Melissaratos commented that he thinks the nation must triple its investments in R&D. "We must get there," Melissaratos said. "If you look at the amount of money that has gone into special projects like saving the financial industry and saving the auto industry, tripling basic research at the national level is a small investment to make." He added that the stimulus package had $11.1 billion in research funding for NIH, $3 billion for the National Science Foundation, and around $1 billion for NIST, numbers that are admirable. Previously, Mr. Melissaratos said, a top presidential advisor had said the Administration was not going to put more money into research because he didn't believe such funding can be sustained. "We must sustain it," he said. "That's the best investment in the future we can make."

Mr. Darmody noted that Maryland universities were very happy that Mr. Melissaratos put a lot of research money into universities when he was the state's economic development director. "It turned out to be a model that worked very, very well," he said.

Dr. Wessner questioned whether a big increase in federal funding for basic research alone can address America's immediate economic challenges. "We need to do a better job of capitalizing on our existing investments in research now," he said. Indeed, "the rest of the world is creating jobs, creating growth, and increasing their national capacity by using the research that is already out there," he observed. He noted that successful strategies such as those pursued by Morgantown, West Virginia, are based on drawing federal programs to their areas and creating jobs and technical capabilities on the basis of existing research.

Dr. Wessner also noted that Dr. Stevens of AUTM showed that three different ways of doing technology transfer all result in success rates of only around 20 percent. "So why the basic research?" he asked.

"Because it starts there," Mr. Melissaratos responded. He noted that he spent the first 25 years of his career as the manufacturing guru of Westinghouse's defense business. "You cannot do successful manufacturing, commercial or otherwise, without having the best technology in it. You need to create a foundation of excellence at the base and build from that by targeting the right kinds of products to improve the world's standard of living."

In the short term, Mr. Melissaratos said he acknowledges that "for the next 10 to 20 years we will be creating new products that will be built in other countries."

But that is fine. "We should be thinking about the planet," he said. Unless the well-being of everybody on the planet improves, there will be inequities. He noted that Apple makes high profits on the iPhone, even though it is put together with components and technologies developed in many other countries. The wealth goes to Apple shareholders. "We need to control the application of intellectual property to develop new products and to sit at the top of the food chain," he said. It is important for U.S. companies to have technology before other nations do.

Dr. Clements said balance is needed. He noted that he spent most of his life doing applied research. Universities need to find a way to value both basic, theoretical research and applied research to solve real-world problems.

Achieving such a balance is difficult because it is hard for universities to find funding for applied research, Mr. Stevens observed. Proposals for applied research often aren't approved by peer-review panels, and finding other funding sources is tough. "It is something that the federal labs can do better because they don't have to compete in peer-review panels," he said. "They have line-item budgets. If they have something hot going, they can continue to fund and develop it and get it to the point where it can be translated for the private sector."

Dr. Stevens also was asked about the critique of university tech-transfer programs by the Ewing Marion Kauffman Foundation and its recommendations for reform.[71] Among other things, the Kauffman Foundation proposed that regional consortia be established to manage commercialization activities on behalf of universities. Pooling tech-transfer resources could lower costs, it said. The foundation also suggested university scientists become free agents who can sell intellectual property on their own. He said most universities are not in favor of the idea that "some of your profitable stuff can walk off campus," he said. He noted that most university technology-transfer programs already are unprofitable. "We very much are a system where the winners support the losers," he said.

Dr. Stevens disagreed that state governments should establish central offices to manage technology-transfer for universities. Efforts to establish such centralized systems in North Carolina and the state of Washington were abandoned. The moment that subsidies for those programs ended, the tech-transfer efforts returned to campus, he said. Central tech-transfer programs for the university systems of California and New York also were dissolved. "The people doing it have to be on campus," Dr. Stevens said. "This is a business of collisions. You have to bump into people casually. A lot of your best leads come in the lunch line." Tech-transfer staff must be pro-active. "You can sit and wait for people to bring inventions to you," he said. "Or you can get out there and look for them."

Michael J. Cleare, executive director of the Center for Technology Transfer at

[71]The Kauffman Foundation proposals are found in Robert E. Litan, Lesa Mitchell, and E. J. Reedy, "Commercializing University Innovations: Alternative Approaches," Boston: National Bureau of Economic Research, Working paper JEL No. O18, M13,033, 034, 038, 2007. The report can be downloaded at <*http://papers.ssrn.com/sol3/papers.cfm?abstract_id=976005*>.

the University of Pennsylvania, returned to the issue of funding balance. He said he had spent 30 years in industry and then 10 years in two major research universities. He said he has a great deal of confidence in the Obama Administration and believes it "gets it" in terms of innovation. "But I am absolutely mystified by the balance of funding," Dr. Cleare said. "I also believe that good funding of basic research is essential." The reality in industry, though, is that 1 in 10 inventions gets fully developed.

Dr. Cleare said the federal government should be doing much more than the SBIR program, which supports proof of concept. He said even the SBIR program focuses too little on development, he said. The linear model of innovation championed by Vannever Bush "is broken because of a bloody great gap in it called the Valley of Death." He said the University of Pennsylvania produces hundreds of inventions, and many discoveries "don't get the attention they deserve because there is not enough funding." There is peer-reviewed funding for research, but not for proof of concept to take an idea through the stage of validation "to the point where the private sector feels the risk is justified to take it on. "So why, oh why, don't we with the stroke of a pen" increase funding for applications? Dr. Cleare asked. What the United Kingdom claims to do better, Mr. Cleare added, is at the proof-of-concept stage. "Nearly all proof-of-concept funding is from the government," he said. "The government gets it in England."

Dr. Stevens noted that the American Association of Universities, which represents university presidents, is opposed to the idea of expanding the use of SBIR funds. He said he would prefer to see a new stream of funding so that money for product development is not taken out of the basic research pie, "which is what we have done up to now."

Mr. Melissaratos said that maybe it is better to get rid of some existing streams of funding. Basic and applied research gets done in about every department of the federal government. "It is not well coordinated across departments," he said. A presidential science advisor could help the departments of Defense, Energy, and Health and Human Services share their research. Companies with large R&D budgets, like Intel and Microsoft, should work more with federal agencies and fill gaps. "We need to really take advantage of what we've got in this country," Mr. Mellisarratos said. "We need to break down some of these bureaucracies because they exist for their own sake. We need a radical re-do of how this money flows."

Mark McDougal of Sematech commented that the United States could make more progress working with industry on innovation if there were more technology roadmaps. When corporations like Cisco and Intel "are hitting on all cylinders, they are working on three generations at the same time. They are de-bugging their current product; they are working on next-generation technology; and they are working on research. They are like well-oiled machines," Mr. McDougal said. "When they look at universities and government, they see bureaucracy, inefficiency, and maybe not something they want to invest with." He said the United

States could achieve more if it better aligned technology roadmaps. Also, private industry, rather than taxpayers, would fund more university research.

An audience member asked what more universities can do internally to change cultural attitudes toward innovation.

Mr. Melissaratos said a major reason Johns Hopkins scientists rank low in commercialization is that "they are comfortable doing research. They know where their next grant will come from. They don't want to take the risk of jumping over, and having to depend on their own entrepreneurship to succeed." One way to change thinking is to focus on the payoff of research and what scientists must do to make their research know.

Returning to the topic of why basic research is critical, Mr. Melissaratos said "you must go beyond three generations of a product." Recalling his experience in aerospace at Westinghouse, he noted that the company had to look beyond the next three generations of a product to succeed. Westinghouse could not rely on the commercial semiconductor industry to provide the components needed to improve performance of certain radar systems, for example. So it developed new semiconductor materials to build systems that would provide a competitive edge. "You need to look at the entire product life cycle," he said. "When industry and government show an interest across this spectrum, we can move technology forward. The faculty will come along and want to participate."

Another way to change culture is to make graduate programs more interdisciplinary, he added. "We need to change the way we create Ph.D. programs," Mr. Melissaratos said. "Digging deep into one area, finishing your dissertation, and not knowing what goes in the world doesn't work."

Panel VII

A Policy Roundtable—What Should U.S. Policy Be?

Moderator:
Mary Good
University of Arkansas at Little Rock
and STEP Board

Mary Good began the roundtable by inviting Rob James, Secretary General of Canada's National Research Council (NRC), to offer some insights.

