Building the Ohio Innovation Economy: Summary of a Symposium

ISBN
978-0-309-26676-5

203 pages
6 x 9
PAPERBACK (2013)

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; National Research Council

Building the Ohio Innovation Economy

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

NATIONAL RESEARCH COUNCIL
OF THE NATIONAL ACADEMIES

THE NATIONAL ACADEMIES PRESS
Washington, D.C.
www.nap.edu

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This study was supported by: Contract/Grant No. DE-DT0000236, TO #28 (base award DE-AM01-04PI45013), between the National Academy of Sciences and the Department of Energy; and Contract/Grant No. N01-OD-4-2139, TO #250 between the National Academy of Sciences and the National Institutes of Health. This report was prepared by the National Academy of Sciences under award number SB134106Z0011, TO# 4 (68059), from the U.S. Department of Commerce, National Institute of Standards and Technology (NIST). This report was prepared by the National Academy of Sciences under award number 99-06-07543-02 from the Economic Development Administration, U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the National Institute of Standards and Technology, the Economic Development Administration, or the U.S. Department of Commerce. Additional support was provided by The University of Akron, NorTech, Case Western Reserve University, Morgenthaler, Jones Day, Cleveland Foundation, The George Gund Foundation, Austen BioInnovation Institute in Akron, The Burton D. Morgan Foundation, Cleveland State University, Kent State University, KeyCorp, Lorain County Community College, Medical Mutual of Ohio, the Heinz Endowments, the Association of University Research Parks, Acciona Energy, Dow Corning, IBM, and SkyFuel, Inc.

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International Standard Book Number 13: 978-0-309-26676-5
International Standard Book Number 10: 0-309-26676-9

Additional copies of this report are available for sale from the National Academies Press, 500 Fifth Street, NW, Keck 360, Washington, DC 20001; (800) 624-6242 or (202) 334-3313; http://www.nap.edu/.

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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 innovation clusters. These state and regionally based initiatives have a broad range of goals and increasingly include significant resources, often with a sector focus and often in partnership with foundations and universities. These are being joined by recent initiatives to coordinate and concentrate investments from a variety of federal agencies that provide significant resources to develop regional centers of innovation, business incubators, and other strategies to encourage entrepreneurship and high-tech development.

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 regional programs 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 new technology focus areas such as nanotechnology, stem cells, and energy in order to improve our understanding of 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 practices 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.[1] 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.[2] They believe that the rising costs and risks associated with new potentially high-payoff technologies, and the growing global dispersal of 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.[3] 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 that 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

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[1]For a review of growth of national programs and policies around the world to support research and accelerate innovation, and the resulting challenges facing the United States, see National Research Council, *Rising the Challenge: U.S. Innovation Policies for the Global Economy*, Charles W. Wessner and Alan. Wm. Wolff, eds., Washington, DC: The National Academies Press, 2012.

[2]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—Report of a Symposium*, Charles W. Wessner, ed., Washington, DC: The National Academies Press, 2009.

[3]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.

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

The symposium reported in this volume convened state officials and staff, business leaders, and leading national figures in early-stage finance, technology, engineering, education, and state and federal policies to review challenges, plans, and opportunities for innovation-led growth in Ohio. The symposium also included an assessment of the state's industrial, and human resources; identification of key sectors and issues; and a discussion of how the state might leverage its universities, development organizations, philanthropic foundations, and national programs focused on manufacturing and innovation to support its economic development goals. Given the location of the conference, a number of speakers highlighted regional initiatives in northeast Ohio although initiatives elsewhere in the state were also given prominence.

The scope of the conference, as with any single meeting, was necessarily limited. The conference rightly placed great emphasis on a wide variety of initiatives underway in Ohio to spur entrepreneurship and grow new industries rather than on how existing large employers are adapting to global competition. Similarly, little attention was focused on the state's investments in its broadband infrastructure, even though this effort is a key element in the state's future capabilities. The role of large employers and automotive supply chains are arguably understated, but this reflects the conference focus. At the same time, the conference did take up initiatives underway at some of Ohio's "traditional" manufacturing industries. For example, the report captures the key factors leading to the turnaround of Timken, a leading manufacturer of steel bearings, and also addresses the new commercial thrust of the region's well-established medical industry.

This summary includes an introduction that highlights key issues raised at the meeting and a summary 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 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 would like to extend special recognition and thanks to Luis Proenza, the President of the University of Akron, for his leadership in bringing this conference to fruition. Special recognition is also due to David Morgenthaler of the STEP Board and Richard Pogue for their leadership and support in galvanizing leading figures in Ohio's business, education, and innovation communities to participate in this activity. We also wish to recognize the key role of NorTech's Rebecca Bagley and Beth Elliot in the planning, support, and organization of the meeting. In addition, we are indebted to Alan Anderson for preparing the draft introduction and summarizing the proceedings of the meeting, as we are to Sujai Shivakumar for his substantive contributions and editorial skills.

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: Anna Barker, Arizona State University; Albert Green, Kent Displays, Inc.; Ellen Perduyn, University of Akron Foundation; and, Stephanie Shipp, Institute for Defense Analyses.

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

Ohio is seeking to revive its once globally competitive economy. According to Cleveland-based venture capitalist David Morgenthaler, "in 1950, Cleveland was king of world. We had world-class manufacturing facilities. … We had 50 of the Fortune 500 headquarters, and were one of the leading manufacturing centers of the world." However, Cleveland was slow to respond when change came. The area had a powerful economic driver in the automobile, from 1900 to 1960, "and unfortunately the region rode it for another 40 years without recognizing that we had missed two new industrial revolutions, the electronics revolution and the biotech revolution." The state and the region are taking important steps to make up for that now, said Mr. Morgenthaler. "We're making investments to maintain the level of economic activity that we've become accustomed to, and to adapt to the changing global economy." [1] These initiatives include a wide range of public-private organizations to bring industry, academia, state and regional governments, and federal agencies together with a common goal of fostering innovation, entrepreneurship, and economic growth.

To document these initiatives, the National Academies Board on Science, Technology, and Economic Policy convened a conference to discuss the variety of initiatives underway to strengthen Ohio's innovation and technology infrastructure and identify areas where federal, state, and foundation contributions could generate positive synergies. The conference also sought to draw attention to the scale and focus of foreign competitive programs and consider their implications for Ohio and the nation, and highlight Ohio's potential as a center for innovation.

In his welcoming address, Richard Pogue, Senior Advisor to Jones Day, identified the key goals of the conference. The first, he said, was to highlight the "global challenges we all face in this very dynamic worldwide economy"—challenges that could be turned into export opportunities for American firms. The second was the effects of global competition on the economy in Ohio, specifically northeast Ohio. The state's response to these challenges, he said, will determine the kind of place Ohio would be in the future. He added that the conference would also review the "substantial progress we're

[1] Daniel R. Denison and Stuart L. Hart, *Revival in the Rust Belt: Tracking the Evolution of an Urban Industrial Region (Research Report Series),* Ann Arbor: Institute for Social Research, 1987.

Box A
Background:
A century of industrial leadership, followed by decline

Blessed with abundant forests, iron ore, water, coal, petroleum, and other natural resources, Ohio was able to generate agricultural and then industrial wealth almost from the time of its initial European settlement. First surveyed by George Washington during the 1750s, Ohio introduced and adopted new industries throughout the 19th century. One of the nation's first iron manufacturing plants opened near Youngstown in 1804. By the mid-nineteenth century, 48 blast furnaces were operating in the state. By 1853, Cleveland was the third largest iron and steel producer in the country, and its Cleveland Rolling Mill Company became part of U.S. Steel, the first billion-dollar U.S. corporation.[a] Cyrus McCormick of Cincinnati invented the McCormick reaper; Dayton was home to the National Cash Register Co.; Herbert Dow, a chemistry graduate of Case Western Reserve, founded Dow Chemical with financing from Cleveland investors. All three of the nation's giant tire companies, Goodyear, Firestone, and Goodrich, grew up in Akron. By the end of the 19th century, northeast Ohio was a global industrial center, linked by the Great Lakes, the Erie Canal, and new railroads to markets around the world.[b]

In addition to its natural resources, the state was home to important innovators. William Procter and James Gamble of Cincinnati built a company around an inexpensive floating soap called Ivory; today P&G is the world's largest consumer products corporation. Wilbur and Orville Wright grew up in Dayton; Michael Owen's glass-blowing company gave rise to Owens-Illinois and Owens Corning; and Charles Kettering co-founded Delco Electronics around his invention of the automatic starter for automobiles. Researchers at Battelle Memorial Institute perfected xerography; Albert Sabin developed the first oral polio vaccine; Noah McVicker concocted a resilient wallpaper cleaner for the Cincinnati school system that became Play-Doh.

'Unparalleled' Decline

During the first half of the 20th century, Ohio's economy was buoyed by its steel, auto, rubber, and aerospace industries. By the 1970s, many of these key heavy industries were subject to growing competition from abroad; at the same time, the state failed to invest sufficiently in the university infrastructure and to attract rapidly growing industries such as electronics and biomedicine.

The Impact

A steady decline in jobs, population, and competitiveness followed, particularly in Ohio's industrial cities. During the recession of 2009, the state

lost 376,500 jobs and suffered some 89,000 housing foreclosures. A drive through modern Cleveland reveals vast stretches of abandoned industrial facilities. Speaking at the conference, Dr. Lavea Brachman of the Greater Ohio Policy Center called the economic decline of northeast Ohio "unparalleled."

[a]Wikipedia, "History of Ohio," Accessed on November 9, 2012.
[b]Joel Garreau, *The Nine Nations of North America,* Boston: Houghton-Mifflin, 1981.

making, particularly in this region but throughout the state, in bringing together the public and private sectors to cooperate and create opportunities for the Ohio economy." The fourth theme, he said, was to explore ways in which the sectors of society can work together in partnership, including the federal government, state government, Ohio foundations, the private sector, investors, and major universities.

A. THE GLOBAL INNOVATION CHALLENGE

In his conference remarks, Dr. Luis Proenza of the University of Akron observed that "the primacy that America has long enjoyed around the world is increasingly being challenged by the very same forces of technological innovation that America has itself unleashed."

He turned to some significant shifts in global investment in research and development, which today totals more than $1 trillion. Global R&D expenditure is dominated by ten countries that together account for almost 80 percent of that the world total. The U.S. alone invests nearly $400 billion annually in R&D. Its present global share of 33 percent, however, has declined from 44 percent five years ago. He said that this relative decline is caused largely by the growth in China's R&D investment at an average of 19 percent during the past decade, moving that nation beyond Japan for second place in R&D investments in 2011.

In his conference remarks, Charles Wessner of the National Academies said that countries around the world are working hard on their own innovation strategies. "These nations recognize that innovation policy is not a hobby," he said. "It is not something you do when you have done everything else on your day-to-day policy agenda. It is the main game, the job of state and federal governments at macro and micro levels. We need to support funding for research, and we need to convert that research into competitive products for the market."

Major U.S. trading partners, Dr. Wessner said, have placed innovation high on their list of national priorities. Leading countries and regions are providing a high-level focus on growth and strength, sustained support for universities, consistent funding for research, imaginative support for small businesses, and support for government-industry partnerships that bring new

products and services to market. "They're committed, they're focused, and they're willing to spend."

In his remarks, Dr. Proenza observed that that although China's R&D spending is presently 1.5 percent of its gross domestic product, compared to 2.7 percent in the United States, but added that China's R&D share of GDP has doubled in the last 10 years. While U.S. spending on R&D is still well beyond that of its closest competitors, the gap between it and other nations is narrowing.

Dr. Proenza went on to say that many countries abroad succeed economically by aligning their R&D strategies with their economic objectives. Other countries and cross-national organizations, he said, appear to be more successful at this than the United States, especially European and Asian countries that focus on public-private partnerships to stimulate their economic development. "I think that the United States can learn a great deal from what these countries are doing," he said, "and indeed the Academies' STEP Board is seeking to identify the best approaches from around the world to better understand the new global challenge and to develop recommendations for the U.S. Government.[2]

B. BUILDING OHIO'S INNOVATION ECONOMY

To revive its economy, Ohio must address its weaknesses and build on its strengths. In her conference remarks, Lavea Brachman of the Brookings Institution noted that, on one hand, the extent of economic decline in Ohio was "unparalleled." On the other hand, she observed, the state's economy is highly diverse, covering seven or so major metropolitan areas with long traditions in manufacturing. (See Figure 1 for a map of Ohio.) Dayton specialized in autos, Toledo in glass, Youngstown in rubber, and so on. Reconciling both these weaknesses and strengths is a challenge as Ohio seeks to build an innovation-based economy. "We're sort of stuck with older economies that still exist. With the layering on top of those older industries, it is harder to identify the key growing clusters." It is also a challenge to connect regional economic growth and the power of the metros with neighborhood revitalization. The cities have emptied out, leaving high concentrations of poverty. For example the population of Cleveland dropped from 900,000 to 400,000 between 1950 and 2010, the population of Cincinnati from 500,000 to 300,000. A disconnect persists between skill level and job creation, and the fragmentation of government makes collaboration more difficult.

[2]For a wide-ranging review of innovation policies around the world and recommendations for sustaining U.S. technological leadership in a changing competitive environment, see National Research Council, *Rising to the Challenge: U.S. Innovation Policy for the Global Economy*, Charles W. Wessner and Alan. Wm. Wolff, eds., Washington, DC: The National Academies Press, 2012.

FIGURE 1 Map of the State of Ohio.
SOURCE: U.S. Geological Survey, 2012.

At the same time, Ms. Brachman added, there are opportunities.[3] Most notably, the state's economic landscape is defined by clusters of concentrated industrial activity rooted in each of its major cities. These seven or eight clusters present a unique opportunity for Ohio; other states such as Illinois and Indiana have only one major city. "Theoretically," she said, "if the metro and regional economies are our drivers, we have many of those. We just have to figure out how to leverage them and return ourselves to a basis where each of these cities can thrive uniquely. We can also make good use of multiple anchor institutions rooted by place, such as the University of Cincinnati, the Uptown Consortium, and University Circle in Cleveland."

Ohio's Innovation Challenges

James Griffith of Timken, a large Ohio-based manufacturer of steel bearings, noted at the conference that the state and its regions no longer benefit from the wealth and leadership of its heavy industries to the degree they once did. Their workforces, accustomed for many years to the presence of established industries and production practices, have not always developed the new skills

[3]See Jennifer Bradley, Lavea Brachman, and Bruce Katz, "Restoring prosperity: transforming Ohio's communities for the next economy," Washington, DC: The Brookings Institution, 2010.

necessary to adapt to global competition. And while the northeast region is home to many small and medium-sized firms, most were accustomed to serving as suppliers for larger firms rather than focused on bringing new technologies to the market. "Many of them," Griffith said, "were founded as outsource suppliers to big companies like Timken, and they have to acquire the skills of innovation and better access to high technology."

John West of Kent State University noted that Ohio is learning from its recent experience of developing liquid crystal displays (LCD) technology but then watching its early leadership slip away to other countries that developed significant programs to promote applied research and support manufacturing.[4] Responding to these challenges Ohio is developing new strategies to rebuild its institutional and economic base. These strategies, as documented in the proceedings of this conference, seek to build on the region's research and development base, capitalize on investments by the federal government, and leverage the catalytic role of regional philanthropic organizations.