From his own personal bias, Mr. James said, science and technology policy is just as important as fiscal and macro-economic policy. "We aren't quite there yet, but these kinds of discussions are helping us move down that line, and that is tremendous for all of us," he said.

Canada's National Research Council has been engaged in developing clusters for around a decade. "We have yet to get it right. We've had some successes and failures, but we've learned a number of things that position us to continue the strengthening of these initiatives," he said. "Many of the points taken today resonated very strongly."

The council defines clusters as "community-based partnerships seeking competitive advantage in research and innovation." Canada's private sector is the economic engine and at the heart of the model, Mr. James explained. The Canadian NRC plays a catalytic role. The Council also is changing its internal culture. Not all veteran scientists agree with the shift toward applied research and commercialization. "It has been an internal barrier for us in some instances," he said.

The Canadian NRC has learned that engagement with the community is absolutely essential. If some kind of community cluster board is not in place, cluster initiatives tend to lag, Mr. James said. In Canada, these boards consist of representatives from government, industry, and universities. They typically meet quarterly to address gaps and challenges facing that cluster, discuss marketing and branding, and keep the momentum going.

The Canadian NRC also learned the value of technology roadmaps to these initiatives. While plans themselves can be relatively useless, the act of planning

is indispensible, he noted. It is important to get members of the supply chain and community around the table on an ongoing basis. Technology roadmaps are important to accomplishing that.

The Council sees several big opportunities to serve as a catalyst. One is by promoting domestic integration. For example, a cluster is developing in Vancouver around fuel cells that can be linked with the automotive cluster in Ontario. The challenge for the Canadian NRC is to "bring the knowledge, expertise, and skills in Vancouver to bear on the Ontario situation," Mr. James said. "That is just one example of many. Domestic integration can be an absolute game-changer."

Canada's NRC also is trying to build on the concept of international twin cities. Ottawa, for example, has been twinned with Amsterdam for many, many years. In this same vein, there could be an opportunity, for example, for the Vancouver cluster to twin with a Shanghai cluster. The goal is to get clusters linked "scientifically, technically, culturally, and as well as from a business standpoint in a sustainable manner," he said. Such bridges could give clusters access to international markets, which is very important for Canada.

Mr. James said the term "clusters" remains problematic when it comes to persuading legislators to back an initiative. Many people in economic development have different ideas of what the term means. Therefore, the Council is considering different tag lines that better convey results, such as "centers of technology advantage," he said. Such a term "would give a bit more of a reason for the existence of these things and gives groups and parties a real reason to come on board with a better understanding of why they are there."

A national advisory body called the Science, Technology, and Innovation Council of Canada is now assessing cluster initiatives over the past decade, Mr. James noted.[72] That body will suggest government policies for the next 8 or 10 years.

Dr. Good thanked Mr. James and added her own observations of the day's proceedings. She said she is "extremely optimistic about the activity that seems to be going on." The message of government representatives seemed to be that instead of just discussing and planning, agencies actually are starting to act. "We can plan the rest of our lives and do nothing, so it's important just to go out and do things," she said.

Dr. Good noted that a meeting the previous day attended by Secretary of Commerce Locke discussed the role of universities in economic development. "It really was an extraordinary exchange," she said. "We expect a lot out of universities these days, and they are some of the real jewels that the United States owns" and where it still enjoys leadership. "They will have to help with job creation and many of the issues we are discussing," she said.

Some university cultures oppose that direction because faculty is not rewarded

[72]See National Research Council of Canada, *State of the Nation 2008: Canada's Science, Technology, and Innovation System*, Ottawa: Government of Canada, 2008. Access at <*http://www.stic-csti.ca/*>.

for applied research, Dr. Good observed. "If you want people to respond, you have to reward them," she said. One way is to make it easier for researchers to get funding to continue their work long enough to develop a working prototype, she suggested. Another is to alter the tenure system. "If that reward of tenure, advancement, and promotion is based just on the number of papers in the best peer-reviewed journals, we won't get there," she said. "There has to be something else attached to that." She said she believes many university researchers would embrace such change because they "actually like to see something useful come of what they do."

Dr. Good said she was very encouraged by the activities discussed at the day's symposium and described it as "one of the better ones we have had. It really was on topics that are timely." She then opened the session to questions.

Jim Hurd of Green Science Exchange observed that many other nations "are more command-and-control than we are." While it is difficult to discuss industrial policy in the United States, he said, "countries like China are happy to throw hundreds of millions of dollars and millions of people at a goal."

William Harris of Science Foundation Arizona responded that the nation has reached a stage where it is not having a discussion. "We have an important issue to discuss, and we make it a Democrat or Republican issue. I think that's a tragedy." The United States lives in a kind of cocoon where it thinks it is exceptional and its universities are the best. "You can imagine the same things being said by GM in 1973," he added. "Right now, the entire system is somewhat at risk because (America) is not having the same kind of serious discussion we are having here and agreeing to solve problems." Mr. Harris said he shares Mr. Hurd's concern that the United States has a political problem in that it is not addressing the opportunities that universities and industry can provide if they work together.

The innovation model that worked for the United States during the Cold War may not be optimal in today's situation, Mr. Harris continued. "Instead of talking about basic and applied research, which are archaic terms, let's talk about world first-rate research and world-class research." He contended that a lot of time is wasted discussing the wrong words. "We are putting a lot of money going into research. Doubling or tripling it is not the right idea unless you have some kind of objective that addresses the needs of society. Just throwing money at it won't do it."

Dr. Good said one of the biggest issues is how to go forward and have a conversation that really affects the country as a whole about what is happening in the rest of the world. "We're losing the middle class at a very, very alarming speed," she said. If that continues, she added, "what we have thought about for last 50 years in this country will change dramatically." Americans still believe our technology is the best, so the country still protects technology other nations already have. "We are still working pretty much under the Cold War regime," Dr. Good said. "That is not where we are, and it is not where the rest of the world is. We have to get a whole lot more realistic."

Jim Jaffe, CEO of the National Association of Seed and Venture Funds, noted that his group's members include small seed funds, state investment funds, and organizations such as national laboratories and university research parks. "I want to bring this down from the 50,000-foot level," Mr. Jaffe said. "One of the dilemmas that our members see is that, if they are on the technology side, they find that they cannot get the word out and appropriately communicate what they have to the people who have money. It's a communication, marketing, and branding issue."

On the other hand, Mr. Jaffe explained, when the association asks venture investors where they get their technologies from, they say they are in great shape because they have universities in their area. Many such investors have told him that they are not aware of the federal laboratory system. "How do technologists better communicate what they have to the money people?" Mr. Jaffe asked. "And how do you make the money people more aware of what the technology people have?"

Dr. Good agreed that the people with the money and the people with ideas often don't talk with each other. Venture capitalists often think there are only two or three spots in the country that are worth mining. Another problem, she said, is that faculty at universities don't think they should be communicating because that is the job of a licensing office. She added that the STEP board should explore this issue.

Michael Borrus of X/Seed said there are really two issues. One is how to get technology out of places around the country doing interesting research. The other is how to finance the resulting start-ups until they can become self-sustaining. Mr. Borrus said the principal way to move technology out of research sources is through entrepreneurs. "Once you have entrepreneurs, you can usually find capital," he said.

As to the question of why it is so hard to commercialize technology from national labs, Mr. Borrus said he thinks one reason is that those institutions are "pretty self-selecting." They attract people who want to do research, as opposed to people who want to build businesses.

Mr. Borrus said he spends most of his time hanging out at a handful of universities, all of which are close to his office in Silicon Valley. That isn't because venture capitalists are opposed to travel, he said. It is because his firm interacts intensively with the companies it funds, "and you can't do that over great distances, despite modern communications and information technologies."

Linking entrepreneurs to more interesting sources of technology is indeed a very hard problem, Mr. Borrus said. There have been small experiments with establishing entrepreneurs in residence at national labs. "But you need a lot of experimentation to figure out what can work and what cannot work in that context."

Another problem, he added, is that traditional capital markets have moved away from very early-stage company building. Mr. Borrus said he established X/Seed after being at a large Silicon Valley venture firm because the traditional

larger venture firms were largely moving away from seed-stage funding. "I can find entrepreneurs and good technology and bring them to a certain point," he said. "But now I'm discovering that to get them even further, there is another growing gap in the capital markets." For certain kinds of difficult technical innovations, it is now getting difficult to find funding at the post-seed level, the so-called Series A funding round, where larger venture funds would typically invest $3 million to $8 million.

Programs such as ARPA-E can help to bridge some funding gaps, he said, but other barriers exist. The crisis in the capital markets in 2008 and 2009, for example, has made many classes of venture capital investors more risk-averse, as has their drift to putting more capital under management and deploying it later after early risk has been removed. The crisis also created a structural problem finding financing for large-scale capital investment projects like scaling up a new solar or bio-fuel production process. Mr. Borrus said he thinks the adjustment period for the problems facing the venture capital industry will last for perhaps a decade.

In the interim, measures are needed to fill these funding gaps, he said. "I am actually quite encouraged," Mr. Borrus said. "I think most of the pieces exist. It's a matter of marshalling the will to apply them systematically to this problem." There does seem to be a will at the local level and growing support at the federal level, he added. If government works together with industry, "I think we can accomplish tremendous things."

Cathy Swain, who heads the research commercialization office for the 15 universities in the University of Texas system, explained that the MD Anderson Cancer Center in Houston has a fund for proof of concept. It took four years for that fund to break even, she said. The long payback should be expected because the fund deals in life sciences. Ms. Swain noted that her office also started a proof-of-concept fund for nine academic and six health institutions in the UT system. In 18 months, it has produced 15 start-ups. Moreover, it has leveraged the initial funding many times over with private funding. "We are staggered by those results," she said.

Of course, the funds could be performing well because they have chased low-hanging fruit, Ms. Swain pointed out. But on the other hand, "our tech-transfer offices are telling us that, without exception, researchers are coming out of the woodwork now that the money became available."

Proof-of-concept funds can be a critical link in the chain and fill an important niche in bridging the Valley of Death. She noted that the first prototype typically is not the one that goes to market. Product development often means the next nine prototypes. "So you don't really rescue a piece of research with a prototype," she said. "More is needed in the development stages."

Market input also is essential. The commercialization program for the UT system is considering making market research part of research grants, she said, such as by requiring applicants to allocate $3,000 to $5,000 of the funding for that purpose.

The UT system has three incubators, Ms. Swain noted. These incubators run into problems stemming from policy, such as private-use restrictions. "I don't know what policy changes can be made to address them, but that is where the rubber meets the road," she said.

Dr. Good noted that these kinds of issues were discussed in the February 24 meeting on university commercialization programs. She said she agrees that are many such impediments, and recommendations should be made to fix them.

Richard Bendis, CEO of Innovation America, offered several suggestions. He noted that several states have had innovation strategies for several decades now and update them regularly. He suggested the federal government study some of these state efforts and learn from them.

Mr. Bendis also noted that other nations, both developed and developing, have long-term innovation roadmaps. "What I hear today from the Administration is that there are a lot of programs," he said. "I see some collaboration, but I do not a long-term integrated roadmap or plan for America that takes us 20 or 30 years out." Somebody has to take the lead in doing that, and a federal leader has not emerged, he said.

Regarding the Valley of Death, Mr. Bendis said, a new funding paradigm is emerging. "It is not just about proof of concept. It is about proof of relevance," he said. In order to raise risk capital, one increasingly has to go beyond proof of concept and show that a new product is relevant, which means that there is a large market, that it can be profitable, and that it can have paying customers already. "I honestly believe we have enough money in the various federal government agencies today," he said. "If we repurpose some of those funds, where we could get a better return on investment, we could deal very adequately with the Valley of Death." For example, SBIR should double the level of funding it offers and increase investments for Phase III commercialization. "How do we impress upon this Administration, which is trying to stimulate the economy and grow new high-paying jobs, that there is a need to proactively address the Valley of Death right now and increase investment in innovative, entrepreneurial small businesses that have led job growth in America for the past five decades?" he asked.

Jo Anne Goodnight, a program manager for NIH, noted that the NIH has developed a program called "pipeline partnerships." This is a way for companies funded by SBIR, the Small Business Technology Transfer program, and licensees to put technologies they develop into a database. Research projects are arranged by disease category and stage of clinical testing. "This allows them to showcase those technologies to an audience of investors and strategic partners," she said. It also helps agencies share information. This year, the NIH is working to expand the program's reach, such as by including technologies developed at universities.

An audience member suggested other issues that the government should study. She complained that the Bayh-Dole Act has had a chilling effect on universities and that its provisions should be reviewed. She also said a lot of federal programs are outmoded and should be re-thought. For insistence, Small Business

Development Centers still focus on mom-and-pop businesses and doughnut shops, rather than technology start-ups and mentoring, she said. The EDA needs more flexibility, she added. "It still basically is about public works, and it is still focused on laying sewer lines instead of really stimulating technology."

Dr. Wessner concluded the proceedings by thanking the panel and Mary Good for her leadership.

III

APPENDIXES

Appendix A

Agenda

Clustering for 21st Century Prosperity

A Symposium organized
in cooperation with
The Association of University Research Parks

Agenda

February 25, 2010

The National Academies
Lecture Room
2100 C Street, NW
Washington, DC

8:45 AM **Welcome**
Charles Wessner, The National Academies

8:50 AM **Introduction**
Mary Good, University of Arkansas at Little Rock and STEP Board

9:00 AM **Panel I: Clustering for Growth**
Moderator: Michael Borrus, X/Seed Capital Management

Regional Innovation Clusters
Ginger Lew, National Economic Council

Building a Clean Energy Economy Through Accelerated Innovation
Kristina M. Johnson, Department of Energy

Enhanced Competitiveness and Speeding Innovation: Design and Initial Results of the NIST Rapid Innovation and Competitiveness Initiative
Marc G. Stanley, National Institute of Standards and Technology

10:15 AM **Panel II: Clustering for Growth (Continued)**
Moderator: William Harris, Science Foundation Arizona

Building Regional Innovation Clusters
Karen Mills, Small Business Administration

Regional Innovation Strategies Initiative
John Fernandez, Economic Development Administration

10:45 AM **Panel III: Building 21st Century Clusters—The Role of State and Regional Governments**
Moderator: Dan Berglund, State Science and Technology Institute

Building on the Battery Initiative in Michigan
Doug Parks, Michigan Economic Development Corporation

Making the Big State Bigger: Current Texas University Initiatives
David Daniel, University of Texas at Dallas

Growing Northeast Ohio's High-Tech Economy
Rebecca Bagley, NorTech

11:30 AM **Panel IV: Lessons from Abroad—Clusters, Parks & Poles in Global Innovation Strategies**
Moderator: Stephen Lehrman, Office of U.S. Senator Mark Pryor (D-AR)

An Integrated Approach: Brazil's Minas Gerais Strategy
Alberto Duque Portugal, Minas Gerais Secretariat for Science, Technology and Higher Education, Brazil

Brazil's New Innovation Strategy
Francelino Grando, Ministry of Development, Industry and Foreign Trade, Brazil

Hong Kong Science Park—Optimizing Synergies
Nicholas Brooke, Hong Kong Science and Technology Parks Corporation

Innovation and Clusters: Why They Are Back on the OECD Policy Agenda
Mario Pezzini, Organisation for Economic Co-operation and Development

1:30 PM **Luncheon Address**
Gary Locke, Secretary of Commerce
Introduced by Ralph J. Cicerone, National Academy of Sciences

2:00 PM **Panel V: Clustering Around the Lab—Best Practice in Federal Laboratory Commercialization**
Moderator: Jonathan Epstein, Office of U.S. Senator Jeff Bingaman (D-NM)

Sandia National Laboratories as a Catalyst for Regional Growth
J. Stephen Rottler, Sandia National Laboratories

Exploration Park at the Kennedy Space Center
Robert Cabana, NASA Kennedy Space Center

Discussant
Ken Zweibel, George Washington University

3:15 PM **Panel VI: University-Based Clusters**
Moderator: Brian Darmody, Association of University Research Parks

Current Trends and Challenges in University Commercialization
Ashley J. Stevens, Boston University and Association of University Technology Management

Improving the University Model
Aris Melissaratos, Johns Hopkins University

Building New Growth Clusters
James Clements, West Virginia University

4:15 PM **Panel VII: A Policy Roundtable—What Should U.S. Policy Be?**
Moderator: Mary Good, University of Arkansas at Little Rock and STEP Board

5:00 PM **Adjourn**

Appendix B

Biographies of Speakers*

REBECCA BAGLEY

Rebecca O. Bagley is president and chief executive officer of NorTech. Previously, Rebecca served as Deputy Secretary for the Technology Investment Office of the Pennsylvania Department of Community and Economic Development (DCED). In that capacity she oversaw the operations of an office that serves as a catalyst for growth and competitiveness for Pennsylvania companies and universities. Rebecca was responsible for the administration of several major state programs, including the Life Sciences Greenhouse initiative, the Ben Franklin Technology Development Authority and the Ben Franklin Technology Partners, the Keystone Innovation Zone program, the Research and Development Tax Credit program, and many other technology-based economic development programs that support research and commercialization activities.