Innovation and Economic Development

As several speakers noted at the conference, changing the region's fortunes requires a shift from standard economic development strategies to an approach that capitalizes on knowledge and innovation. Traditional economic development strategies call on policy makers, political leaders, or community members to strengthen the standard of living and economic growth through more human capital, financial capital, and business infrastructure.[5]

Analyses by MIT economist Robert Solow and others emphasized that knowledge, along with capital and labor, is an essential driver of economic development.[6] More specifically, they showed that scientific and engineering knowledge, generated largely by research universities with funding from the Federal government, is a primary driver of new ideas that find value through the invention, innovation and commercialization at scale. This process further

[4]Kent State University's Liquid Crystal Institute helped pioneer LCD technology and patented the first LCD wristwatch in 1971. Yet Japanese, Korean, and Taiwanese companies have dominated the vast LCD display industry for decades. For a historical review, see Insoo Han et al., "Changes in Competitiveness of LCD Industry of East Asia: From Bamboo Capitalism to Water Lily," *International Telecommunications Policy Review*, 19(1), 2012. Likewise, the University of Toledo has been at the forefront in thin-film photovoltaic technology. Yet little manufacturing of solar cells and modules has been based northeastern Ohio. See presentation by Norman Johnston of Solar Fields, Calyxo, and Ohio Advanced Energy in National Research Council, *The Future of Photovoltaics Manufacturing in the United States: Summary of Two Symposia*, Charles W. Wessner, ed., Washington, DC: The National Academies Press, 2011.

[5]Ricardo Conteras, "How the Concept of Development Got Started," University of Iowa Center for International Finance and Development E-Book, *<http://www.uiowa.edu/ifdebook/ebook2/contents/part1-I.shtml>*.

[6]Robert M. Solow, "Technical change and the aggregate production function," *The Review of Economics and Statistics* 39(3):312-320, 1957. Solow attributes nearly 90 percent of U.S. economic growth during the period 1909-1949 to improvements in technology.

depends on entrepreneurship and access to capital. Together, these activities were understood to stimulate economic growth and global competitiveness.[7]

More recently, economists have pointed out that innovation-based development relies on successful cooperation among a variety of participants to develop new research ideas into market competitive products and services.[8] Innovation is thus more focused on services, processes, and ways of communicating, partnering, and working together—not just about creating the next best widget. This new paradigm calls for more public investment and risk taking, developing trust through collaboration, ensuring responsiveness to partners' missions, and building consensus among all constituents.

This cooperation can falter where there are market failures. For example, information asymmetries can lead to the "valley of death," a perilous stage when the inventor runs out of money before investors, who lack the necessary information, are ready to join in.[9] Because young, knowledge-based firms tend to face both technical and financial risks as they mature, most of them perish before achieving the commercial success necessary for their survival. A robust industrial commons that includes effective intermediating institutions can help solve many of these challenges of collective action.

Reviving the Industrial Commons

In order to cross the valley of death, a young firm needs not only financing, but also a host of relationships, perspectives, and resources, many of which are local or regional in scope. Elements of what is sometimes called the industrial commons" include engineering R&D, materials, standards, tools, equipment, and scalable processes, components and manufacturing competencies. These elements underpin the "platform technologies" needed to produce cost-effective, safe, and reliable products.[10] As Sridhar Kota, then of White House Office of Science and Technology Policy, noted at the conference, a weakening industrial commons erodes strength in manufacturing, and without

[7]According to EDA, "Because regions compete in a global economy, they must have an economic base of firms that constantly innovate and maximize the use of technology in the workplace." For this reason, "Technology-based economic development is the approach used to help create a climate where that new economic base can thrive." Economic Development Administration, *A Resource Guide for Technology-Based Economic Development,* Washington, DC: Economic Development Administration, 2006.

[8]See, for example, H. W. Chesbrough, "A better way to innovate," *Harvard Business Review* 81(7):12-13, 2003. See also J. E. L. Bercovitz and M. Feldman, "Fishing upstream: firm innovation strategy and university research alliances," *Research Policy* 36(7):930-948, 2007. See also Pedro de Faria, Francisco Lima, and Rui Santos, "Cooperation in innovation activities: The importance of partners," *Research Policy* 39(8):1082-1092, 2010.

[9]George Akerlof, Michael Spence, and Joseph Stiglitz were awarded the 2001 Nobel Prize in Economics for their contributions to the understanding of Asymmetric Information. Even firms with venture funding have high failure rates.

[10]Gary P. Pisano and Willy C. Shih, "Restoring American Competitiveness," *Harvard Business Review* July 2009.

manufacturing and its feedbacks to designers comes lowered ability to innovate next-generation products.

Ohio is trying to pull together many of the actors in its innovation ecosystem, including the universities and community colleges, private companies, private capital, state and local governments, foundations, and NGOs though a series of state and regional initiatives.

C. OHIO'S INNOVATION INTERMEDIARIES

The conference presentations highlighted the emergence of a number of small, agile, flexible "innovation intermediaries" in Ohio that specialize in seed funding, business formation, or business incubation. Because they are typically homegrown and linked with local organizations, their missions are often adapted to local needs and benefit from the bonds of personal trust. In many cases, these small economic development organizations benefit from strong leadership, backed by active linkages with academia, industry, philanthropic organizations, and state and local government. The conference presentations also emphasized the importance of regional clusters and multi-party partnerships in developing state and regional innovation ecosystems.

Representatives of some of Ohio's leading innovation intermediaries described the mission of their organizations at the conference:

- **NorTech** is a nonprofit economic development organization that champions growth in northeastern Ohio. Speaking at the conference, NorTech's Rebecca Bagley said that her organization develops regional innovation clusters by attracting new members, building relationships, creating market-driven roadmaps, engaging with government, and utilizing data and metrics. "The important point," she said, "is that we develop a model that operationalizes the desire to accelerate emerging industry clusters." This is done by a partnership of companies, including larger companies, and the goal is to reduce the time required to strengthen a given sector.
- **BioEnterprise** is a leading development catalyst for growing the Ohio biomedical sector. According to Baiju Shah, BioEnterprise's director, health care had been the leading growth sector of the Cleveland region for most of the past decade. He included not just health care delivery, led by the Cleveland Clinic, but also the health care industry as well. "Nor is this an accident," he said. "In 2001, our health care leadership and civic leadership came together and established the goal of making northeast Ohio a nationally recognized center for health care innovation. Those leaders recognized that this could not be the role of any single institution, but had to be a collective commitment, including investments in translational research capabilities, the identification of capital sources, and supportive state policy in the form of the statewide

Third Frontier program.[11] It required investments in talent to help professional service firms reposition themselves and allow manufacturing firms to realign the supply chains. It required changed perspectives of clinicians and clinical institutions in their willingness to work with innovations.

- **Jumpstart** works toward economic transformation by providing resources to entrepreneurs to grow their high-potential, early-stage companies. Speaking at the conference, Jumpstart's Ray Leach said that his organization "directly invests in and assists entrepreneurs leading high growth companies in the Greater Cleveland area." Jumpstart also works "to develop the region's entrepreneurial ecosystem by raising funds for other support organizations and by managing a network of incubators, accelerators, and investors."
- **Magnet** *(*the Manufacturing Advocacy and Growth Network) is a not-for-profit economic development enterprise that supports Ohio-based manufacturing. It provides consulting services to help companies realize higher efficiencies through increased productivity and process improvement programs. It also helps companies improve top-line sales through a variety of new product development and growth strategies. Speaking at the conference, James Griffith (who serves on MAGNET's board) observed that a part of the mission of MAGNET is to better link manufacturers and universities, so that students acquire the skills needed by the manufacturers.

These and other participants cited some best practices they strive to instill in Ohio's innovative companies, including independence, continuous reinvention, private sector leadership, accountability, longevity, and inclusion of bipartisan champions. They also described how they often act in concert with each other while following their own particular missions. Describing northeast Ohio's evolving innovation ecosystem, Lisa Delp of the Ohio Department of Development remarked that "the collaborative nature of the organizations here is frankly phenomenal." Rebecca Bagley, executive director of NorTech, agreed, saying that the region's economic development strategy "includes all the partners: Jumpstart, BioEnterprise, Magnet, and NorTech." Similarly, its cluster strategy involves forming a partnership of companies, building relationships, and "reducing the time required to strengthen a given sector."

D. THE ROLE OF INDUSTRY

Illustrating the positive role that industry can play in the revival of the region's economy, Mr. Griffith said that he became involved in economic development in northeast Ohio "because we were going through a

[11]Begun in 2002, the Third Frontier is an economic development initiative by the State of Ohio to expand research and technology economic development in the state.

transformation at Timken" which applied directly to issues experienced by other manufacturers. Like Ohio, Mr. Griffith said, Timken has a strong heritage of success. From 1960 to 1980, the firm performed strongly, with returns on invested capital above 20 percent year after year.

This changed in the 1980s when profits shrank into losses, and for the next 20 years, Mr. Griffith said, the company struggled to right itself. In the late 1990s the company changed its strategy and profits began to return, and after 2009 they reached record levels. "How we did this is not a secret," Mr. Griffith said, "and it didn't happen overnight. It is the result of a ten-year application of a highly focused strategy." This "grow and optimize," strategy, he said, began with an understanding of where the company best differentiates itself from others, and identifies which markets to target. "We were a bearing company when we started. We're still mostly a bearing and steel company. But we've learned to take the technology and apply it to markets where we could differentiate and expand."

Timken had to be "the world's best manufacturer of steel bearings," he said, so the company invested heavily in growing, building its skills, and spent a quarter of billion dollars redoing the company's systems infrastructure. At the same time, Mr. Griffith added, "we had to divest $1.5 billion worth of businesses that we couldn't win in, and we closed 30 manufacturing sites in northeast Ohio. That's the hard side to innovation."

In addition to reviving the region's traditional industries, speakers at the conference also discussed efforts to encourage the growth of new industries—in particular, the biomedical, flexible electronics, and energy sectors—in northeast Ohio through university-industry partnerships. In his presentation, Dr. Toby Cosgrove of the Cleveland Clinic noted that after many early failures to commercialize new biomedical products and services developed by its doctors and researchers, the Cleveland Clinic instituted in 2000 a freestanding venture capital firm, and a tech-transfer organization called Cleveland Clinic Innovations. Through these organizations, the Clinic encouraged doctors to bring forth their innovative ideas. They also provided some financial and support resources, including legal advice, space, and other forms of encouragement.

Northeast Ohio is also seeking to develop its renewable energy. At the conference, Lorry Wagner described the initiatives of LEEDCo, the Lake Erie Energy Development Corporation, to make Cleveland a national and perhaps an international leader in offshore wind power. Created by the Great Lakes Energy Development Task Force, LEEDCo is supported by a diverse partnership including the Cleveland Foundation, NorTech, Lake County, Ashtabula County, Cuyahoga County, Lorrain County, and the city of Cleveland. If it is successful in building and installing its initial 20- to 30-megawatt pilot project, he said, it will be the first offshore freshwater wind energy project in North America.

Statewide, Ohio is also poised to benefit from new sources of energy production. In his presentation, David Wilhelm described his ambitious plans to develop a solar project "that will be the largest ever constructed east of the

Rockies when it is finished in 2014." Mr. Wilhelm said that he realized that the coal companies had erected a vast electricity infrastructure to strip mine coal in southeastern Ohio, most of which was still in place. "It was a utility-scale solar project waiting to happen," he realized. He said that he planned to buy 250,000 solar panels, and that the likely European manufacturer would base its permanent North American operation in Ohio, creating 350 manufacturing jobs. "We are absolutely building out an Ohio-based supply chain in every instance we can," he said. "We are a state of steel vendors. ... Already in Cleveland is a manufacturer of silver paste supplying the solar industry in the U.S. We are going to create a total of at least 650 direct jobs, and probably four times as many indirect jobs."

Mr. Wilhelm recalled many energy technologies in which Ohio had been a national leader. The first U.S. oil derrick was built in Ohio; more coal was transported out of Nelsonville, Ohio, than any other train station. "Today," he said, "when you study this transitional energy economy, you see the opportunities that exist here. We can build nuclear containment vessels; for natural gas, we have the Marcellus shale and the Utica shale; for carbon sequestration, the Mount Simon formation covers much of western Ohio."[12]

E. THE ROLE OF OHIO'S UNIVERSITIES

Ross DeVol of the Milken Institute reminded the conference audience that "universities are the most important assets of an innovation economy," and that "among high-tech clusters, those most successful in building a regional economy have universities that recognize that role." Effective university participation is most often determined by the leadership of the president or chancellor. Mr. DeVol added that the largest contribution by a university, especially a public university, is simply the willingness to work with industry in ways that can speed their technology development. This includes providing access to relevant research or agreeing to jointly favorable licensing arrangements.

In his conference remarks, Luis Proenza, President of the University of Akron, said that "developing and attracting talent, particularly entrepreneurial and competitively funded scientists and engineers, is considered the essential ingredient for any economic development strategy."

Dr. Proenza noted that as late as the 1990s, a majority of university leaders were reluctant to get involved in "any aspect of economic development."

[12]Preliminary estimates by Ohio's Department of Natural Resources (ODNR) suggest a recoverable reserve potential of between 1.3 and 5.5 billion barrels of oil as well as 3.8 to 15.7 trillion cubic feet of natural gas. The overall economic value of the Utica Shale region in Ohio may be especially large, because it lies relatively close to the surface, which reduces exploration and development costs. The expected drop in natural gas prices is expected to yield significant benefits for Ohio energy consumers as well as the public at large. Access at *<https://ohiodnr.com/tabid/23415/default.aspx>*.

Box B
Fostering University-Industry Cooperation

Moderating the panel on universities as drivers of regional growth and employment, William Harris of Science Foundation Arizona observed the difficulty often experienced by businesses in dealing with the academic community. "The university community often says they are easy to deal with," he said, "but to the average citizen, the universities have a wall around them and it is hard to make contact. I have seen that in Arizona, where I work, and in South Carolina where I also worked, and other places."

By contrast, he said, he had worked in Ireland where he found the opposite—"an academic community with a hunger to be more successful in working with the business community. The Irish recognized that if academia didn't find a way to work with industry, it was likely that their industry was going to move to China, or Eastern Europe, where they could find cheaper manufacturing." While Ireland had major banking and real estate problems, they were still sustained by a serious biotechnology industry, he said, which manufactured nine of the ten top-selling drugs in the world. They also manufactured more software than any other country. "The presidents of the universities, in particular, were willing to try new things to help bolster their manufacturing. They had to try to protect that technology base. And they have done so, by creating friendly approaches to IP and making it easy to contact and work with the faculty."

He called this "a major disconnect in our innovation ecosystem," which he and several colleagues worked hard to change. For the last 12 years, the University of Akron has sought to play an active role in Ohio's innovation-based economic development. According to Dr. Proenza, "The universities, especially public universities, cannot exist in the future if they do not become relevant in their communities. They cannot be isolated as ivory towers. To prosper, they must be connected with other sectors of the community." His primary hope for the "Akron model," as he calls his university's approach, is that it functions as a "broad-based and robust platform for economic engagement."