As part of her responsibilities, Rebecca managed the $650 million Energy Independence Strategy that was signed into law in 2008, as well as approximately $79 million in appropriations and more than $1.7 billion in investments for the Commonwealth of Pennsylvania. She previously served as director of Venture Investment for DCED and was responsible for managing the New PA Venture Investment, the New PA Venture Guarantee Programs, and the Ben Franklin Technology Development Authority Venture Program.

Before joining DCED, Rebecca worked as an investment banker at WFG Capital Advisors where she advised technology companies on merger and acquisitions and capital-raising activities. Rebecca also worked at JPMorgan Chase in

*As of February 2010. Appendix includes bios distributed at the symposium.

New York City, in the high yield-bond group as well as the oil and gas mergers and acquisitions groups. Rebecca started her investment banking career at Howell International in Boulder, Colorado, after returning from a corporate relations position in Caracas, Venezuela.

Rebecca is currently a member of the board of the National Association for Seed and Venture Funds (NASVF), an organization of innovation capital leaders in private, public, and nonprofit organizations that are committed to building local economies by investing in local entrepreneurs. She also has served as a member of the Board of Trustees of the State Science Technology Institute (SSTI), a national nonprofit organization that leads, supports, and strengthens efforts to improve state and regional economies through science, technology, and innovation.

She holds a B.S. from the University of Colorado at Boulder College of Business and Administration.

DAN BERGLUND

Dan Berglund is the president and CEO of the State Science and Technology Institute (SSTI), a nonprofit organization that leads, supports, and strengthens efforts to improve state and regional economies through science, technology, and innovation.

SSTI is the most comprehensive resource available for those involved in technology-based economic development. Leading SSTI since its inception in 1996, Mr. Berglund has helped SSTI develop a nationwide network of practitioners and policymakers dedicated to improving the economy through science and technology. SSTI works with this network to assist states and communities as they build tech-based economies, conduct research on best practices and trends in tech-based economic development, and encourage cooperation among and between state and federal programs.

Prior to joining SSTI, Mr. Berglund worked as a consultant and for the Ohio Department of Development in a variety of positions, including acting deputy director of the Division of Technological Innovation. Mr. Berglund holds a B.A. in economics and political science and a B.A. in history from Ohio University.

MICHAEL BORRUS

Michael Borrus is the founding general partner of X/Seed Capital Management, a seed-focused, early-stage venture fund that invests in entrepreneurs pursuing breakthrough innovation. Prior to founding X/Seed, he was an executive in residence (EIR) at Mohr Davidow Ventures (MDV) in Silicon Valley.

From 1999 to 2004, Michael led the technology banking unit at The Petkevich Group, a financial services start-up. Before that, Michael was adjunct professor

in the University of California (UC) at Berkeley's College of Engineering and a partner in the business consulting firm Industry and Trade Strategies. While at UC Berkeley, he co-founded and co-directed the Berkeley Roundtable on the International Economy.

He is the author of 3 books and more than 70 chapters, articles, and monographs on a variety of topics including management of technology, high-technology competition, international trade and investment, and financial strategies for technology companies.

Michael serves on several National Academy of Sciences/National Research Council steering committees including the Committee on Competing in the 21st Century. He also serves on the board of trustees for the National Center for Women and Information Technology (NCWIT) and the UC Berkeley School of Mechanical Engineering External Advisory Board. He is a director of multiple privately held technology start-ups creating products for cleantech, life science, and information technology markets.

Michael is an honors graduate of Harvard Law School, UC Berkeley, and Princeton University. He is a member of the California State Bar.

NICHOLAS BROOKE

Nicholas Brooke is the chairman the Hong Kong Science and Technology Parks Corporation and also of the Professional Property Services Group, which is a specialist real estate consultancy based in Hong Kong, providing a selected range of advisory services across the Asia Pacific Region.

The Hong Kong Science and Technology Parks Corporation was established in 2001 with the objectives of fostering Hong Kong's role as a hub for innovation and technology and R&D and to take advantage of Hong Kong's unique position as the historic gateway to Southern China. Since its inception, the corporation has built and now manages an unmatched range of advanced facilities and services with a particular emphasis on sustainability and green technologies.

He is a past president of the Royal Institution of Chartered Surveyors and a former member of the Hong Kong Housing Authority and the Hong Kong Town Planning Board. He is the current chairman of the Hong Kong Coalition of Service Industries and is a member of the Hong Kong Harbour-front Enhancement Committee. He is also the member of the Steering Committee on Promotion of Electric Vehicle in Hong Kong.

He is a non-executive director on the board of MAF Properties, one of the Middle East's leading shopping center developers, of VinaLand Vietnam Real Estate Fund, the first Vietnam property fund to be listed on the AIM Board of the London Stock Exchange, and of Shanghai Forte Land.

ROBERT CABANA

Robert D. Cabana is the 10th director of NASA's John F. Kennedy Space Center in Florida where he manages a team of approximately 2,200 civil servants and about 13,000 contractor employees. Prior to his appointment to Kennedy in October 2008, the former space shuttle astronaut served as the director of NASA's Stennis Space Center in Mississippi.

Originally from Minneapolis, Minnesota, Cabana graduated from the U.S. Naval Academy in 1971, with a B.S. in mathematics and was commissioned as an officer in the U.S. Marine Corps. He is a distinguished graduate of the U.S. Naval Test Pilot School and has logged over 7,000 hours in 36 different aircraft.

Cabana was selected as an astronaut candidate in June of 1985, completing his training in 1986. He has flown four space shuttle missions serving as the pilot of Discovery on STS-41 in October 1990, the pilot of Discovery on STS-53 in December 1992, the commander of Columbia on STS-65 in July 1994, and the commander of Endeavour on STS-88, the first space station assembly mission, in December 1998.

Before being named the director of Stennis Space Center in October 2007, Cabana served as deputy director of NASA's Lyndon B. Johnson Space Center in Houston, Texas. In addition to his duties as an astronaut, Cabana's NASA experience includes assignments as deputy chief, Aircraft Operations Division; chief, NASA Astronaut Office; manager, International Operations, International Space Station Program; director, NASA Human Space Flight Program in Russia; deputy, International Space Station Program; and director, Flight Crew Operations.

JAMES CLEMENTS

James P. Clements became West Virginia University's (WVU's) 23rd president on June 30, 2009. His primary focus has been strengthening local and global partnerships that produce meaningful results for the university and lasting benefits for all West Virginians.

Before going to WVU, Dr. Clements served as provost and vice president at Towson University, the second largest public university in Maryland, and before that, as Towson's vice president for economic and community outreach. During his four-year tenure in the latter role, he helped Towson secure more than $50 million in external funding through linked centers and institutes.

Dr. Clements also served on Towson's faculty as the Robert W. Deutsch Distinguished Professor and chair of the Department of Computer and Information Sciences. While on the faculty, he founded and led the Center for Applied Information Technology, a self-supporting academic center. Within the first few years, the center had engaged in more than two dozen research and consulting projects, generating more than $2 million in revenue.

Dr. Clements initiated and led the effort for Towson to receive recognition from the National Security Agency as a Center of Academic Excellence in Information Assurance Education.

He has a B.S. in computer science and an M.S. and Ph.D. in operations analysis from the University of Maryland, Baltimore County (UMBC), as well as an M.S. in computer science from Johns Hopkins University. His project management textbook, in its fourth edition, is used in more than 20 countries and is published in four languages.

In October 2009, he was named UMBC's Alumnus of the Year in the Engineering and Information Technology category.

DAVID DANIEL

David E. Daniel is the fourth president of the University of Texas at Dallas. Dr. Daniel received his bachelor's, master's, and Ph.D. degrees in engineering from the University of Texas at Austin (UT-Austin) and served on the faculty at UT-Austin from 1980 to 1996. In 1996, he moved to the University of Illinois, finishing his service there as dean of engineering before joining the University of Texas at Dallas (UT-Dallas) as its president in 2005.

Dr. Daniel's professional work has focused on environmental controls for contaminated land and groundwater. He has published over 100 technical articles and authored or edited 5 books. His work has been recognized by the American Society of Civil Engineers, which awarded him its highest award for papers published in its journals (the Norman Medal) and on two separate occasions awarded him its second highest award, the J. James Croes Medal. In 2000, he was elected to the National Academy of Engineering.

In 2005 through 2007, he served as chair of the External Review Panel of the American Society of Civil Engineers, which reviewed the facts surrounding the performance of New Orleans' levees during Hurricane Katrina. In 2009 Daniel served as president of The Academy of Medicine, Engineering, and Science of Texas (TAMEST), which is an organization comprised of all Texas residents who have won Nobel Prizes or been elected to one of the three National Academies. Daniel serves on the Sandia Corporation Board of Directors, which oversees management of Sandia National Laboratory.

During his presidency, UT-Dallas has doubled its research expenditures, initiated or completed $300 million of construction of new buildings, added 20 new degree programs, raised $125 million in private funds, and won two national collegiate championships in chess. He has advocated widely for UT-Dallas to become one of the nation's top research universities. The approach that he suggested for creating more top-tier research universities in Texas gained widespread support that led to two legislative initiatives that pumped more than $500 million of state funds into this effort. His work on this legislation led to his being named a finalist for "Texan of the Year" by the *Dallas Morning News* in December 2009.

BRIAN DARMODY

Brian Darmody is associate vice president for research and economic development, and special assistant vice chancellor for technology development with the University System of Maryland.

Projects led by Dr. Darmody include organizing the university's first technology transfer office, authoring reforms to the state's ethics legislation for entrepreneurial start-ups, developing legislation creating the Maryland Technology Development Corporation (TEDCO), initiating Research Parks Maryland (RPM), the nation's first statewide research park organization, and serving as director of the University of Maryland Center for Applied Policy Studies (UMCAPS). He is the principal author of the *Power of Place*, a national policy document focused on technology-led economic development, and serves as co-principal investigator on the $3.5 million Proof of Concept Alliances, a Department of Defense-funded commercialization project, and he has served as a reviewer to the National Science Foundation and the National Academy of Sciences.

Dr. Darmody previously served as a staff member for the U.S. House of Representatives, the Maryland General Assembly in Annapolis, Maryland, and in the Office of the Attorney-Advisor in the U.S. Health Care Financing Administration. In his role with the University System of Maryland, he focuses on improving technology commercialization across the University System of Maryland and representing higher education regarding BRAC (Base Realignment and Closure Commission) recommendations affecting federal facilities in the region.

Dr. Darmody serves on local and national boards, including the Maryland Space Business Roundtable, Greater Baltimore Technology Council, and the Maryland Technology Council Legislative Committee, is president of the Association of University Research Parks, and is the previous chair of the University of Maryland's Network of Entrepreneurs. He holds a J.D. from the University of Baltimore and an undergraduate degree from the University of Maryland, College Park.

JONATHAN EPSTEIN

Jonathan Epstein performs oversight of energy research and development and Department of Energy matters on the Senate Energy and Natural Resources Committee, as well as the Department of Defense (DoD), nuclear weapons, and nonproliferation issues on the personal staff of Senator Bingaman. He participated in drafting the research and development, coal and hydrogen fuel titles of the Energy Policy Act of 2005 and 2007 as well as the Protecting America's Competitive Edge Act based upon National Academies report *Rising Above the Gathering Storm* as requested by Senators Alexander and Bingaman. This legislation was signed into law on August 8, 2007. Dr. Epstein holds a Ph.D. in engineering science and applied mechanics from Virginia Polytechnic Institute.

Dr. Epstein was a postdoctorate fellow at Oxford University. He has a law degree from the University of Idaho specializing in intellectual property and an LL.M. from Georgetown University Law Center in securities and financial regulation.

Dr. Epstein has published over 50 refereed papers in the areas of photonics and material behavior; he was past editor-in-chief of *Optics and Lasers in Engineering*. He was a congressional fellow sponsored by the American Welding Society and is a fellow of the American Society of Mechanical Engineers. Dr. Epstein has worked in a wide variety of areas involving energy and national security. He was the scientific advisor to the assistant to the Secretary of Defense for Nuclear, Chemical, and Biological Defense Programs with responsibility for special forces programs to counter weapons of mass destruction, for which he received the Joint Service Commendation (civilian) for his work in initiating this effort. He worked at the Department of Commerce's Bureau of Export Administration as a policy analyst reviewing high-technology exports to India, Russia, and China. Dr. Epstein was a Carnegie Science Fellow at the Center for International Security and Arms Control at Stanford and an assistant professor at the Georgia Institute of Technology.

From 1984 to 2006 Dr. Epstein was employed by the Idaho National Laboratory performing research in the areas of nuclear power, material fracture, optical information processing systems and nonproliferation programs. From 2000 to 2006 he was detailed by the Idaho National Laboratory to the personal office of Senator Bingaman, assisting on defense matters, energy research, and development and competitiveness issues.

JOHN FERNANDEZ

John Fernandez was appointed by President Obama to serve as the Assistant Secretary of Commerce for Economic Development and sworn into office on September 14, 2009.

As the administrator of the U.S. Department of Commerce's Economic Development Administration (EDA), Mr. Fernandez is charged with leading the federal economic development agenda by promoting innovation and competitiveness, preparing American regions for growth and success in the global economy.

With over 13 years of executive experience, Mr. Fernandez has earned a reputation as a strategic thinker, creative problem solver, and effective manager. Prior to his appointment, Fernandez led the new development and acquisition team at First Capital Group, an Indiana-based real estate investment firm. Mr. Fernandez played a critical role in expanding the firm's regional and national investment footprint.

Mr. Fernandez also served as Of Counsel for Krieg Devault, an Indianapolis-based law firm, where he advised private and governmental organizations on economic development, public finance, and policy issues.

Mr. Fernandez served as Bloomington, Indiana's mayor from 1996 to 2003. With his leadership, Bloomington's economy thrived despite facing significant changes arising from the new global economy. Fernandez worked with business and Indiana University leaders to launch Bloomington's Life Sciences Partnership, securing more than $243 million in private investments and creating more than 3,700 jobs. He also developed an aggressive downtown revitalization plan resulting in more than $100 million in new investments.

A first generation American, Mr. Fernandez received a J.D. from Indiana University. He also earned an M.P.A. and B.S. from Indiana University's School of Public and Environmental Affairs.

MARY GOOD

Mary L. Good, founding dean and Donaghey University Professor in the Donaghey College of Engineering and Information Technology at the University of Arkansas at Little Rock, is well known for her distinguished career. She has held many high-level positions in academia, industry, and government. The 143,000-member American Association for the Advancement of Science (AAAS) elected Dr. Good to serve as president, following Dr. Stephen Jay Gould. In 2004, Dr. Good was recipient of the National Science Foundation's highest honor, the Vannevar Bush Award. She also was the first female winner of the AAAS's prestigious Philip Hogue Abelson prize for outstanding achievements in education, research, development management, and public service, spanning the academic, industrial, and government sectors. Two of her more than 27 awards include the National Science Foundation Distinguished Service medal and the esteemed American Chemical Society Priestly Medal. She also is the sixth Annual Heinz Award Winner.

During the terms of Presidents Carter and Reagan, Dr. Good served on the National Science Board and chaired it from 1988 to 1991. She was the Under Secretary for Technology in the U.S. Department of Commerce and Technology during President Clinton's first term. This agency assists American industry to advance productivity, technology, and innovation in order to make U.S. companies more competitive in the global market.