Among the many university programs for broad-based engagement, Dr. Proenza highlighted the following:

- **The University of Akron Research Foundation** is "the core of the university's programs," he said "— a "robust, boundary-spanning" organization. He said that its activities go beyond those of mainstream technology offices, most of which focus primarily on traditional licensing and commercialization agreements. Among the foundation's unusual initiatives has been a project to develop an inventory of "Rust

Belt-era assets" and assemble them for productive uses. The university has also identified potentially useful space and equipment that is underutilized; inventoried the university's patent portfolio to make it more productive; and partnered with companies to make better use of their neglected, non-core technologies.

- **The University-Park Alliance** is a joint creation of the University of Akron and the Knight Foundation that seeks to revitalize a 50-block, 1,000-acre area adjacent to the university. To date, outcomes include more than $300 million in private sector investment, some 920 new jobs, 80 new housing units, and 34 acres of green space.
- **The ARCHAngel network**, formed in 2005 under sponsorship of the Research Foundation, seeks to "create wealth in the northeast Ohio community" through networks and partnerships among universities, industry, the business leadership, and regional governments. The network provides not only investment financing for promising young firms, but also advice, services, and mentoring from business leaders and volunteers who wish to "give back to the community."
- **The Austen BioInnovation Institute**, a joint venture with the Knight Foundation, three hospitals, and the medical school works to join the university's expertise in materials science with the hospitals' skills in orthopedic and wound-healing to "establish Akron as the world's leading biomaterials and orthopedic research program within 10 years."

Case Western's Multidisciplinary Approach

In his conference presentation, W. A. "Bud" Baeslack, provost and executive vice president of Case Western Reserve University said that universities must now be key partners in the innovation ecosystem, and to this end, they must be more efficient and flexible. They must also support more entrepreneurship. For example, he said, some professional interdisciplinary degree programs at Case Western Reserve provide joint training at premier health care and corporate partner sites. Such collaborative activities have helped to spin-off more than 20 bioscience companies in the past decade. Dr. Baeslack also drew attention to Case's multidisciplinary NSF Center for Layered Polymer Systems (one of 17 NSF Science and Technology Centers around the nation) which emphasizes the development of research results into viable technologies and products. To provide momentum for these activities, Case employs more than 40 professionals to help faculty expand and capitalize on research ideas.

In addition, the university has its own pre-seed fund, and faculty are encouraged to move beyond the traditional activities of writing grants and publishing papers to become more entrepreneurial—to patent their discoveries and start businesses. "We're doing self-study on how we can be more user-friendly and to take a less rigid approach to IP," Dr. Baeslack said.

The Special Role of a Community College

Speaking at the conference, Roy Church of the Lorain County Community College observed that while his college was doing a good job at work force development, especially in training more technically-adept graduates, those same graduates had few opportunities to use their new skills near home after graduation. The college knew that Lorain County, which is located west of Cleveland, did not on its own have the resources to help new firms grow, become profitable, and create jobs for new graduates. Dr. Church said that this led the college to form the Lorain County Innovation Fund, and to reach out to other counties and economic development organizations in northeast Ohio. Finding that many successful innovators have little experience in business, the fund started a business incubator called the Great Lakes Innovation and Development Enterprise (GLIDE). "The entrepreneurs just didn't know how to wrap a good business around their idea and breathe life into it," said Dr. Church.

After five years of helping young businesses, the Lorain County Innovation Fund won the support of the Ohio Third Frontier program, which funded GLIDE as an Edison Technology Incubator. In 2007, to spread its reach more broadly, the Lorain County Innovation Fund changed its name to the Ohio Innovation Fund. Since then it has been successful by many metrics, making 71 awards totaling $4.3 million to 60 companies.

"The most exciting aspect to me is the return on investment," said Dr. Church. The $3.8 million invested by GLIDE by the end of September 2010, he said, had attracted $42 million in follow-on investments. "So this is a good indication that these companies are going to be successful, launch, and move forward. The whole notion behind the Innovation Fund was to help reinvent and rejuvenate the entrepreneurial spirit of northeast Ohio."

F. THE ROLE OF FOUNDATIONS

Even as Ohio develops multiple innovation intermediaries, the Cleveland Foundation, the state's largest philanthropic organization, continues to be a powerful force for change. The foundation is both the world's first community foundation (1914) and Ohio's largest grant making organization, holding nearly $2 billion in assets. Speaking at the conference, Ronn Richard said that until recently, his foundation had devoted two-thirds of its grants in "purely responsive" fashion, many of them to support local arts and cultural organizations. Today, after a radical revision of its mission, two-third of its grants are "proactive," generated by as the foundation itself in seeking programs and organizations deemed likely to have long-term economic impact.

Mr. Richard said that the Cleveland Foundation addresses its new mission in economic development and industrial revitalization in multiple ways: by seeking to attract foreign companies; by helping local companies find overseas markets; by prioritizing advanced energy programs, especially wind

power and solar energy; by providing strong support for the biosciences industry; and by engaging in close partnerships with anchor institutions. In all, Mr. Richard said that he believes that his organization's effectiveness is magnified by the collaboration among the economic development organizations, especially in northeast Ohio, with their focus on partnering industry with government. In his conference remarks, Philip Singerman of NIST observed that only two other foundations in the country had such strongly positive effects on their communities as the Cleveland Foundation: the Heinz Foundation in Pittsburgh and the Danforth Foundation in St. Louis.

A key to the successful work of these foundations, according to Dr. Church, was an Internal Revenue Service a rule change that allows philanthropic dollars invested in small, early-stage firms to be tax deductible—as long as one or more students gain a work-place learning experience with the firm.

G. THE GOVERNMENT ROLE

In partnership with innovation intermediaries, governments at the state and local levels are playing a strong, even leading role in Ohio. The lead state actor is the Ohio Third Frontier, which has its own compelling story. The Third Frontier program is a bottom-up initiative first funded in 2002 by a $1.6 billion bond issue passed by Ohio voters. The state's voters were sufficiently impressed by the results of the Third Frontier's first phase that they voted in 2010 to spend another $700 million on the program and extend it for another five years.[13] At the local level, Roy Church cited as an example the work of the Lorain County Board of Commissioners who, along with the Lorain county Chamber of Commerce, were instrumental in founding the Great Lakes Innovation and Development Enterprise (GLIDE).

The federal government is supporting these local and state initiatives. Speaking at the conference, John Fernandez, then the Assistant Commerce Secretary for Economic Development, defined EDA's role as providing "the ground troops that try to build up these regional environments." He said that since its founding in the 1960s, the EDA had evolved considerably from an economic development organization focused primarily on basic infrastructure to one now focused on building an innovation economy. In his presentation, Philip Singerman, Associate Director for Innovation and Industry Services at the National Institute for Standards and Technology (NIST), introduced his organization's unique mission of working directly in support of industry as a non-regulatory agency. Its role, he said, has deepened in response to changing requirements of industrial development. Dr. Singerman quoted NIST director

[13] According to the Third Frontier's website, "The $2.3 billion initiative supports applied research and commercialization, entrepreneurial assistance, early-stage capital formation, and expansion of a skilled talent pool that can support technology-based economic growth. The Ohio Third Frontier's strategic intent is to create an 'innovation ecosystem' that supports the efficient and seamless transition of great ideas from the laboratory to the marketplace." *<http://thirdfrontier.com/History.htm>*.

Box C
A New Federal Partnership for Additive Manufacturing in Ohio

"On August 15, 2012, the White House announced the launch of a new public-private institute for manufacturing innovation in Youngstown, Ohio. The new partnership, the National Additive Manufacturing Innovation Institute (NAMII), includes manufacturing firms, universities, community colleges, and nonprofit organizations from the Ohio-Pennsylvania-West Virginia "Tech Belt. The consortium was selected through a competitive process led by the Department of Defense and will receive an initial $30 million in federal funding, matched by $40 million from the consortium itself."

SOURCE: National Institute of Standards and Technology, "National Additive Manufacturing Innovation Institute Announced," *Tech Beat*, Gaithersburg, MD: National Institute of Standards and Technology, August 21, 2012.

Pat Gallagher, the first Undersecretary of Standards for Technology at the U.S. Department of Commerce in saying that NIST serves as "industry's national laboratory. With the decline of the corporate laboratories created over a century ago," Dr. Singerman said, "NIST now performs many of those functions."

Federal and State Synergies for Clusters

Regional innovation clusters are the focal points where talent, knowledge, and entrepreneurship come together. According to NorTech's Rebecca Bagley, a cluster is an economically interconnected and geographically bound ecosystem that includes the entire "value chain" of technological innovation: research institutions, materials suppliers, equipment manufacturers, service providers, sub-component manufacturers, product developers. The point of clusters, said Lester Lefton of Kent State University, is to accelerate the processes of business formation and development—"to make 2 plus 2 plus 2 equal 16, or even 27."

Cluster formation is seldom easy to achieve, and easily hindered by antiquated governance structures that prohibit mergers, consolidation, shared services, and other alternative governance structures. Nevertheless, Ohio's innovation intermediaries are working hard to make these structures more "permissive," in the phrase of Lavea Brachman of the Greater Ohio Policy Center. NorTech, in particular, has had success in developing regional innovation clusters by attracting new members, building relationships, creating market-driven roadmaps, engaging with government, and utilizing data and metrics. "The important point," Ms. Brachman said, "is that we develop a model that operationalizes the desire to accelerate an emerging cluster." This is best done, she said, by ensuring the partnership of multiple companies, including

larger companies, who share the common goal of reducing the time required to strengthen a given sector.

One new fast-growing cluster in northeast Ohio is FlexMatters, which was established to promote the development of flexible electronics. The region is a world leader in the R&D aspects of this technology, and it is devoting considerable energy to extend that leadership into manufacturing and commercialization. Cluster members are well aware of how easy it is to lose a desirable new technology to competitors elsewhere, which happened in the case of liquid crystal displays, also developed in Ohio. Today, said John West of Kent State University, "LCDs are everywhere. It is the display of choice. I invite you to count the number of LCDs you use in your personal life."

The downside, Dr. West continued, is that "none of those LCDs are made in northeast Ohio; none are made in the U.S. The next generation of displays is going to be flexible displays, and flexible electronics. We have to make sure this does not happen again. We have the leadership now, and we should claim it, hold it, and have the vision for the future."

The first companies in the world to manufacture flexible electronic products by roll-to-roll manufacturing are part of the FlexMatters cluster, he said. The cluster includes partnerships throughout the value chain: universities, community colleges, small businesses, large businesses, potential end users, economic development organizations, and others. FlexMatters focuses specifically on five areas: technology innovation, capital attraction, supply chain building and networking, talent development, and market development. According to Byron Clayton of NorTech, "Collaborating around all those areas is what it will take for us to compete on the world stage." Success, he said, will depend on experts from universities and industry collaborating for years on every stage of the development process, from basic research to commercialization. Only then will northeast Ohio have a chance to be ready when demand suddenly arrives.

Development: A Matter of Urgency

Northeast Ohio is well aware of the urgency of following their technology and development roadmaps. The region—and the state—have far to go to attain the level of leadership in advanced technology that they long took for granted during the industrial era. For example, several experts at the conference warned that the region could easily lose its current leadership in flexible electronics to any country whose government adopts an aggressive investment policy. Dr. Clayton, for example, spoke of touring Taiwan's flexible electronics facilities. "I had 15 different meetings," he said, "and I could see that we are doing the right things here in the U.S. What we are not doing is investing enough money. In Taiwan they are putting $600 million a year into new technologies, one of which is flexible electronics."

Dr. West agreed that Ohio, like the U.S. as a whole, faces an investment gap in roll-to-roll (RTR) manufacturing, and that whoever controls

RTR will control flexible electronics. For example, Germany, South Korea, and Japan have all made large funding commitments to industry. "We still have a lead," said Dr. West, "but that doesn't mean we can sit on it." He said that Ohio's Third Frontier and the Federal government were making significant investments in basic research and early product development, but emphasized the need to invest in manufacturing research.

"I think we have an opportunity," Dr. West continued. "We are the first in doing the manufacturing. Our companies are learning how to do yields, put the product out into the marketplace at low cost, and gaining manufacturing expertise that will be the basis of this industry. A window of opportunity is open, and we could seize this industry." Dr. Clayton added that the market for flexible electronics is still "pre-demand." Major market demand has not yet hit, he said, "and when it does, people will be looking for which companies have the knowledge to actually manufacture these products. We want those companies to be in northeast Ohio."

H. MOVING FORWARD

To spur its economic development, Ohio's business, university, and government leaders are leveraging the state's assets through a variety of innovation intermediaries and new institutions. The state and the region are also benefiting from a vibrant tradition of "giving back," seen in the high level of civic volunteerism by leading citizens like David Morgenthaler, David Pogue, and James Griffith. Another potential asset for development is the state's pension funds, which are currently invested outside of the state. If only 5 percent of these funds were invested in new Ohio businesses, one participant speculated, they would create a powerful $5 billion driver for new business formation in the state.

Indeed, despite several decades of gloomy economic news, many conference participants expressed cautious optimism about the future of the state. Dr. DeVol of the Milken Institute noted that the state's crucial development indicators are moving in a positive direction. Despite Ohio's overall development ranking of 29th among the 50 states on the Milken Index, the state also tied for the largest increase since the previous survey, moving up seven places. This was propelled partly by significant improvement in the risk capital infrastructure and business startup rates. "So you're starting to see from the early indicators that Ohio's moving in the right direction. But it must continue to improve on many of these," he concluded, "especially in the human capital area and success in commercialization."

Encouraging Entrepreneurship

Dr. DeVol added that a key to success for Ohio would be not only higher levels of training but also a change in the mindset of those entering the labor market. By tradition, young graduates of Ohio's universities have gone to

work for someone else, typically a medium-sized or large company, in the assumption that entrepreneurship was not an option.

Encouraging entrepreneurship and innovation will require a change of culture within organizations so that they offer not only encouragement and rewards but also bear a greater tolerance for failure. Describing the experience of the Cleveland Clinic in encouraging doctors to commercialize new medical products, Dr. Cosgrove conceded that "It's been a long trip of trial and error." Emphasizing the importance of long-term commitment, he added "It is essential to encourage physicians to bring their ideas and their inventions forward, but it is just as important to stay with them all the way through to commercialization." In his discussion remarks, Dr. Albert Green of Kent Displays agreed that the "challenge for us is to realize it's not just the innovation part, which we do really well, but to translate that innovation into manufacturing and the expertise that goes out into the marketplace."

David Morgenthaler, a long-time Cleveland venture capitalist, said that he, too, saw the urgent need to encourage more entrepreneurial and manufacturing activity in Ohio—and in the rest of the United States. He had helped organize the conference, he said, in part to ensure that the innovation initiatives of the region would not only be noticed, but also strengthened and emulated. "I am working hard for Ohio," he said, "because I don't want to see what happened to Ohio happen to the country."

A Call for Commitment

The conference provided a unique opportunity to document the variety of initiatives underway by industry, universities, federal, state, and local governments to renew Ohio's economy. Many speakers cautioned, however, that this change would not happen overnight. Dan Berglund noted that raising state income levels requires a long-term commitment and effort by all involved. Research Triangle Park has made significant contributions to North Carolina's economy, he said, but it took thirty years of sustained commitment to accomplish this goal.[14] Reflecting on his own firm's experience with renewal, James Griffith noted that Timken's transformation "came after 10 years of hard work, including a strong focus on innovating and the need to rip out the infrastructure and habits that inhibited innovation within a 100-year-old company." The key lesson from the northeast Ohio experience, he said, is to restructure existing assets to take advantage of regional strengths and new opportunities, to reinvest in the skills and technologies of the future, to create the right incentives for innovation and entrepreneurship, and to stay the course.