Dr. Good has received 21 honorary degrees. Her undergraduate degree in chemistry is from the University of Central Arkansas. She earned her doctoral degree in inorganic chemistry from the University of Arkansas, Fayetteville, at age 24. Dr. Good spent 25 years teaching and researching at Louisiana State University and the University of New Orleans before becoming a guiding force in research and development for Allied Signal. Dr. Good was voted one of Arkansas' Top 100 Women by *Arkansas Business*.

FRANCELINO GRANDO

Francelino Grando is the Secretary of Innovation at the Ministry of Development, Industry, and Foreign Trade of the Government of Brazil. From 2003 to 2005, Dr. Grando was the Secretary of Technological Development and Innovation at the Ministry of Science and Technology. He is an associate professor in the Department of Ecology at the Federal University of São Carlos. He holds a bachelor of laws from the University of São Paulo (USP) where he majored in economic law, and he holds a Ph.D. in ecology and natural resources from the Federal University of São Carlos (UFSCar).

Dr. Grando is currently a member of the following councils and boards: the National Council of Water Resources, the Brazil Internet Steering Committee, the Board of Directors of the Center for Strategic Studies and Management, the Development Committee of the Board on Brazilian Digitial Television, the Managing Council of the Fund for the Development of Telecommunications, and the Advisory Board of the Studies and Projects Committee, and he is the executive secretary of the Interministerial Group for Intellectual Property.

WILLIAM HARRIS

William Harris is the president and chief executive officer of Science Foundation Arizona (SFAz). Prior to joining SFAz, Dr. Harris was in Ireland serving as director general of Science Foundation Ireland (SFI), a new Irish agency that helped facilitate tremendous growth in Ireland's R&D sector during Dr. Harris' tenure. Immediately prior to going to Ireland, Dr. Harris was vice president of research and professor of chemistry and biochemistry at the University of South Carolina (USC). There, he oversaw research activities throughout the USC system, several interdisciplinary centers and institutes, the USC Research Foundation, and sponsored research programs.

Dr. Harris served at the U.S. National Science Foundation (NSF) from 1978 to 1996, including as the director for mathematical and physical sciences (1991-1996). He was responsible for federal grants appropriation of $750 million. He also established 25 Science and Technology Centers to support investigative, interdisciplinary research by multi-university consortia. Earlier in his career, he catalyzed the Research Experience for Undergraduates program in the chemistry division, and it became an NSF-wide activity.

In 2005, Dr. Harris was elected a member of the Irish Royal Academy, and he received the Wiley Lifetime Achievement Award from California Polytechnic State University. He has authored more than 50 research papers and review articles in spectroscopy and is a fellow of the American Association for the Advancement of Science.

Dr. Harris earned his undergraduate degree at the College of William and Mary and received his Ph.D. in chemistry from the University of South Carolina.

KRISTINA M. JOHNSON

Kristina M. Johnson is currently the Under Secretary for Energy at the Department of Energy in Washington, DC. Prior to her appointment as Under Secretary, Dr. Johnson was provost and senior vice president for academic affairs at The Johns Hopkins University. She received her B.S. (with distinction), M.S., and Ph.D. in electrical engineering from Stanford University. After a NATO post-doctoral fellowship at Trinity College, Dublin, Ireland, she joined the University of Colorado-Boulder's faculty in 1985 as an assistant professor and was promoted to full professor in 1994. From 1994 to 1999, Dr. Johnson directed the NSF/ERC for Optoelectronics Computing Systems Center at the University of Colorado and Colorado State University, and then served as dean of the Pratt School of Engineering at Duke University from 1999 to 2007.

Dr. Johnson was named an NSF Presidential Young Investigator in 1985 and a Fulbright Faculty Scholar fellowship in 1991. Her awards include the Dennis Gabor Prize for creativity and innovation in modern optics (1993); State of Colorado and North Carolina Technology Transfer Awards (1997, 2001); induction into the Women in Technology International Hall of Fame (2003); the Society of Women Engineers Lifetime Achievement Award (2004); and in May of 2008, the John Fritz Medal, widely considered the highest award in the engineering profession. Previous recipients of the Fritz Medal include Alexander Graham Bell, Thomas Edison, and Orville Wright. In December of 2009, she was awarded an honorary doctorate of science from the University of Alabama at Huntsville.

Dr. Johnson has 142 refereed papers and proceedings and holds 45 U.S. patents (129 U.S. and international patents) and patents pending.

A fellow of the Optical Society of America, International Electronics and Electrical Engineering (IEEE), SPIE, the International Society for Optical Engineering (former Board Member), Dr. Johnson has served on the Board of Directors of Mineral Technologies Inc., Boston Scientific Corporation, AES Corporation, and Nortel Networks. She helped found several companies, including ColorLink, Inc, SouthEast Techinventures, and Unyos.

STEPHEN LEHRMAN

Stephen Lehrman is a legislative assistant in the Office of Senator Mark Pryor (D-AR). Before joining Senator Pryor's professional staff, he served the senator as a congressional fellow sponsored by the American Society of Mechanical Engineers. Mr. Lehrman advises the office on science and technology policy.

Mr. Lehrman was president of LabraTek Consulting, a company he founded to provide technology-transfer and commercialization services on emerging technologies in mechanical engineering, material science, nano and micro technologies, and optics for federal, state, industry, and university clients. From 1998 to 1999, Mr. Lehrman was adjunct professor and visiting lecturer in engineering at

the Community College of Rhode Island. He previously worked for RTI International supporting the NASA and Missile Defense Agency technology transfer programs. Prior to joining RTI, Mr. Lehrman was a graduate fellow in precision engineering at North Carolina State University; manager of the structural mechanics department at Corporate Consulting and Development Company; and mechanical engineer in the engineering mechanics division at Stone & Webster Engineering Corporation. Mr. Lehrman is a registered professional engineer, was a member of the Brown University Division of Engineering Advisory Council, and is a member of ASME and Tau Beta Pi.

GINGER LEW

Ginger Lew is senior advisor to the White House National Economic Council and the U.S. Small Business Administration (SBA) Administrator. She provides economic policy advice on a broad range of matters that impact small businesses. In addition, she co-chairs the White House Interagency Group on Innovation and Entrepreneurship.

Prior to joining the Obama Administration, Ms. Lew was the managing partner of a communications venture capital fund and a venture advisor to a Web 2.0 venture fund.

Under the Clinton Administration, Ms. Lew was the deputy administrator and chief operating officer of the Small Business Administration where she provided day-to-day management and operational oversight of a $42 billion loan portfolio. Before joining SBA, Ms. Lew was the general counsel at the Department of Commerce where she specialized in international trade issues. Ms. Lew was unanimously confirmed by the United States Senate for both positions.

For the past 10 years, Ms. Lew was chairman and board member of an investment fund based in Europe. She has served on the boards of publicly traded companies, private companies, and nonprofit organizations.

GARY LOCKE

Gary Locke was appointed by President Obama as the 36th Secretary of Commerce and sworn into office on March 26, 2009.

At the Department of Commerce, Locke is charged with helping implement President Obama's ambitious agenda to turn around the economy and put people back to work.

As the first Chinese-American to hold this post in a president's cabinet, Locke has a distinctly American story. His grandfather emigrated from China to Washington state, initially finding employment as a servant, working in exchange for English lessons. Locke's father, also born in China, was a small business owner, operating a grocery store where Locke worked while receiving his education from Seattle's public school system. His strong work ethic

and determination eventually took him to the highest office in the state of Washington.

Prior to his appointment, Locke helped U.S. companies break into international markets as a partner in the Seattle office of the international law firm, Davis Wright Tremaine LLP. There, he co-chaired the firm's China practice and was active in its governmental relations practice.

As the popular two-term governor of Washington, the nation's most trade-dependent state, Locke broke down trade barriers around the world to advance American products. He helped open doors for Washington state businesses by leading 10 productive trade missions to Asia, Mexico, and Europe, significantly expanding the sale of Washington products and services. He also successfully strengthened economic ties between China and Washington state. His visits are credited with introducing Washington companies to China and helping to more than double the state's exports to China to over $5 billion per year.

As part of his considerable trade and economic development efforts, Locke launched Washington's Competitiveness Council with business, labor, and civic leaders working together to effectively position Washington state for success at home and around the world. During the eight years of the Locke Administration, the state gained 280,000 jobs.