[14]For a history of Research Triangle Park, See Albert N. Link, *A Generosity of Spirit: The Early History of the Research Triangle Park,* Research Triangle Park: Research Triangle Foundation of North Carolina, 1995. See also Albert N. Link, *From Seed to Harvest: The Growth of the Research Triangle Park*. Research Triangle Park: Research Triangle Foundation of North Carolina, 2002.

This overview has highlighted many of the key issues discussed over the course of the conference. The proceedings of the conference, summarized in the next chapter, provide rich detail on the new policies, institutions, and initiatives now underway in Ohio.

II

PROCEEDINGS

DAY 1

Welcome and Introduction

Richard Pogue
Jones Day

Mr. Pogue, one of the chief organizers of the symposium, welcomed the audience. He noted that the National Academies, the University of Akron, and NorTech jointly planned and supported this conference.

He said that the conference, one of a series being held in various regions of the country by the National Academies, would address four broad themes. The first was the nation's concern about "global challenges we all face in this very dynamic worldwide economy"—challenges that could be turned into export opportunities for American firms. The second was the effects of global competition on the economy in Ohio, specifically northeast Ohio. The region's response to these challenges, he said, will determine the kind of place Ohio would be in the future. The conference would also review the "substantial progress we're making, particularly in this region but throughout the state, in bringing together the public and private sectors to cooperate and create opportunities for the Ohio economy." The fourth theme was to explore ways in which the sectors of society can work together in partnership, including the federal government, state government, Ohio foundations, the private sector, investors, and major universities.

In past years, Mr. Pogue said, Ohio has faced significant challenges in its core industries. "It's important that we identify those challenges," he said, "and understand what they mean, because policy solutions depend on clear understanding." The state had responded effectively to many such challenges, he said, by taking advantage of its scientific and technical capabilities, and moving to newer, high-value industries. The state had also initiated programs to spur innovation and entrepreneurship, and some of those programs had been adopted as models by other areas. As examples he cited Jumpstart and the Innovation Fund at Lorain County Community College. "One goal of this conference," he said, "is to develop a better understanding of what makes for effective programs, and how they might be leveraged throughout the state and beyond to promote economic growth."

Mr. Pogue then introduced Mary Good, Dean of the College of Engineering and Information Technology at the University of Arkansas in Little Rock and member of the National Academies Board on Science, Technology, and Economic Policy. Dr. Good also chairs the National Academies' Committee on State and Regional Innovation Initiatives, under whose auspices this conference was organized.

Mary Good
University of Arkansas at Little Rock

Dr. Good thanked the attendees for their participation on behalf of the National Academies' Board on Science, Technology, and Economic Policy (STEP) and the Committee on State and Regional Innovation Initiatives. She said that the symposium was part of a series on Best Practices in State and Regional Innovation Initiatives. "Our study is reviewing state, regional, and Federal efforts to develop a robust manufacturing base," she said, "and address critical national needs, such as development of renewable energy."

A second goal of the study is to review best practices among state and regional innovation programs that seek to develop and reinforce high-technology clusters. The committee had held meetings on innovation policies in a number of states, she said, and had found them to be a diverse set. "This has given us some idea of the value of innovation strategies that are appropriate for small, medium, and large states; in those that have a strong tradition in manufacturing and those that do not." Previous meetings had been held in Arkansas, Michigan, and Hawaii; the Ohio meeting would be followed by a symposium at the new nanotechnology cluster in Albany, New York.

Dr. Good called the Ohio conference an important part of the study because of the "substantial progress Ohio has made in addressing its many challenges. Specifically we hope to highlight best practices among innovation programs and their goals, structures, funding levels and mechanisms. We also hope to hear more about how Ohio is capitalizing on the Federal investments that have been made in developing a knowledge-based, innovation-led economy."

Dr. Good closed by paying tribute to the organizers and supporters of the symposium, citing in particular the leadership of the George Gund Foundation of Cleveland, the lead sponsor, along with Dr. Luis Proenza of the University of Akron, Rebecca Bagley of NorTech, David Morgenthaler, and Richard Pogue. She then introduced Dr. Proenza, saying that "he has led the transformation of the University of Akron into a powerful engine for regional economic development, a catalyst for collaborative initiatives, and the pre-eminent public university in northeastern Ohio."

Keynote Address

Luis Proenza
The University of Akron

Dr. Proenza observed that "America now stands at the nexus of opportunity and necessity," and that "the primacy that America has long enjoyed around the world is increasingly being challenged by the very same forces of technological innovation that America has itself unleashed." To provide perspective for these mounting challenges, his address included a description of an innovation ecosystem, reference points about the size and scope of the innovation economy, and discussion of policy frameworks from around the world, at the Federal level, and in Ohio."

An "innovation ecosystem," Dr. Proenza said, refers to loosely interconnected elements that fuel research and development and enable "a society to make new discoveries, capture the value of these discoveries in the marketplace, enhance productivity, and increase the standard of living." The innovation ecosystem, he said, is complex and interactive, and is shaped by such factors as "(1) the quantity and sources of funds available to support research, (2) the capabilities of the scientists and engineers who conduct research, and (3) the settings in which research is conducted. These settings include infrastructure, facilities, institutional cultures, attributes of geographic location, and regulatory and other types of organizations. It also is shaped by factors that are increasingly global and devoid of boundaries."

OPTIMIZING THE INNOVATION ECOSYSTEM

Public attitudes about the importance and usefulness of research also affect the innovation ecosystem, Proenza said, and may result in policy environments that are contradictory and laden with unintended consequences. A shortcoming in any part of the innovation ecosystem may create inefficiencies, and even undermine its capacity for commercialization and economic growth.

"As you can gather, our national innovation ecosystem is far more complex, nuanced, and interactive than most debates about these matters acknowledge. Therefore it is our goal at this symposium to highlight ways to optimize the positive interactions, minimize or eliminate the negative ones, and seek ways to enhance the innovation process."

Dr. Proenza told participants that this issue should be of concern to all because America's capacity to innovate determines its capability for economic growth. "Knowledge builds new capacities just as surely as new materials build new structures," he said, "and our nation's investments in research have built real assets that yield real and large returns. When new knowledge is quantified in a market environment, it creates fuller employment, capital formation, growing profits and surpluses for reinvestment.

"In other words, research discoveries lead to new companies and new jobs; the economy expands, and new wealth is created."

TRENDS IN GLOBAL AND NATIONAL R&D INVESTMENT

Dr. Proenza then discussed the recent significant shifts in global research and development investment, estimated at more than $1 trillion. He pointed out that ten countries collectively account for almost 80 percent of that total, and that the U.S. with annual R&D expenditures of nearly $400 billion, itself accounted for 33 percent. However, the U.S.' global share is down from 44 percent five years ago. Dr. Proenza said this relative decline is attributed primarily to China's increasing R&D investment, which has an annual average growth rate of 19 percent during the past decade, moving it beyond Japan for second place in R&D investments in 2011.

He added that China's R&D spending is presently only 1.5 percent of its gross domestic product, compared to 2.7 percent in the U.S., and that China's R&D share of GDP has doubled in the last 10 years. While U.S. spending on R&D is still far beyond that of its closest competitors, the gap between it and other nations is narrowing.

Within the U.S., approximately 67 percent of R&D expenditures flow from industry, 26 percent from the Federal government, and 7 percent from foundations, states, and research universities, which are increasing pressed into cost sharing with the Federal government. The U.S. spends about $69 billion on basic research, $89 billion on applied research, and $240 billion on development activities.

Dr. Proenza noted that while U.S. colleges and universities perform a little over half of the country's basic research, they perform only a nominal percentage of development. Industry now supports less than 5 percent of research in universities, a figure that has declined from a high of 7 percent. He linked that dismal rate to the reluctance of a majority of university leaders to participate in commercialization or to accept responsibility for any aspect of economic development. Dr. Proenza said this "major disconnect in our innovation ecosystem" is being addressed through initiatives such as the National Academies' University-Industry Demonstration Project, as well as by other regionally based efforts.

Research and development activity in the U.S. also is geographically concentrated, with states varying significantly by type of research, he said. For example, 10 states account for nearly 64 percent of U.S. R&D expenditures.

California represents 22 percent; triple that of Massachusetts, the next highest. Some states, such as Massachusetts, Illinois, California, and Texas account for about two-thirds of R&D performed by computer and electronic products, whereas New Jersey, Ohio, and Pennsylvania are leaders in chemical research.

Another asymmetry identified by Dr. Proenza is the degree to which the United States has an unbalanced R&D portfolio. Approximately 70 cents of every research dollar support biomedical research, while only 30 cents go to the physical sciences and engineering. "No one would advocate reducing the investment in biomedical research," he said, "but it is important to balance that, since we anticipate that the interface between them will increasingly drive new innovations and discoveries."

In fact, many countries succeed economically by aligning their R&D strategies with economic objectives. Other countries and cross-national organizations, Dr. Proenza said, appear to be more successful at this than the United States, especially European and Asian countries that focus on public-private partnerships to stimulate their economic development. "I think that the United States can learn a great deal from what these countries are doing," he said. Dr. Proenza noted that in 2004 and 2008, the President's Council of Advisors on Science and Technology attempted to address this fault in the U.S. innovation ecosystem with calls for better deployment of R&D resources and increased public-private partnerships. While CRADAs, SBIRs, STTRs and similar collaborative programs have improved the situation, there are still far too few cross-state R&D collaborations and alignment of state and federal R&D initiatives.

TOOLS TO STRENGTHEN THE INNOVATION ECOSYSTEM

Concerning Ohio, Dr. Proenza said "the big question that lies ahead: Is Ohio on a path that leads to economic resurgence? When I came to the University of Akron in 1999, I often noted the irony that 20 years before I had urged the state of Georgia to emulate Ohio and its Edison programs. Then, in 1999, I found myself encouraging Ohio to emulate Georgia, which had done so much in the ensuing time while Ohio lagged." A dozen years ago, northeast Ohio largely lacked entrepreneurial drive, risk tolerance, and innovation capital, he said. "Today, while all of the pieces are not yet in place, there is little doubt that the region is again moving in the right direction."

As evidence, he offered a brief review of actions taken in last decade that supported a view of "cautious optimism."

- The founding of NorTech, an organization designed to advance industrial strengths and opportunities.
- BioEnterprise was spun off two year later with a commitment to grow health care companies and commercialize biomedical technologies.

- At about same time, the Ohio Polymer Strategy Council was formed to further strengthen the polymer chemistry industry in northeast Ohio.
- Team NEO was formed as the region's business recruitment organization.
- In 2004, both Jumpstart and MAGNET were established to energize the manufacturing industry.
- Several foundations were brought together under the Fund for an Economic Future with a goal of boosting the region's economic competitiveness.
- This fund in turn launched Advance Northeast Ohio in 2007, and has become one of only three participants across the country in partnership with the Brookings Institution, creating the Northeast Ohio Regional Business Plan, a new approach to creating economic growth across our region.

A decade ago, new legislation allowed faculty at Ohio's public universities to become stakeholders in startup companies derived from their own research findings. And in 2002 the Ohio Third Frontier program was established to create new technology-based products, companies, industries and jobs. With an initial $1.6 billion investment, it supports the elements that drive innovation. Equally impressive, he said, was the decision by Ohio voters in 2010 to invest an additional $700 million of public money in the Third Frontier, bringing the total investment through 2015 to $2.3 billion. The Third Frontier program has partnered with the National Academies to gain objective third-party evaluations of its proposals.

Despite all of these measures, however, Dr. Proenza said more remains to be done. For example, the state lags others in federally funded academic research, and has achieved true distinction in only a handful of areas. Several industrial and business clusters are virtually devoid of R&D support. Also, at a time when developing and attracting technical and entrepreneurial talent is considered an essential ingredient of an economic development strategy, Northeast Ohio has no organization focused specifically on this critical element. And both domestic and international competitors are now "running faster, often from better-established innovation ecosystems."

In closing, he called on the participants to learn from one another, to discover what those outside the region are doing, and to create the engagement of ideas that will generate new economic vitality.

"As we well know, the work before us is not easy, or we would have done it long ago. We must be committed to innovate on innovation itself, to focus our entire regional society on innovation," Dr. Proenza said. "As Paul Romer reminds us, 'the most important job for economic policy is to create an institutional environment that supports technological change… (and to) resist the temptation to impede change when it causes temporary disruption.'" That is

not a simple task, he said, because social and political concerns often slow and even derail efforts to change existing systems.

"Success in this new economy," he concluded, "will belong to those regions that create and nurture the human resources of intellectual capital, the people who create new knowledge and new technologies, and then quickly translate these research discoveries into marketable products and services. To succeed, universities, business, industry and government must work together. So let us be cheerful and plunge ahead."

Panel I

The Ohio Innovation Economy in the Global Context

Moderator:
Richard A. Stoff
Ohio Business Roundtable

Mr. Stoff began by thanking the meeting organizers, recognizing in particular Glenn Brown, whom he called "the first true science advisor to a governor and a distinguished scientist and industrialist. He started us on the march in science and technology in the public sector in this state," he said.

He described the Ohio Business Roundtable as a partnership of chief executives of major businesses that is "committed to working with public leaders to build a stronger Ohio." He said that the organization was selective in the issues it addressed, advocating "public policies that foster vigorous and sustained economic growth and an improved standard of living for all the citizens of this state."

Mr. Stoff emphasized his organization's commitment to "major system change," and their efforts to serve as a catalyst for change over the last two decades. The Roundtable acts in the belief that knowledge and innovation are the "keys to global competitiveness, and certainly the foundation for economic strength and prosperity." He noted that several years ago the Federal Reserve Bank of Cleveland, under leadership of Sandra Pianalto, conducted a comparative analysis of the states' economic strength over the previous 75 years, as measured by relative per capita income growth. The analysis identified two basic variables that differentiated the wealthy states from the less-wealthy. One was innovation, as measured by the pace of technological advance and the strength of commercialization engines. The other was talent, as measured by citizens' level of education. The Cleveland Fed's analysis, he said, might be expressed by the equation "innovation plus talent equals prosperity, or I + T = P, with Ohio stuck firmly in the middle of the pack then."

"At the Business Roundtable," he continued, "we have used this research over the last several years as our central organizing device." In developing talent, the group has helped shape statewide education reforms,

primarily in grades K-16, including the "nationally acclaimed" Ohio STEM Learning Network.

Mr. Stoff said that the Roundtable had also "played a major role" in building statewide bipartisan support for the Ohio Third Frontier, which he called the premier public-private innovation platform in the state and a model that has been replicated by many other states. He reiterated the good news mentioned earlier by Dr. Proenza—that the program was significantly extended shortly before the symposium by "a successful bipartisan effort to secure another $700 million for an additional five years of support. I think the real headline of the story is that in the face of a crippling recession and a time of government distrust, Ohio voters overwhelming approved the Third Frontier bond renewal measure by 62 to 38. The voters acted on their belief that Ohio needs to continue to invest in building its innovation economy."

Mr. Stoff said that the Third Frontier results have been "impressive." An independent analysis sponsored by the Roundtable and performed under the direction of the CFO of Cleveland-based Eaton Corporation, found that the investments produced a leverage ratio of 8.5 to 1, , generating some $6 billion in venture funding from venture capital, the private sector, and the Federal government. It reported a return on investment of 22 percent per year, and creation of 68,000 jobs with average salaries of $65,000. Some 650 companies had been created, capitalized, or attracted. "We've now set the bar even higher," he said, "as the Third Frontier enters its next phase."

Mr. Stoff concluded by noting that this encouraging news was to some degree offset by significant challenges, which would be described by panel members at the symposium. "But that tension is stimulating and thought provoking," he said, introducing the first speaker and the topic of relative state performance across the country.

CHALLENGES AND OPPORTUNITIES FOR THE OHIO INNOVATION ECONOMY

Ross DeVol
Milken Institute

Mr. DeVol, then executive director of economic research at the Milken Institute, said he would describe recent findings of Milken's State Technology and Science Index (STSI), which annually compares technology innovation activities in all 50 states. [1] He said that according to the index, begun in 2002, innovation is becoming steadily more important in determining state and regional economic success.

He said that many of the factors that determine national economic performance also affect regional growth. The regions, however, do not face the same

[1]Ross C. DeVol, Kevin Klowden, and Benjamin Yeo, "State Technology and Science Index 2010," Miliken Institute, January 2011. Access at <*http://www.milkeninstitute.org/pdf/STSI_exec.pdf*>.

constraints as the national economy. An example is that labor is much more mobile between regions than between countries, with individuals able to move more quickly toward job opportunities. In addition, regional migration trends can affect growth for long periods. Any explanation of regional growth patterns, he said, must recognize these factors.

There are also barriers to the flow of economic activity across state borders. Regions actively compete for new and expanding businesses, and depend on the growth of industries that produce "exports"—goods and services sold beyond their borders. The manufacturing sector is one of the most export-intensive activities, he said, and the output of manufacturing circulates and multiplies within a regional economy to create a large "ripple effect." Health-care services is also an export sector in some regions, including northeast Ohio. This sector both attracts patients from throughout the Midwest, based on the reputation of the Cleveland Clinic and other facilities, and acts as a magnet in attracting firms engaged in biotech, pharmaceuticals, and medical devices. Such firms commonly act as engines of economic growth.

Many factors create disparities in growth among regions, he said, factors which interact in complex and dynamic ways. "The existing industrial structure can determine growth for a number of years. Each region inherits its industrial structure from historically determined factors, especially the costs of doing business, including tax rates, capital costs, wage rates, real estate prices, energy costs, and health care costs." Increasingly important, he said, are "labor force skills, access to markets, access to capital, research and development, innovation capacity, and "quality of place" issues." In the future, he predicted, new factors are likely to emerge.

A Review of the Milken S&T Index

The most recent index had been released a few months earlier, using five composite categories with a total of 77 individual components. For example, the research and development composite had 18 components, beginning with Federal R&D, Industry R&D, and Academic R&D. The 50 states were ranked in "tiers" of 10 by colors on a map of the U.S. Those in the top tier were portrayed in green, the second tier in yellow, the third in orange, and the fourth in red. He said that many of the region's leading the R&D category were clustered together by region "because knowledge is generated, transmitted, and shared more efficiently in close geographic proximity."

"To build a new industry cluster, the research and innovation capacities of a region are critical," Mr. DeVol said. "You can start a new cluster by importing firms that have commercialized technology elsewhere, but those regions that have the basic research and development activities have an advantage in building a cluster than can hold together over the long term."

The R&D composite, he said, measured type of R&D funding as well as how funds are spent. Also, everything was calculated on a per capita basis. He noted substantial strength in the Northeast, New England, the Mid-Atlantic

states, and in the West. The good news for Ohio, he said, is that it had moved up to the 20th position in the 2010 index in the R&D component from 28th two years ago, and from the third tier to the second tier.

In the R&D composite, Mr. DeVol noted "pockets of strength," but found the low "NSF funding"—in which Ohio ranked 44th—"troubling," because it suggests "less than a full-strength innovation pipeline." Ohio had seen a noticeable improvement in Academic R&D, rising from 30th to 21st place, and had moved up five places in Industry R&D to 19th. Some strengths in the state included R&D Expenditures on Engineering, where it ranked 10th, and Biomedical Sciences, where it ranked 14th and Life Sciences, ranking 19th. Improvement in STTRs and SBIRs was notable, both rising from the 2007 and 2008 positions.

"So Ohio is in the upper tier of most indicators," he said, "including the very good news that Ohio was in the top 10 in Phase I and II SBIRs. So there is some evidence of improvement in the R&D pipeline." He called its ranking of 9th and 10th in Phase I and II SBIRs "a dramatic improvement" from eight years ago, when the index was first released.

Improvement in Access to Capital

Turning to the composite for risk capital and entrepreneurial infrastructure, Mr. DeVol said that "if you want to be successful over the long term, a state needs capable entrepreneurs and the risk capital that fuels growth and allows them to convert research to commercially viable technology products and services. We think this [composite] does a fairly accurate job of capturing that." He added that a new conceptual framework recognizes the role of entrepreneurship in determining the economic growth of states and regions. The index included entrepreneurial activities influenced by training and support from both private and public sectors and availability of early stage financing. "But we really need to measure the intensity of the entrepreneurial activity through the extent to which individuals recognize opportunities and have the skills to exploit them. This determines the number of new startups, how many grow to be successful firms, and ultimately the jobs that are created." He noted that Ohio has moved up rapidly to 20th from 40th two years ago in this indicator, indicating "significant improvement in entrepreneurial activities in the state of Ohio."

Mr. DeVol added that the index uses the term "access to risk capital" to refer to "the smart money," to angel investors and venture capitalists whose connections are part of dynamic ecosystems with links to management talent where it is needed. "So it's about the skills, the connections they help establish in an area." Ohio had improved quickly in the availability of venture capital, moving to 11th position. It had also risen sharply in the number of companies receiving VC investments, moving from 39th to 11th. He added that of all the indicators he reviewed for the index, the most encouraging was the jump in business startup rates to 15th on a per capita basis, up from 49th two years ago.

"This was a tremendous increase in early-stage startups," he said. "And the state also scored very high in VC investments in clean technology."

Less Progress in Human Capital

In the composite for investment in human capital, however, he found less progress. Mr. DeVol said that concentrations of talent today are more important than "industry agglomerations" in attracting firms to states. "They both matter," he said, "but the key is really the ability to attract talent." Among the indicators he described were "stock," the percentage of a population with a bachelor's degree or above, and "flow," recent graduation rates in STEM fields. U.S. states cannot compete on a low-cost, low skill basis, he said; they must compete on the ability to generate ideas in the global marketplace and, more importantly, in the new products and markets that accompany productivity growth. "You have to understand the importance of harnessing the knowledge that's generated locally and importing it where necessary to be successful in the long term to fuel economic growth," he said. Ohio ranked just 35th in the 20 indicators in the Human Capital Investment Composite. Generally, Ohio's best rank was 17th in the stock measures for Students in Science, Engineering, and Health as a percentage of the adult population. The ranking of 37th in the number of Bachelor's Degrees Per Capita "is not an encouraging sign." Another unfavorable statistic is State Appropriations for Higher Education, where Ohio ranks 40th.

Mr. DeVol saw some strength in the number of Doctoral Science and Engineering Degrees Awarded and the number of Doctoral Engineers, at 19th and 22nd. "But when you look across the indicators, Ohio is typically in the middle tier of most of these human capital measures."

Attracting Talent

Mr. DeVol turned to the Technology and Science Workforce, which he called "a little different" because it describes the ability to attract talent from other places in terms of "intensity." "Regions with a high concentration of skilled technology and science workers," he said, "have the advantage of being able to pool intellectual capital with labor force skills specific to those sectors. As design engineers, programmers, and microbiologists migrate from one region to another, they reinforce the initial advantages of a region and bring new comparative advantages from people outside the region." This is because young people who are highly mobile and geographically discriminating are "the most important labor assets a state can have." At 23rd, Ohio scored a little better in this category, he said. The 18 occupational categories were divided into computing, information sciences, and life sciences. The states that have above-average scores in these categories, he said, are typically highly dependent on technology and high-value-added industries. Massachusetts has been number one on the index since it was created, while Ohio is in the middle of the pack in

most of these indicators. Its best score is for Biochemists and Biophysicists, at 9th, and Database and Network Administrators, at 13th. He also reported "fairly strong rankings for Physicists and for 'Other Life Sciences,' both at 7th," and for the catchall category Other Engineers, at 9th. "These are the occupational categories that are critical for Ohio moving forward," he said.

The last major category is the Technology Concentration and Dynamism composite, which measures technology "as it is deployed on the ground." Indicators include payroll, employment, and net business formation, "all pointing to the success of a region as its tries to move forward." Mr. DeVol called this "more of a measure of technology outcomes, as opposed to the innovation pipeline as it flows through." Most states that score well here, he said, have a diverse technology background and composition of industry clusters. Entrepreneurism plays a large role here, too, "because it's about new companies being started in the technology and science areas, and about your ability to grow them." Unfortunately, Ohio scored 44th in this category. He said that part of the reason for the low score was that part of the data came from 2008, the depths of the great recession, which hit Ohio harder than many other states. But even adjusting for this, he said, did not do much for Ohio's scores, which were typically 30th or 31st. The best score was in the Number of Inc. 500 Companies per 10,000 Establishments, where Ohio was 19th.

'A Definite Improvement' for Ohio

Putting together the five composites and their 77 indicators, Mr. DeVol said, gave Ohio a rank of 29th, which he called "a definite improvement from where it was a few years ago." At the top of the list, Massachusetts was number one, Maryland had moved to second place, Colorado had moved ahead of California on a per capita basis to third place, California scored fourth, and Utah had risen rapidly to fifth, "now nipping at California's heels."

Despite Ohio's position of 29th, he said, the state tied for the biggest increase from the previous index, having moved up seven places. This was propelled by significant improvement in the risk capital infrastructure and business startup rates. "So you're starting to see from many of the early indicators that Ohio's moving in the right direction. But it must continue to improve on many of these, especially in human capital area and success in commercialization."

One of the clearest barometers of a state's economic standing, Mr. DeVol said, is the per capita income of the working age population. About three-fourths of the variation in per capita income can be explained by how well the states score on the 77 indicators of the State Technological and Science Index. "But we think the most dominant of these explanatory variables are the human capital measures, including the talent and the entrepreneurial indicators, which are growing increasingly important."

DISCUSSION

Mr. Stoff asked what it would take for Ohio, at best a second-tier state, to move into the first tier. Mr. DeVol said that he had argued for years that universities are the most important assets of an innovation economy. Among high-tech clusters, those most successful in building a regional economy have universities that recognize that role. Whether they are effective is most often determined by the leadership of the president or chancellor. "I would argue that the most important thing any region can do is see that universities, especially public universities, do have a role to play. Many times that just means being willing to work with industry, allowing them to have access to some of the top research, or arranging a formal licensing arrangement."

Such relationships are essential for attracting new firms, he added. "When you look around the country, a key factor that firms look at is whether the universities are engaged with the private sector. Do they have the research capacity, the will, and the support to allow scientists to interact with the private sector?" He said that while an active university is necessary, it is not sufficient. "You also need incentives to encourage entrepreneurism—not only in the universities but also in the private sector. I would say a key challenge for Ohio and other states in the Midwest is the historical assumption among those entering the labor market that you're going to work for someone else, typically a medium or large company, and that entrepreneurship is not an option for you. This cannot be changed overnight, but it must be part of a relearning process."

Dr. Wessner commented that other states are making substantial investments to enhance the innovation potential of their universities. He said that Texas is investing in two new research universities, partly to reduce the outflow of top graduate students. "They also recognize that if you have research universities, you have the potential to receive substantial R&D funding from the Federal government." He also asked about the increase in VC activity detected by the Milken index, asked whether it represented a trend or merely the impact of a few large deals. Mr. DeVol said that the index included not just the total VC dollars but also the number of deals, but that it was too early to tell whether the rise represented a trend. While VC investments in Ohio were encouraging, he said, it was essential to "follow through to make sure startup companies that have been funded actually grow to become medium-sized firms that create jobs."

MEETING THE GLOBAL INNOVATION IMPERATIVE

Charles Wessner
The National Academies

On behalf of the National Academies, Dr. Wessner expressed his thanks to the co-organizers of the symposium, and expressed his admiration for the region in generating so many agile innovation based development

organizations that encourage cooperation among sectors. He said he was also encouraged by the portions of Mr. DeVol's report that indicate a firmer and more collaborative base for innovation in northeast Ohio. "When a community begins to understand that they can, or have to, do things differently, that is the point when bringing in best practices from around the world can be most helpful."

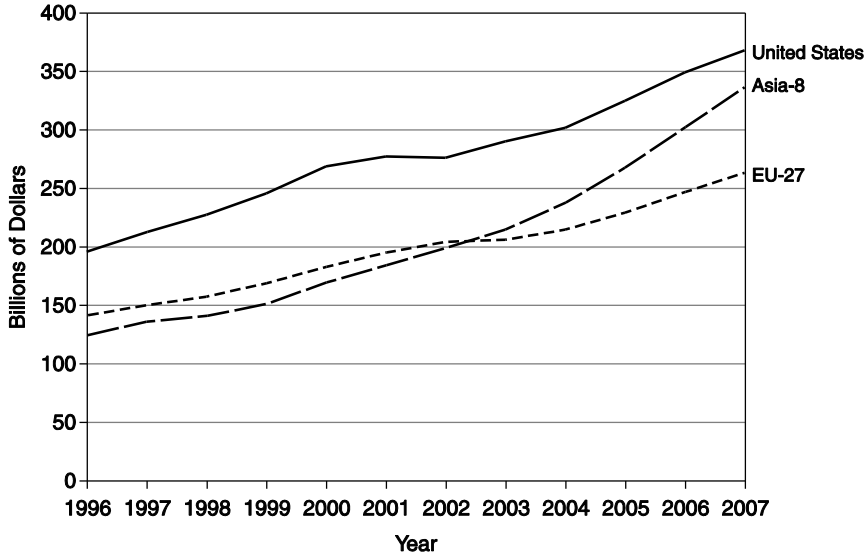
Dr. Wessner said that the key to economic development for regions as well as for nations in the future is a well-functioning innovation ecosystem, and offered the following definition: Innovation means transforming ideas into new products, services, or improvements in organization or process. What this means, he added, is that "innovation translates knowledge into economic growth and social well-being." He said that while many academics and policy makers "could debate with you for hours about the correct definition of innovation," he found an informal description to be useful: "Research converts dollars into knowledge, and innovation converts knowledge back into many more dollars."

"It's a virtuous cycle," he said. "Why is there an imperative to innovate? Because we have no alternative; if we want to grow our economy, maintain our place in the world, provide a future for our children and grandchildren, it is imperative that we innovate."

'Innovation Policy is Not a Hobby'

Adding urgency to the debate in the United States, he said, is the fact that countries around the world are working hard on their own innovation strategies. "Innovation policy is not a hobby," he said. "It is not something you do when you have done everything else on your day-to-day policy agenda. It is the main game, the job of government at macro and micro levels. You need to support funding for research, and you need to convert that research to something we can use—not just another publication."

Virtually all U.S. trading partners, Dr. Wessner said, have placed innovation high on their list of national priorities. Leading countries and regions are providing a high-level focus on growth and strength, sustained support for universities, consistent funding for research, imaginative support for small businesses, and support for government-industry partnerships that bring new products and services to market. "They're committed, they're focused, and they're willing to spend."