Locke earned a bachelor's degree in political science from Yale University and a law degree from Boston University. He is married to Mona Lee Locke. They have three children: Emily, Dylan, and Madeline.

ARIS MELISSARATOS

Aris Melissaratos joined The Johns Hopkins University in 2007 as senior advisor to the president for enterprise development.

Melissaratos, a 1966 Johns Hopkins graduate and longtime member of the Whiting School of Engineering's National Advisory Council, has overall responsibility for building the university's relationship with business and forging new connections between the research and corporate communities.

Specific assignments include supervision of Johns Hopkins Technology Transfer, the office that links university researchers and businesses interested in commercializing their inventions. Melissaratos also markets opportunities for businesses to locate at Johns Hopkins-related research parks such as the Montgomery County Campus, the nearby Belward Research Campus, and the Science + Technology Park at Johns Hopkins, now under construction as part of the comprehensive New EastSide redevelopment in East Baltimore.

Melissaratos, whose undergraduate degree from Johns Hopkins is in electrical engineering, spent most of his career with Westinghouse Electronics in Baltimore, eventually becoming vice president of science and technology and chief technology officer at corporate headquarters in Pittsburgh. Before joining state government in 2003 as Secretary of the Maryland Department of Business

and Economic Development, he also served as vice president of Thermo Electron Corporation and founded Armel Private Equity Investments.

He was a founding co-chair of the Greater Baltimore Technology Council and is a former vice president of the Maryland Chamber of Commerce. He holds a master's degree in engineering management from George Washington University and did graduate work in international politics at Catholic University of America. Melissaratos also completed a program for management development at Harvard Business School.

KAREN MILLS

Karen G. Mills was sworn in April 6, 2009, as the 23rd Administrator of the U.S. Small Business Administration (SBA). Appointed by President Barack Obama and confirmed unanimously by the Senate, Ms. Mills directs a federal agency with more than 2,000 full-time employees that plays a leading role helping small business owners and entrepreneurs secure financing, technical assistance, training, and federal contracts. SBA also plays a leading role in disaster recovery by making low-interest loans for businesses and residents. With a portfolio of direct and guaranteed business loans and disaster loans worth more than $90 billion, SBA is the nation's largest single financial backer of small business.

Since 1983, Ms. Mills has been an active hands-on investor in and successful manager of small businesses. Ms. Mills also has distinguished herself as a passionate advocate for small business policy that encourages innovation, economic development, and job creation.

Most recently, as the president of MMP Group, Ms. Mills invested in and took a leading role in companies involved in the consumer products, food, distribution, textile, and industrial components sectors. Prior to that, in the late 1990s, she was a co-founder and a managing director of Solera Capital.

Ms. Mills has spent much of her career working with small manufacturing firms, including producers of hardwood flooring, refrigerator motors, and plastic injection molding. During the recession of the early 1990s, her hands-on management and commitment to innovation is credited with helping several small manufacturers increase efficiency and competitiveness and ultimately survive in a tough economy.

Her background also includes consulting in the United States and Europe for the management consulting firm McKinsey and Company and product management for General Foods. In 2007, she was appointed by Maine Governor John Baldacci as chair of the state's Council on Competitiveness and the Economy, where she focused on attracting investment in rural and regional development initiatives. She also served on the Governor's Council for the Redevelopment of the Brunswick Naval Air Station.

For several years Ms. Mills has been a leading voice in the U.S. competitiveness discussion and is author of an influential Brookings Institution paper on the

federal role in regional economic development clusters—geographic concentrations of interconnected businesses that share knowledge and resources to spur innovation, economic growth, and higher wage employment.

Ms. Mills' work with boat builders in Maine in using composite materials to increase global competitiveness is one of the leading examples of the success of economic development clusters.

She is a member of the Council on Foreign Relations and has been vice chairman of the Harvard Overseers. Ms. Mills has an A.B. in economics from Harvard University and an M.B.A. from Harvard Business School where she was a Baker Scholar. Mills and her husband Barry Mills, president of Bowdoin College in Brunswick, Maine, have three sons.

DOUG PARKS

Doug Parks is senior vice president of business development & attraction for the Michigan Economic Development Corporation (MEDC). In his current role, he leads the MEDC's business development efforts focusing on national and international attraction, as well as Michigan expansion and retention. He leads a broad-based team who are all dedicated to continue to increase the economy of Michigan while leveraging the state's significant strengths.

Doug has filled several roles while at the MEDC. Earlier, as vice president of administration, he was responsible for managing the corporation's budget and finance, contracts and grants, office services, human resources, information technology, web development, telecommunications, and customer relationship management services. He also directed the efforts of the organization's research team. In addition, Doug has served as the MEDC's chief technology officer and as deputy director of the Travel Michigan Office.

Prior to joining the MEDC, Doug was a vice president at Valassis Communications, heading a division that developed print, software, and Web site solutions for travel industry organizations.

Doug is a retired U.S. Army Intelligence Officer and a graduate of Lake Superior State University.

MARIO PEZZINI

Mario Pezzini is deputy director in the Organisation for Economic Co-operation and Development (OECD) Public Governance and Territorial Development Directorate. Mr. Pezzini is in charge of the OECD activities that promote regional competitiveness and effectiveness of regional policies. In order to advise national governments and sub-national authorities, Mr. Pezzini coordinates the work of the OECD Territorial Development Policy Committee, the main international forum for debate in the field of regional policy. Twice a year this forum brings together officials from prime ministers' offices or national economic

ministries from the 30 OECD member countries to discuss within three working parties: Territorial Indicators, Territorial Policies in Urban Areas, and Territorial Policies in Rural Areas.

In his work, Mr. Pezzini liaises between the OECD and ministers, cabinet's members, and high-level policy makers. More recently, he has been increasingly engaged in promoting dialogue with non-member countries and has developed high-level cooperation with international organisations such as the World Bank, the Inter-American Development Bank, and the Council of Europe. Before joining the OECD, he was a professor in industrial economics at the *Ecole Nationale Superieure des Mines de Paris* as well as in U.S. and Italian universities. On several occasions Mr. Pezzini has served as an advisor for international organisations (UNIDO, UNDP, and ILO) and think tanks in the fields of economic development, industrial organization, and regional economics such as the Italian economics research institute, Nomisa. A member of several governmental advisory boards, Mr. Pezzini was also manager in the regional government of the Emilia-Romagna region in Italy.

ALBERTO DUQUE PORTUGAL

Alberto Duque Portugal is the Secretary of State for Science, Technology, and Higher Studies of Minas Gerais State Government.

Mr. Portugal is an agronomist engineer and graduated at the Federal University of Rio de Janeiro (UFRJ, Brazil). He also has a doctoral degree in agricultural systems from the University of Reading, England.

At the beginning of his professional life he worked as a technician and as a researcher. In 1983, he was the director of technical operations at EPAMIG—Agricultural Research Company of Minas Gerais and, four years later, he took over the coordination of the Technology Dissemination Sector of the National Center for Research of Dairy Cattle at EMBRAPA—Brazilian Agricultural Research Corporation. In 1993, he was named the executive director of EMBRAPA and left the office to work as executive secretary and Temporary Minister of Agriculture, Supply, and Agrarian Reform in Brazil. At the ministry, he coordinated and led the negotiations to implement the "Crop Plan" for the period 1993-1994 and worked at the negotiations of international agreements on export and import of agricultural products. He also acted to obtain the funding to implement the projects in the ministry.

At EMBRAPA, Mr. Portugal also worked as executive director and chairman for the period 1995-2003. During this time, he coordinated and implemented a management model with innovative features that represented an important contribution to management of public organizations of research and development and innovation.

Mr. Portugal also was director of the Agency for Innovation of UNICAMP—University of Campinas (São Paulo, Brazil), Assistant Secretary of State for

Agriculture, Cattle, and Supply of Minas Gerais State, and executive director of the National Council of Coffee.

J. STEPHEN ROTTLER

J. Stephen (Steve) Rottler is chief technology officer and vice president of science and technology at Sandia National Laboratories, which is located in Albuquerque, New Mexico, and Livermore, California. Dr. Rottler is the executive responsible for leadership and management of corporate research and development and capabilities stewardship at Sandia National Laboratories. He also is responsible for leadership of technology transfer and strategic relationships with universities, industry, and the state of New Mexico.