The rapidly growing R&D expenditures of the Asia-8 economies (China, India, Japan, Malaysia, Singapore, South Korea, Taiwan, Thailand) surpassed those of the EU-27 in 2003.

SOURCE: National Science Board, *Science and Engineering Indicators 2010*, Arlington, VA: National Science Foundation, 2010.

FIGURE 1 Asia's surge: Global R&D—Measuring commitment to innovation. SOURCE: Charles Wessner, Presentation at the April 25-26, 2011, National Academies Symposium on "Building the Ohio Innovation Economy."

Dr. Wessner singled out the case of China, which is doubling its R&D investments, building out R&D infrastructure and facilities, creating world-class universities, and investing in education at all levels to enhance its economy and national security. He cited President Hu Jintao's Report to the 17th National Congress of the Community Party of China: "Innovation is the core of our national development strategy and a crucial link in enhancing the overall national strength." He also cited Mu Rongpin of the Chinese Academy of Sciences, who wrote in the 2010 UNESCO Science Report that China's goal is to become an "innovation-driven economy" by 2020.

The payoff of this commitment in China and in Asia more broadly can already be seen, he said, pointing out that the rapidly growing R&D expenditures of the Asia-8 economies (China, India, Japan, Malaysia, Singapore, South Korea, Taiwan, and Thailand) surpassed those of the EU-27 in 2003 and were poised to overtake those of the U.S.[2] "If these trends continue," he asked,

[2]National Science Board, *Science and Engineering Indicators 2010*, Arlington, VA: National Science Foundation, 2010.

"how can we be ahead of the rest of the world? How can we even stay where we are if we don't make these investments in research and development?"

The Fallacy of the Low-wage Argument

Dr. Wessner also added that the U.S. can no longer use the excuse that it can't compete with China because of its low wage structure. "Germany is a high-wage, highly-regulated economy," he said, "with high welfare costs and government health insurance programs. But German companies do well in sending products abroad because they understand that technological capacity matters. They know that this is what produces jobs and trade surpluses." He added that the Germans understand the importance of the manufacturing sector, and have created the institutional structure necessary to maintain it, including investments in job training and worker retention; support for raising productivity to offset high wages; assistance to small manufacturers in global marketing; and energy and transportation policies that have fostered an edge in manufacturing. This structure includes the Fraunhofer Gesellschaft—a network of 59 institutes, 17,000 employees, and a budget of about 1.6 billion euro—that conducts focused, product-based research in partnership with private firms. Dr. Wessner noted that this focus on advanced manufacturing and exports is paying off for Germany: "Germany has learned to send products to China and cooperate with the Chinese on standards. It has now almost balanced its trading account with that country." German exports have jumped 17 percent this year, driven in large part by a 55 percent rise in exports to China.

The major risk for the U.S., Dr. Wessner suggested, is complacency—a belief that the U.S. can expect economic leadership without working very hard for it. "One of the myths we have," he said, "is that U.S. workers can outcompete anyone in the world on a level playing field. There are two problems with this myth. First, the whole world works hard to make sure we're never on a level playing field." Second, he said, studies by the OECD's Program for International Student Assessment (PISA) show that U.S. workers are less well educated than those of U.S. trading partners. In addition, Americans are increasingly spending more on current consumption rather than on investments in R&D as previous generations did and as other nations do. Since the late 1950s, federal spending on research and development as a percentage of GDP has been declining.[3]

The Power of Public-sector Investment

While, some argue that private investment in R&D is more than makes up for the decline in Federal investment, Dr. Wessner said that this private investment is limited largely to market-stage applications rather than to basic

[3]KPCE; National Science Board, *Science and Engineering Indicators 2008*, Arlington, VA: National Science Foundation, 2008.

research. In many cases, privately funded R&D builds on technology platforms developed through substantial federal investments. He cited a comment by a leading venture capitalist, Mary Meeker of Kleiner Perkins, who noted: "Private investment may have given us Facebook and Garmin, but public sector investment gave us the Internet and GPS." He stated that government investment in technology, education, and infrastructure, which has been a strong tradition since the late 18th century,[4] will be a key part of addressing the challenge of innovation.

Ohio, Dr. Wessner said, can learn from the diverse approaches taken by other states to grow their innovation economies. New York, for example, has started a major nanotechnology initiative—despite having limited previous semiconductor industry or nanotechnology expertise. The state drew in what it needed, finding major partners in IBM and other global-scale firms. It attracted SEMATECH, then located in Texas and secured funding from investors in Abu Dhabi. Funding from the New York state government, which committed $2 billion to the effort, helped build a new College of Nanoscale Science and Engineering. To date, the this effort has yielded more than $5 billion in private-firm investments, and new jobs in manufacturing and other high-value fields. For example, one of America's only green-field silicon wafer fabrication plants is being built near Albany by Global Foundries at a cost of $5.6 billion, providing 1,400 new jobs. Dr. Wessner said that the lessons from the New York initiative include: addressing emerging technological needs; concentrate resources; encouraging innovative management, allowing universities freedom from restrictive rules; and creating strong connections between universities and the private sector to identify needs and attract funding.

Turning to Ohio, Dr. Wessner suggested that the state does stand out in making a "remarkable multi-institutional effort, which in itself ought to be one of the Milken categories." He also said that the state has invested well and has made substantial progress in growing more than 400 advanced energy companies. It has also promoted development of new clusters for flexible electronics, photovoltaic manufacturing, and polymer-based technologies. He encouraged the state to seek more partnerships in Washington, capitalizing on new federal commitments to innovation and the bipartisan support for the kinds of initiatives Ohio has already launched.

[4]In 1798, for example, Eli Whitney received a government grant to produce muskets with interchangeable parts, leading to the first machine tool industry. In 1842, Samuel Morse received a federal award to demonstrate the feasibility of the telegraph. In 1903, the Wright Brothers fulfilled the terms of a U.S. Army contract by demonstrating the first flying machine. More recently, many platforms of the modern economy, including radar, computers, jet aircraft, semiconductors, the Internet, nanotechnology, flexible electronics, and solar technologies, have been built on government-funded research and public-private partnerships.

The Financing Needs of Early-stage Firms

Dr. Wessner urged a greater focus on small businesses, which make multiple contributions to a region. They create jobs, new products, increase market competition, generate taxable wealth, create welfare-enhancing technologies, and, over time, transform the composition of the economy. Equally important, they have the potential to become the "new big businesses." A key impediment to the growth of small innovative businesses, however, is the 'Valley of Death,' the popular term for the phase of development where firms do not yet have sufficient revenue to grow on their own but lack the revenues demanded by VC investors. "It's hard to attract VC funding," said Dr. Wessner, "because new ideas are new, and no one can know what they will ultimately be worth." He recalled that the Larry Page and Sergy Brin of Google had difficulty raising early-stage funding because no one could foresee the value of their particular search engine. "It's not always clear at first," he said. "You need that capital to get across the valley and demonstrate value."

Dr. Wessner recommended several government mechanisms designed to help small, early-stage firms, beginning with the Small Business Innovation Research (SBIR) program. "Not enough people in Ohio know about this $3 billion annual program. It is very competitive; only about 20 percent of companies are selected in the first round. But it provides you with an initial $150,000, which brings validation and opportunity to explore." A key feature of SBIR is that it is a set-aside from existing research budgets, rather than a program with annual budget fluctuations. He suggested that other Federal programs, notably the Technology Innovation Program, and the Manufacturing Extension Program at the National Institute for Standards and Technology (NIST), and the various initiatives of the Economic Development Administration (Department of Commerce), would all be useful in providing support for Ohio's innovation strategy.

Dr. Wessner concluded with the suggestion that Ohio could best accelerate its drive for innovation through local leadership—especially support for infrastructure, matching R&D grants. For example, "Phase Zero" grants by the state can help small Ohio firms apply for federal SBIR funding. The state can also offer bridging money for firms that are making the transition from SBIR Phase I to Phase II. These and other initiatives are underway in a number of other states, he said, as a way to encourage new businesses and promote regional growth. Other states are also taking steps to ensure that taxes are applied intelligently, and that regulations are not "worse than the tax structure." In short, Dr. Wessner concluded that the region and the state can do much more to make northeast Ohio attractive to companies and better prepared to compete globally.

"The question is," Dr. Wessner said in summary, "will we make the necessary investments in research and universities, and will we help our small companies compete? Our companies are one of our principal assets. We need to preserve the ones we have, and we need to grow new ones. Quite literally, the

future of our children depends on what we do over the next decade. I congratulate you on the progress you've made so far."

DISCUSSION

Mr. DeVol affirmed the danger of excessive complacency in the U.S. "One thing I find troubling when I talk to legislators and their staffs is the idea that we have a divine right to lead in innovation. That biomedical, pharmaceutical, biotech, and other firms are here because they deserve to be. That we don't have to worry about whether they are innovative or what other countries are doing." He asked, "How do we cut through the idea that we've always been number one, and therefore we always will be?"

Illustrating the point, Anna Barker, a former deputy director for strategic scientific initiatives at the National Cancer Institute, said that leadership in life sciences is now moving offshore. Responding to the enormous looming problem of lung cancer in China, a nation of some 300 million cigarette smokers, Chinese officials told her on an earlier visit to Beijing that they were planning a new genomic center to address this problem. When she went back a year later, she expected to see no more than plans for the center. Instead she found a completed institution with 2,400 people, including 1,000 in bioinformatics. "This is a field where we are faltering," she said. "We haven't trained our kids well in computational biology or computation in general. So on every front China is driving innovation in education, in the new areas of science, like nanotechnology. In the next 10 years we're either going to have to partner with China to get some of that information back, and gain from what we have invested, or we're going to fall very far behind. We still have a choice, but time is running out."

Bob Schmidt, of Cleveland Medical Devices, said that while universities receive far more funding than the SBIR program, small firms produce far more patents, and asked whether the SBIR should not logically receive more money. Dr. Wessner agreed that small businesses are effective in developing patents and, above all, products, but that the "universities are where many of the ideas come from." Furthermore, the distinction between universities and small business may be blurred when "a researcher has an idea in the lab, and then goes across the street to become a small business." He suggested that it was appropriate to see both activities as part of the same system. He said that in a recent study of the SBIR program, the National Academies had found additional resources in the SBIR program would be effectively used, but also noted the need for expanded support for basic research, applied research, and especially translational research to move innovations toward the marketplace.[5]

[5]National Research Council, *An Assessment of the SBIR Program*, Charles W. Wessner, ed., Washington, DC: The National Academies Press, 2008.

Panel II

Stimulating Manufacturing in Ohio

Moderator:
Sridhar Kota
Office of Science and Technology Policy
White House

INNOVATION AND U.S.-BASED MANUFACTURING

Sridhar Kota
Office of Science and Technology Policy
White House

Dr. Kota, the moderator for this panel, began with reflections on his own studies of innovation and manufacturing. He proposed a definition of innovation from the National Academies' *Rising Above the Gathering Storm, Revisited* report: "Innovation commonly consists of being first to acquire new knowledge through leading edge research, being first to apply that knowledge to create sought-after products and services…, and being first to introduce those products and services into the marketplace…."[6] He said that the U.S. does "really well in the first two," the acquisition and application of knowledge, but has been falling behind over the last 30 years in seizing commercial leadership in new products.

As illustrations of this falling behind, Dr. Kota pointed to many valuable high-technology products already lost to foreign competitors, including "fabless" chips, LCDs, electrophoresis displays for e-readers, lithium-ion and other batteries for cell phones and portable electronics, advanced rechargeable batteries for hybrid vehicles, personal computers, and advanced composites used in sporting goods and other consumer gear. Some of these, he said, can no longer be produced in the U.S. because the supply chains have moved abroad. Many more technologies are at risk, including LEDs for solid-state lighting, next-generation "electronic paper" displays, thin-film solar cells, mobile

[6]Members of the 2005 "Rising Above the Gathering Storm" Committee, *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5,* Washington, DC: The National Academies Press, 2010.

handsets, and carbon composite components for aerospace and wind energy. "I'm not sure we'll end up capitalizing on our own inventions in those areas," he said.

The Strong Link Between Innovation and Manufacturing

The reason that technologies can be lost to the nation, Dr. Kota said, is that manufacturing and innovation are strongly linked. The Federal government's investments are made primarily in basic research, especially through the universities. "We are very good at that, and being the best in the world in scientific discoveries is vital to our success." However, he continued, "this is no longer sufficient to compete in the global economy. We need to be able to do the rest of it—translating those ideas into prototyping centers, taking them into scaling. We're pretty good at the first one percent, the inspiration, but it's that ninety-nine percent, the 'perspiration,' where the real challenge is."

Unless U.S. companies improve at commercializing new technology, Dr. Kota said, they will not be able to innovate the next-generation products. "As you do the scaling, a lot of new product and process innovations come about," he said. "As an idea moves from a PowerPoint slide into a real product, it must be made safe, cost effective, light-weight, and reliable. If you don't do that, you will not be able to capture the market."

A Weakened Industrial Commons

Of central importance, Dr. Kota said, was the collective, overlapping set of competencies and resources known as the "industrial commons" that underlie the development of new technology products. The commons includes engineering R&D, materials, standards, tools, equipment, scalable processes, components, and manufacturing competencies in platform technologies. "Without those commons we cannot innovate," Dr. Kota said. [7]

The U.S. industrial commons has become weak in high-technology sectors, including biotechnology, life science, optoelectronics, information and communications electronics, flexible manufacturing, advanced materials, aerospace, weapons, nuclear technology, and computer software.[8] As evidence, he referred to the nation's expanding trade deficits in advanced technology products. In this category the U.S. maintained a trade surplus until the year 2000, but today suffers a deficit of about $80 billion.

[7]Dr. Kota referred to the ideas expressed by Gary P. Pisano and Willy C. Shih in "Restoring American Competitiveness," *Harvard Business Review* 87(7-8), July-August 2009.
[8]National Science Board, *Science and Engineering Indicators 2008*, op. cit.

Innovation and the 'Missing Middle'

Dr. Kota called innovation the "missing middle" in the process of developing new industries. "You have to put money into knowledge," he said, "but unless you apply that knowledge, you don't generate money at the other end. Someone else is then free to take those ideas and capitalize on them. The engineering and manufacturing is what converts that knowledge—something done far more effectively by other countries. For example, he said, Germany spends one-sixth as much as the U.S. in total R&D, but it spends six times as much on industrial production and technology."

As further illustration he referred to TRLs, or technology readiness levels, that are used to characterize technology development on a scale of 1 to 9. The research supported by the NSF and the NIH, he said, is usually at TRL 1 to 3. "After that," he said, "when you've proved this idea does not violate laws of physics, and it seems to be interesting or potentially useful, you need to build a proof of concept prototype and a simulated environment to advance to TRL 8 or so. Unless you do that the private companies don't have the confidence to invest." In the U.S., he said, the Valley of Death exists between TRLs 4 and 7, the realm of engineering and systems work, where both the technology and the manufacturing readiness are tested. Successful models for doing this exist in the German Fraunhofer Institutes and Taiwan's Industrial Technology Research Institutes. "To transition home-grown discoveries into home-grown products," he said, "we need 'Edison Institutes' modeled after Fraunhofer Institutes for maturing technology and manufacturing readiness."[9]

In order to improve this transitional process, Dr. Kota said, we also need a new balance of strategic investments. In the FY2010 budget, approximately $100 billion were designated for R&D all the Federal agencies. Outside the Department of Defense, which focuses on weapons systems, most of this amount supports work below TRL 3. "That is new knowledge for the public good," he said, "but that's only the first step. None of the agencies spend enough in the middle, where innovation happens, where an idea is converted into a product."

"How do we reconcile with investing so much and having little to show?" Dr. Kota continued. "Some might say there's nothing we can do because there is too much labor competition from China and India." He echoed Dr. Wessner's point about Germany and Japan, however, which competed effectively without the advantage of lower wages. In Germany, he said, taxes are somewhat lower, but wages, overhead rates, energy expenses, and the raw cost index are higher. Yet, the bottom line is that Germany has a $200 billion surplus in manufacturing, vs. an $800 billion deficit for the U.S. The comparison with Japan, he said, shows similar results.

[9]The Fraunhofer-Gesellschaft undertake applied research of direct utility to private industry. It uses a clustered approach with pilot production centers to close the gap between research and products.

Investing in the Innovation Gap

The challenge for the U.S., Dr. Kota said, is less an issue of how much we invest in R&D, but where we invest it. We should be investing in that innovation gap, he said, and using other tools we already have, such as early procurement, Federal loan guarantees, and scaling through industry cost sharing. "The government can accelerate innovation with a better strategy. And it certainly needs to coordinate Federal investments rather than having every agency following a different direction."

With regards to strengthening the manufacturing base, Dr. Kota praised public-private partnerships for their ability to catalyze new industries and strengthen existing industries. This could be done in shared facilities, such as technology parks and institutes for technology development, and make better use of the "building blocks" of manufacturing innovation, such as access to capital, tax credits and loan guarantees, a skilled workforce at all levels, and better access to markets. New industries in which the U.S. must be competitive include flexible electronics, nanomanufacturing, advanced vehicle technologies, and robotics. Complex and costly skills that are required in these industries will require both government and industry forces, especially modeling and simulation and IT-enabled manufacturing. These will require more coordinated actions across agencies and industries if they are to play a fundamental role in revitalizing American manufacturing. "Industry and the Federal government must come together," he said, "to co-invest in technologies."

Dr. Kota closed by emphasizing several steps that the Federal government is taking to enable manufacturing in the states and regions. One is NSF support for proof of concept centers in universities—"a small step, but in the right direction." Another is the emphasis on advanced manufacturing featured in the FY12 budget, including a new initiative by the Economic Development Administration to help small businesses gain access to modeling and simulation tools. These are currently too expensive for most new firms, even though they are known to reduce costs, improve quality, and cut time to market. This initiative, called the Midwest Pilot, offers modeling and simulation access in the form of software services to lower the barriers to entry and allow "small manufacturers to move up the food chain in terms of innovation and improvements in design and quality." Other examples of Federal-local initiatives, small process manufacturing, robotics, flexible electronics, and other technologies, to allow small companies to gain the skills they need to compete globally.

THE STATE MANUFACTURING CHALLENGE

Eric Burkland
Ohio Manufacturing Association

Mr. Burkland said he would offer information and data that show why Ohioans are optimistic about the future of manufacturing in the state and how it can be a platform for innovation. Manufacturing generates about 18 percent of the gross state product, about twice that of any other private-sector activity (next in rank is real estate, rental, and leasing, at 10 percent.). Manufacturing output in 2008 was $84 billion, which was $37 billion higher than the next nongovernment sector. The sector employs about 600,000 people, or 14 percent of the work force. The largest employer in the state is government. In terms of payroll, however, manufacturing still leads, with about $38 billion in 2008, followed by government, health care, social assistance, and retail trade. Ohio is the seventh largest exporting state, selling about $34 billion worth of goods in 213 countries and territories. The state ranks first, second, or third among U.S. manufacturers in 84 different categories of manufacturing, as specified by the North American Industry Classification System.[10]

The level of leadership in manufacturing, Mr. Burkland said, was largely a function of government policies and practices. These include:

- Labor: government is largely responsible for educating a skilled workforce.
- Technology and business practices: Government has significant inputs, including support for research, protection of intellectual property, and creation of an environment that facilitates technology commercialization.
- Equipment: Availability of capital is influenced by how government regulates the flow of credit. Capital availability for this has been "pretty much a crisis" for the last couple of years, though it is starting to ease.
- Location: Governments establish zoning, regulatory, and environmental rules and provide incentives.
- Transportation: Most of the infrastructure is publicly held and all of it publicly regulated.
- Energy: Government drives prices by numerous policies.
- Environmental regulations: Government drives costs through emission and control laws.

[10]For example, Ohio ranks #1 in wood products, adhesives, plastic bottles, refractory goods, rolling and drawing steel, nonaluminum foundries, paint and coatings, resins, rubber products, pressed and blown glass, ferrous metal foundries, custom roll forming, hand tools and saw blades, bearings, plastic and rubber machinery, rolling mill machinery, wood kitchen cabinets, heat treating, ordinance, machine tools, heavy duty trucks, and brooms, brushes and mops.

- Access to markets: Government facilitates access, promotes exports, and prevents unfair imports.
- Taxation: A major cost driver. "We do not have a tax structure that's favorable to manufacturing."

Mr. Burkland offered a preview of the Ohio Manufacturing Network of Innovation, which was about to be launched. It is an on-line technology platform to support open innovation, and to connect Ohio manufacturers with researchers in universities, Federal labs, and economic organizations. "The supply chains here have been pretty rigid for many years," he said, "and all this pain has caused us to reach outside of ourselves. So we now have a lot more networked capacity than we used to."

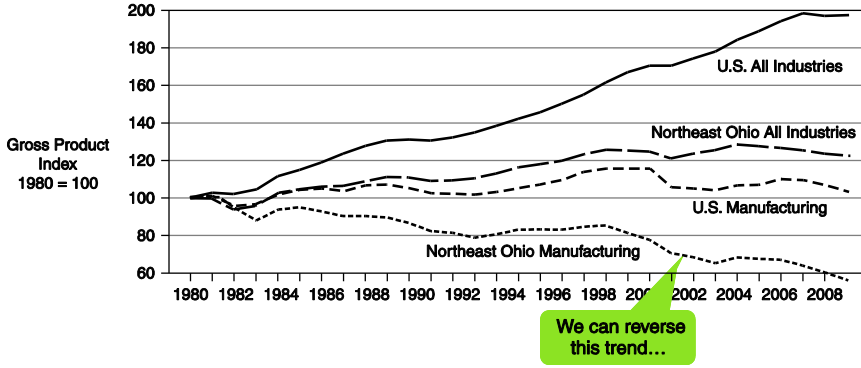
An Open Innovation Approach

This includes, for example, companies in the auto supply chain that are now connected to the appliance supply chain and the aerospace supply chain. It allows companies to showcase their areas of expertise and interest, especially in design, materials, and process technologies, and to quickly identify and contact "best-in-class" technical experts relevant to needs. The network was patterned somewhat after Proctor and Gamble's open innovation approach, allowing a researcher at Timken, for example, to discover that someone at the University of Dayton has already solved a particular problem. "We're trying to see through this opaqueness between institutions to discover if we can create a culture for cooperation," he said. One of the two Manufacturing Extension Partners, administered by NIST, has taken a lead in developing the technology, along with P&G, GE, and NorTech. "What we need is not new organizations," he concluded, "but better connectivity and productivity out of what we have."
In conclusion, Mr. Burkland said that the Ohio Manufacturing Network would have pleased Col. John G. Battelle, the Ohio industrialist whose fortune formed the basis for today's Battelle Institute, the world's largest independent R&D organization. Battelle saw the advantages of networking a century ago when he sent a letter to 20 other leading industrialists. "His message was: 'Let's find a better way to work together.' Now there was an innovator."

STIMULATING MANUFACTURING IN OHIO: AN INDUSTRY PERSPECTIVE

James Griffith
Timken Company

Mr. Griffith began by saying he represented two enterprises at the symposium: Timken, a $4+ billion manufacturing firm of which he is CEO, and Magnet, the Manufacturing Advocacy and Growth Network, which he also chairs. Magnet is a not-for-profit economic development enterprise in northeast



SOURCE: Cleveland State University Levin College of Urban Affairs update of data contained in <*http://urban.csuohio.edu/economicdevelopment/reports/EconomicBrief_2010_Final.pdf*>.

FIGURE 2 Northeast Ohio faces a severe economic challenge.
SOURCE: James W. Griffith, Presentation at the April 25-26, 2011, National Academies Symposium on "Building the Ohio Innovation Economy."

Ohio with a mission "to support, educate, and champion manufacturing with the goal of transforming the region's economy into a powerful, global player."

He said that he became involved in economic development in northeast Ohio "because we were going through a transformation at Timken" which applied directly to issues experienced by other manufacturers. He displayed a graph, generated by NorTech, that showed Ohio falling steadily from a leadership position in 1980 to its present position far behind the rest of the nation, both in manufacturing and in all industrial growth. "I am a believer that we can change this," he said. "We've done it at Timken, and I believe we have learned some lessons that apply broadly."

Like Ohio, Mr. Griffith said, Timken has a strong heritage of success. From 1960 to 1980, the firm performed strongly, with returns on invested capital above 20 percent year after year. "A bad year was just 20 percent," he said. "And this kind of world-leading success was typical of northeast Ohio then." In the 1980s profits shrank into losses, and for the next 20 years the company struggled to right itself. "I've been there for 26 years and I never knew that good time," said Mr. Griffith. "I've been there for the struggling time."

10 Years of a 'Grow and Optimize' Strategy

In the late 1990s the company changed its strategy and profits began to return, and after 2009 they reached record levels. "How we did this is not a secret," Mr. Griffith said, "and it didn't happen overnight. It is the result of a 10-year application of a highly focused strategy." This strategy, which he called "grow and optimize," began with innovation, he said: understanding where the company differentiates itself from others, and which markets to target. "We

were a bearing company when we started. We're still mostly a bearing and steel company. But we've learned to take the technology and apply it to markets where we could differentiate and expand. We started as primarily an automotive manufacturer; today we're an aerospace manufacturer, and infrastructure manufacturer. We have a very aggressive growth business in Asia. We're a steel company. We melt a million and half tons of scrap a year and turn it into super high alloy for new markets. The management team of our steel business gets paid an incentive on new product generation. Last year they earned a nice bonus because 35 percent of what they sold was a product in new markets. $35 million of that was exported to China. So when you're selling China steel that is made in Ohio, you're doing something radically different." This part of the strategy, he said, was fundamental. Timken had to be the world's best manufacturer, he said, so the company invested heavily in growing, building its skills, and spent a quarter of billion dollars redoing the company's systems infrastructure.

That part of the strategy, Mr. Griffith said, was "fun"—but another part was not. "We looked at our business and saw there was a big chunk of it we couldn't afford to fix. And the company couldn't survive if we didn't deal with it. The company invested a quarter of a billion dollars in China, and now exports as much to China as it makes in China. But to be in that market we had to be a very different company. We had to divest $1.5 billion worth of businesses that we couldn't win in, and we closed 30 manufacturing sites in northeast Ohio. That's the hard side to innovation."

This "grow and optimize" model worked. "By the time our strategy was noticed, we were an instant success on Wall Street," he said. "Our stock price popped 100 percent. We were one of the top industrial stocks last year. But we were not an overnight success. This came after 10 years of hard work, innovating, ripping out the infrastructure that inhibited innovation within a 100-year-old company."

A Heritage that Threatens Development

Mr. Griffith continued that the same principles apply to much of northeast Ohio. The region has a strong heritage of manufacturing. It was a pioneer in the aerospace industry; it built up the auto industry, which brought Timken to the region originally; it was a leader in the national steel industry. "Unfortunately, that heritage created an infrastructure that threatened to strangle the kind of economic development we need—the sense of innovation."

In addition, the state is heavily taxed. A study by the Tax Foundation ranked Ohio 46th in its business tax environment. "There are three major corporations that wouldn't be here if the state government hadn't taken specific action to address their circumstances in the last year," he said. "This is an infrastructure issue we have to deal with." Another is the presence of more than 2,300 governmental entities in the state, which are costly to maintain and have overlapping functions. "Someone has to pay for those entities," he said. Because governments have proliferated to this extent, he said, it is "confusing to do

business here. We've done a lot in Columbus, and a lot in Cuyahoga County, but there's a lot more to do. We're inventing new kinds of government. We've simply got to continue to drive at that."

Mr. Griffith also said that Ohio is not competitive when it comes to "union participation," being in the top quartile in union membership. "That's a heritage of being a large industrial manufacturing economy," he said, "along with a legal system that reinforces it." He said that a pending senate bill would address some of those issues, but that the issue was complex and difficult to change. "When you look at those two heritages," he said, "the implication is, many large manufacturers who are looking to invest somewhere see this infrastructure and we don't even make the short list. We have to have the fundamentals that make us a competitive state for investment."

Strengths in SMEs and Education

Turning to "the positives," Mr. Griffith said, the region's heritage had left it with two pillars of strength. The first is small and medium-sized businesses. The 16 counties of northeast Ohio have some 8,000 SMEs, which provide a broad foundation on which to build. "Unfortunately," he said, "many of them were founded as outsource suppliers to big companies like Timken, and they have to acquire the skills to innovate and better access to high technology."

A second pillar, Mr. Griffith said, is great strength in higher education, including a network of 23 colleges and universities enrolling 160,000 students. "The challenge for us is to leverage those students into an innovation economy." Part of the mission of MAGNET, he said, along with NorTech, is to better link manufacturers and universities, so that students acquire the skills needed by the manufacturers. "That's exactly what happened at Timken," he said. "We were manufacturers, but we had to learn the skills of reaching out and investing in R&D in the regional universities." A new initiative to encourage this is the Partnership for Regional Innovation Services to Manufacturers (PRISM), which is funded jointly by the Fund for Our Economic Future, the Cleveland Foundation, and the Brookings Institution. The program will reach out to small businesses to teach them skills, build networks, and begin an "embryonic phase of growth within existing businesses."

In closing, Mr. Griffith urged his fellow Ohioans to "keep it simple." He said that Ohio already has a strong network of enterprises focused on innovation, which would be described during the symposium. "There is no need for new organizations, but for better use of existing ones. They're focused on entrepreneurship, on intrapreneurship—internal innovation—and on changing the infrastructure. We have an incredible wealth of assets. We simply have to fix the infrastructure underneath them that is a heritage of our historic success, drive the success of our universities, and bridge it across the small enterprises. Then we can leverage those enterprises to create the innovation economy we need."

REVIVING MANUFACTURING: THE ROLE OF NIST

Phillip Singerman
National Institute of Standards and Technology

Dr. Singerman, who arrived at NIST only three months previously after some three decades in technology-based economic development, professed a long-standing personal connection to the region. A graduate of Oberlin College, he has worked with institutions in the region on Federal engagement strategies, including NorTech, Jumpstart, BioEenterprise, the Fund for Our Economic Future, and MAGNET. "Today," he said, "I'm delighted to represent NIST, whose Technology Innovation Program is one of the three Federal co-sponsors of this event."