In his previous position as chief engineer for nuclear weapons and vice president of weapon engineering and product realization, Dr. Rottler was the central technical authority for nuclear weapons and led all nuclear weapon engineering and production activities at Sandia. Prior to that position, Dr. Rottler served in a number of senior leadership positions at the Laboratories. He has been responsible for nuclear warhead system engineering and integration, development of high-performance electronic systems, and performance of system analyses and assessments for Sandia and National Nuclear Security Administration senior management. He also managed organizations and programs responsible for the research, development, and application of advanced computational and experimental techniques in the engineering sciences. As a member of the technical staff at Sandia, Dr. Rottler was part of a research team that developed multidimensional radiation-hydrodynamics simulation codes for nuclear weapon applications, and he led projects that supported the development of advanced nuclear and conventional weapon concepts.

Dr. Rottler is a fellow of the American Institute of Aeronautics and Astronautics and past chair of the Institute's Technical Committee on Management. He is a recipient of the Department of the Air Force Award for Exemplary Civilian Service. Dr. Rottler is a fellow of Seminar XXI at the Massachusetts Institute of Technology. He serves on the boards of directors of the United Kingdom Atomic Weapons Establishment, New Mexico Computing Applications Center, New Mexico Humanities Council, and Explora Science Museum. He is a member of the external advisory board for the Texas A&M University Dwight Look College of Engineering. He has led or served on independent review panels for the U.S. Navy Strategic Systems Programs Office and the United Kingdom Atomic Weapons Establishment.

Dr. Rottler received his B.S., M.S., and Ph.D. degrees in nuclear engineering from Texas A&M University in 1980, 1982, and 1984, respectively. He has published papers, reports, and conference presentations on the development and application of computational radiation-hydrodynamics codes.

Dr. Rottler and his wife have two children and reside in Albuquerque, New

Mexico. In his spare time, he finds relaxation through golf, long-distance running, and year-round hiking and camping in the mountains of New Mexico and Colorado. He is also an amateur astronomer, and enjoys the study of music, foreign affairs, and U.S., English, and world history.

MARC G. STANLEY

Marc G. Stanley is currently serving as acting deputy director of the National Institute of Standards and Technology (NIST), effective December 1, 2009. Mr. Stanley has served as director of the Technology Innovation Program (TIP) at NIST since December 31, 2007. He was appointed acting director of TIP on September 10, 2007. He also serves as a U.S. governor on the Israel-U.S. bi-national Industrial Research and Development (BIRD) Foundation Board of Governors and as the American director on the Trilateral Industrial Development (TRIDE) Executive Committee.

Mr. Stanley served as the director of the Advanced Technology Program (ATP) since June 2003. He was the acting director of ATP from 2001 to 2003 and as the associate director for ATP from 1993 to 2001.

Before going to NIST, Mr. Stanley was the Associate Deputy Secretary of the U.S. Department of Commerce (DoC) by Presidential appointment. He served as counselor to the NIST director, as a consultant to DoC's Technology Administration, and as Assistant Secretary for Congressional and Intergovernmental Affairs at DoC.

Mr. Stanley earned a B.A. from George Washington University and a bachelor of law degree from the University of Baltimore.

ASHLEY J. STEVENS

Ashley J. Stevens is the president-elect of the Association of University Technology Managers and the special assistant to the vice president for research at Boston University, following 15 years as director of the Office of Technology Transfer and then executive director for technology transfer in the Office of Technology Development. In his current capacity, he has been tasked with creating university-wide teaching and research programs on the role of intellectual property in the transformation of ideas, knowledge, and creative works into economic development.

He also is senior research associate in the Institute for Technology Entrepreneurship and Commercialization in Boston University's School of Management, where he teaches two graduate-level, inter-disciplinary courses on technology commercialization. Before joining Boston University, he was director of the Office of Technology Transfer at the Dana-Farber Cancer Institute, a teaching affiliate of the Harvard Medical School.

Since he joined Boston University, the Office of Technology Development

has grown to a total of 16 professionals and has spun out over 50 companies based on the university's research, a number of which have raised substantial amounts of capital, and the university's licensing income has climbed steadily.

Prior to entering the technology transfer profession, Dr. Stevens worked in the biotechnology industry for nearly 10 years. He was a co-founder of Kytogenics, Inc., of which he is still a director, was co-founder and general manager of Genmap, Inc., and was vice president of business development for BioTechnica International. He started his career with The Procter & Gamble Company, where he held a number of positions in sales, marketing, strategic planning, and acquisitions.

Dr. Stevens publishes and lectures frequently on many aspects of technology transfer, including the Bayh-Dole Act, the economic impact of technology transfer and its role in economic development, the contribution of academia to the discovery of new drugs and vaccines, and the role of technology transfer in global health and technology valuation. He was the recipient of the Bayh-Dole Award at the Association of University Technology Managers' (AUTM's) 2007 Annual Meeting and was recently elected president-elect of AUTM. He will become president of AUTM in March 2010. He is also active in the Licensing Executives Society and the Massachusetts Biotechnology Council.

Dr. Stevens holds a B.A. in natural sciences and an M.A. and a D.Phil. in physical chemistry from Oxford University. He is a Certified Licensing Professional.

CHARLES WESSNER

Charles Wessner is a National Academy Scholar and director of the Program on Technology, Innovation, and Entrepreneurship. He is recognized nationally and internationally for his expertise on innovation policy, including public-private partnerships, entrepreneurship, early-stage financing for new firms, and the special needs and benefits of high-technology industry. He testifies to the U.S. Congress and major national commissions, advises agencies of the U.S. government and international organizations, and lectures at major universities in the United States and abroad. Reflecting the strong global interest in innovation, he is frequently asked to address issues of shared policy interest with foreign governments, universities, research institutes, and international organizations, often briefing government ministers and senior officials. He has a strong commitment to international cooperation, reflected in his work with a wide variety of countries around the world.

Dr. Wessner's work addresses the linkages between science-based economic growth, entrepreneurship, new technology development, university-industry clusters, regional development, small-firm finance and public-private partnerships. His program at the National Academies also addresses policy issues associated with international technology cooperation, investment, and trade in high-technology industries.

Currently, he directs a series of studies centered on government measures to encourage entrepreneurship and support the development of new technologies and the cooperation between industry, universities, laboratories, and government to capitalize on a nation's investment in research. Foremost among these is a congressionally mandated study of the Small Business Innovation Research (SBIR) Program, reviewing the operation and achievements of this $2.3 billion award program for small companies and start-ups. He also is directing a major study on best practice in global innovation programs, titled *Comparative National Innovation Policies: Best Practice for the 21st Century*. Today's meeting on "Clustering for 21st Century Prosperity" forms part of a complementary analysis entitled *Competing in the 21st Century: Best Practice in State & Regional Innovation Initiatives*. The overarching goal of Dr. Wessner's work is to develop a better understanding of how we can bring new technologies forward to address global challenges in health, climate, energy, water, infrastructure, and security.

KEN ZWEIBEL

Ken Zweibel is the founding director of the George Washington University Solar Institute. He has almost 30 years of experience in solar photovoltaics (PV). He was the program leader for the Thin Film PV Partnership Program at the National Renewable Energy Lab until 2006. The Thin Film Partnership worked with most participants in thin film PV (companies, universities, scientists) and is often credited with being crucial to the development of thin film PV in the United States. Corporate graduates of the Partnership include First Solar, Unisolar, Global Solar, and numerous others. Ken subsequently co-founded and became president and chairman of a thin film CdTe PV start-up, PrimeStar Solar. PrimeStar was subsequently purchased by General Electric and is now the feature company in its solar portfolio. In 2008 he became founding director of The George Washington University Solar Institute.

Ken is well known worldwide in solar energy. Recently, he co-authored a *Scientific American* article (January 2008) on solar PV and concentrating solar power as solutions to climate change and energy problems. He also has written two books and numerous articles on solar PV. He is participating on the Department of Energy "Solar Vision" activity, which is defining a pathway for solar to be deployed on an energy significant scale in the United States. Ken is a graduate of the University of Chicago in physics.

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