He began by "reintroducing" his audience to NIST, and some of its activities in Ohio. NIST was founded in 1901, contemporaneously with many corporate laboratories, including Bell Labs, AT&T, and General Electric. It was "one of Ohio's presidents," he said, William McKinley, who recognized that the U.S. needed a sophisticated national system of industrial standards and measurements to compete with the more developed industries of Europe.

Working Directly in Support of Industry

NIST has the unique Federal mission of working directly in support of industry as a non-regulatory agency. Its role has deepened in response to changing requirements of industrial development. Dr. Singerman quoted NIST director Pat Gallagher, the first Undersecretary of Standards for Technology: NIST has become "industry's national laboratory. With the decline of the corporate laboratories created over a century ago," he said, "NIST now performs many of those functions."

Last year NIST reorganized, combining 12 academically oriented laboratories into six mission-driven operating units: national user facilities, the center for nanoscale science, the center for neutron research, technology laboratories in engineering and information, and measurement sciences. NIST also combined the external partnership programs into one directorate which Dr. Singerman was selected in 2011 to head. This reorganization was driven by NIST's central role as an innovation agency, especially for manufacturing. Also driving the reorganization was the projected doubling of the R&D budget in the physical sciences and the rebalancing of R&D investments among the NSF, the DoE's Office of Science, and NIST. This reorganization was proposed in the 2007 America COMPETES legislation, and reaffirmed in the 2010 reauthorization of the America COMPETES Act.

Dr. Singerman offered specific examples of how NIST attempts to strengthen innovation. The first is the Manufacturing Extension Program (MEP), an external partnership in which James Griffith of Timken and others in Ohio have been "consistently involved." He said that the MEP is "the closest we have

to the Fraunhofer network, but it is really 'Fraunhofer lite.'" The MEP is a national program with about $125 million in annual funding, with two-thirds matching by the states and private sector. "This is a sustainable model that has endured for over a quarter of a century," he said. "The MEP is the gold standard for effective national networks of technology dissemination and adoption to drive economic growth."

Dr. Singerman said that through the MEP, NIST has made major contribution to the Ohio economy over the last several years. From fiscal years 2006 to 2012, NIST funding of $27 million has been matched by over $70 million in cost sharing from the state and partner organizations, and has led to significant increases in sales, new investments, and jobs. While the MEP is best known for promoting lean manufacturing and cost savings, it is now developing national network programs to promote new products and innovation services, in partnership with regional organizations. Last fall the MEP awarded $9.1 million to 22 projects, including two in Ohio, one of them to MAGNET.

The second example was the TIP program, which, Dr. Singerman said, resembles the SBIR awards "on steroids." That is, the TIP grants, at $3 to 5 million, are larger, but still aimed primarily at small, technology-based companies. TIP succeeds the Advanced Technology Program, which for 15 years provided competitively awarded funding matched by the private sector for technology research and development. Over a third of all ATP awards supported manufacturing technologies. Ohio received 26 ATP awards across all categories totaling nearly $90 million. The TIP program supports precompetitive technologies of small and mid-sized companies, with an increasing focus on manufacturing technology. In the past two years, 21 awards have been made to manufacturing firms, representing over $60 million in Federal funds.

'Enormous Interest' in Innovative Manufacturing

Dr. Singerman noted an "enormous capability and interest" in industry in innovative manufacturing. The most recent TIP solicitation for manufacturing technology drew 110 proposals, of which only nine could be funded. Some 85 percent of those recipients had fewer than 35 employees and were less than 10 years old; two-thirds were less than five years old, with 15 or fewer employees. "So this program really targets the small, high-growth companies that are the key to our economic success," he said.

Ohio has been active in the both ATP and TIP programs, with 10 percent of all TIP awards and 14 percent of all TIP manufacturing awards going to Ohio companies. Companies receiving awards are MesoCoat, Angstrom Materials, Hypertech Research, and Kent Displays. NorTech helped position Kent Displays to successfully compete for the TIP award, with MAGNET and the University of Akron as participants. He called this an illustration of the power of connectivity.

Dr. Singerman closed by mentioning several other NIST programs:

- NIST has managed the Malcolm Baldwin National Quality Award for 25 years. Again, he said, Ohio has been active in this program. Of a total of 87 winners of the Baldridge Award since 1988, four are based in Ohio.
- NIST's Technology Partnerships Office builds and sustains technology partnering activities between NIST laboratories and industries. This includes "an active and specialized technology transfer SBIR program." Since 2005, the office has issued three patent licenses to Ohio firms, five SBIR awards, and 12 cooperative research and development agreements (CRADAs).
- The Israel-U.S. Binational Industrial Research and Development (BIRD) foundation has for more than 30 years lent support to companies working jointly in the two countries. Its mission is to "stimulate, promote, and support industrial R&D of mutual benefit to the U.S. and Israel."
- A new program in the planning stage for 2012 is an Advanced Manufacturing Technology Consortium. Based partially on the Sematech model, its goal is to support creation of industry-led research and development consortia. He closed by inviting ideas from the audience: "We will be reaching out to the community for your ideas on how to structure this."

DISCUSSION

A questioner noted that he had not heard any comment about the new manufacturing technology known by a variety of names, such as rapid prototyping, custom production of parts, or additive manufacturing, and asked if it was more than a curiosity. Dr. Kota said that it is "very much more than a curiosity," and that he had begun experimenting with such techniques more than 12 years ago in studio lithography. He said that rapid prototyping has brought many changes, such as shortening the product development cycle and enhancing the ability to see from packaging considerations how a product fits. "These techniques are still not ready for mass manufacturing," he said, "but they will bring great advances in making one-off parts and custom-designed parts."

High-tech Behavior by Traditional Business

Mr. Griffith said he used this high-technology process at Timken, and that even though some people do not see the manufacture of specialty steel, bearings, and even helicopter transmissions as "high-tech," a goal is to transform traditional businesses by using just such new technologies. "It does change the way you think about product proliferation and the ability to enter new markets, and differentiate yourself in the marketplace. Let me tell you, "Timken is a very high-tech company," even though it is not part of the new

categories that occur to many people, such as biotechnology or nanotechnology. The questioner noted that the polymer industry offers a "big opportunity for this technology to produce a broader array of parts and get into smaller scale manufacturing, rather than simply one-off projects. Mr. Griffith added that his company had "a great cooperative program at the University of Akron to advance our polymer products" that lowers cost and raises competitiveness.

Mr. Baeslack added that Ohio is "brilliant at materials, and there are a lot of applications in new tooling. Figuring out a faster, cheaper, more flexible tooling set opens up all kinds of new product development opportunities."

Dr. Wessner posed two questions: (1) What could we do from the Federal or state levels to provide greater support for public-private partnerships, which are "the type of thing that our German colleagues excel at;" and (2) how significant is the 13.6 percent rate of unionization in Ohio, which only modestly exceeds the 11.6 percent national average for states? He added that Germany is "heavily unionized," with union members on corporate boards, and yet it is successful at manufacturing and exporting.

Mr. Griffith, in response to the query about how Washington can help, praised the Partnership for Regional Innovation Services to Manufacturers (PRISM) initiative being developed by NorTech and MAGNET as an "interesting opportunity. "One-half of it helps educate people like me on how to work on partnerships," he said. "The other half makes sure places like Akron and Case have robust R&D capabilities. Both have to happen; then you have to leave those of us at the state level to make it work."

With regard to unions, Mr. Griffith said that the state's legal infrastructure does reinforce unionization, as do the traditional mindsets. One challenge for Ohio is that the compensation paid by older unionized industries is in the range of $60,000 to $80,000 to workers who tend to have only high school training but who have acquired seniority in their jobs. These positions were now in decline "because in a competitive market there are people who will do the same job for lower cost. When people who want to invest in manufacturing see our environment, and compare it with South Carolina where wages are half as much and state laws are supportive of people working for a company vs. having a third party represent them, they choose to invest there. That is a fact of economic development in building new factories."

Dr. Proenza asked about some confusion surrounding the manufacturing industry. "Many believe it is dying, but much of the data seems to show it is growing in value, but growing by productivity and automation." Mr. Baeslack agreed with the second premise, adding that that "the biggest problem in manufacturing is misunderstanding its foundation. Each presidential election year we get calls from outside newspapers wanting to take pictures of boarded up steel mills. That's not Ohio today. Ohio today is a remarkable productivity engine in manufacturing, and most of the job losses have come because of new technologies and new management."

The Role of Venture Capital

A questioner turned to the topic of funding for small and medium-sized enterprises (SMEs). "The equity and venture capital groups really do not seem interested in providing funding to small companies because they do not make enough money." She asked whether VC companies were "getting back into the game." Dr. Kota replied that smaller companies bring with them a higher level of technological risk, and to address their needs "you need to do more than SBIR bridge funding to mature the technology" until it is proven and ready VC firms. This, he said, is an opportunity for Federal and state entities to work together with companies.

The questioner asked if venture capital firms are too risk averse. Mr. Pogue said that "as a venture capitalist, it is not a question of being risk averse; we live with risk all the time, including the risks of very early-stage startup companies." He went on to say that of about 700,000 new companies started every year, VC firms invest in only about 1,000 of them, or 1 in 700. They lose all of their investment in about 30 percent of companies they invest in, and earn just marginal gains in another 30 percent. "A major concern," he said, is that most of the small companies seeking capital do not have business plans that are ambitious or believable enough to make the kinds of returns that the pension funds and endowments who supply capital to VCs require. We venture capitalists have to do better than the stock market over a period of time if we are to sustain funding and not be shut off from the pension funds. We find that in most cases, small firms looking for support are not really interested in high growth, in diluting ownership, or becoming public companies. They are interested in cheap capital."

The questioner proposed further that one responsibility for venture capital companies is to help small firms create jobs. Mr. Griffith agreed with the urgent need for job creation, but that this had to be built on a strong business foundation. "The investments of VC firms aren't aimed at creating jobs, they're aimed at getting a return," he continued. "It's the same for Timken. We're not about employing people, we're about getting an economic return, and that's the only way we get the right to employ people. Our objective is to build an economy, and if you build an economy, the jobs will come."

Panel III

Innovation Clusters and Economic Development

Moderator:
Lester Lefton
Kent State University

Dr. Lefton, the moderator, set the tone for a panel on clusters by using a mathematical analogy. "In the case of economic development," he said, "we talk about putting groups of things together in a situation where we hope 2 + 2 + 2 will equal 14, or, in the case of Ohio, maybe even 27. That's our focus: how to leverage existing resources by combining similar industries where people are doing similar kinds of work. Our panel is going to focus on how we can create policy changes, an economic climate, and a set of cooperative ventures that will provide the platform needed to generate great leverage."

CLUSTERS AND THE NEXT OHIO ECONOMY: WHAT IS NEEDED

Lavea Brachman
Greater Ohio Policy Center

Ms. Brachman, executive director of the Greater Ohio Policy Center, whose office is located in Columbus, said that she is also a non-resident senior fellow at the Brookings Institution, where she has worked to identify a structure for policy reforms in Ohio. She said that this has necessarily meant working in partnership with not only the state government, but also with local governments, metro areas, and regions. "While state participation is necessary for economic development," she said, "it's not sufficient."

Ms. Brachman said that if regional economies and "metros" are the economic drivers of the 21st century, and if cluster development is a promising strategy, and if anchor institutions are important sources for growing clusters, then Ohio should be well positioned. However, she averred that the picture is more mixed, especially as applied to transitional economies. I believe we will prevail, but today I want to explore the premises, and some barriers."

Putting a "cluster growth" policy into action, she said, begins with a place-based approach, aligning multiple players with "intense knowledge about

the sectors." The application of a cluster strategy in the context of transitional economies must be paired with a broader economic restructuring.

The Greater Ohio Policy Center, Ms. Brachman said, thought of itself as the "smart growth" organization, with a mission of "promoting public policy to grow Ohio's economy and improve the quality of life through intelligent land use."

Initially, Ms. Brachman said, the group began with a study of sprawl and urban core revitalization. But when it joined with Brookings Institution's Metropolitan Policy Program, it saw that land use challenges could only be addressed after examining the local economies and determine why they were not growing. Last February it issued a report, "Restoring Prosperity," with 39 policy recommendations, beginning with "Ohio can compete in the next economy."[11] The report concluded that "metro areas and regions will drive that economy," but that substantial improvements in governance must be made if positive changes are to be affected.

Ms. Brachman offered the working definition of clusters as "geographic concentrations of interconnected firms and supporting or coordinated organizations." She said that a cluster could be an effective tool to jumpstart the economy, "but it's not a panacea. Emerging clusters should be supported only when they can be justified by data."

Among the general challenges she saw were that "transferring knowledge is a complicated process," as is knowing where to intervene and when to bring products to market. It is difficult to find a fit between university research strengths and local economic structures, a problem that "can't be solved entirely by a cluster approach." Finally, it is difficult to generate win-win strategies that can both benefit institutions and transform the community.

A Challenging Business Climate

Certain features of Ohio, Ms. Brachman said, made for a challenging business climate. First, the extent of economic decline, she said, was "unparalleled." There is also an unusual diversity of regional economies. The seven or so major metropolitan areas were all grounded in specific, mostly different industries: Dayton specialized in autos, Toledo in glass, Youngstown in rubber, and so on. "We're sort of stuck with older economies that still exist. With the layering on top of those older industries, it is harder to identify the key growing clusters." It is also a challenge to connect regional economic growth and the power of the metros with neighborhood revitalization. The cities have emptied out, leaving high concentrations of poverty. For example the population of Cleveland dropped from 900,000 to 400,000 between 1950 and 2010, the population of Cincinnati from 500,000 to 300,000. A disconnect persists between skill level and job creation, and a fragmentation of government reduces

[11] Jennifer Vey et al., "Restoring Prosperity: Greater Ohio and the Brookings Institution," Washington, DC: The Brookings Institution, 2010.

the possibilities for collaboration. "That makes it difficult to use clusters as the panacea," she said.

Ms. Brachman also agreed with Mr. Timken that Ohio is a state with antiquated governance systems and high costs. "These detract from the innovation focus we need, from business development, and tends to promote interlocal competition and 'poaching' that undercuts regional competitive capacity." She said that 86 percent of states have fewer governments per 100 square miles than Ohio.

The state suffers from a confusing combination of historic factors and modern sprawl. In the early agricultural economy, county lines were drawn so that one could travel to the county seat and home again in a horse and buggy from anywhere in the county in one day. Agrarian economies were more localized, and not easily compatible with today's global economy based in metro regions. Land consumption, or sprawl, has outpaced population growth, and sprawl without population growth results in more local government.

At the same time, Ms. Brachman added, there are opportunities. For example, the state's economic history is defined by pockets of concentrated industrial activity rooted in the major cities. Because there are seven or eight of those, they present an opportunity exceeding other states, most of which (Illinois, Indiana) have only one major city. "Theoretically," she said, "if the metro and regional economies are our drivers, we have many of those. We just have to figure out how to leverage them and return ourselves to a basis where each of these cities can thrive uniquely. We can also make good use of multiple anchor institutions rooted by place, such as the University of Cincinnati, the Uptown Consortium, and University Circle in Cleveland.

The Need for Governance Reform

In planning next steps, Ms. Brachman said, the state needs to be "very intentional," beginning by encouraging natural clusters, but also by removing obstacles, especially through governance reform. "Otherwise these will continue to undercut our competitiveness and prosperity," she said. "The role of governance should be to facilitate, not hinder, cluster growth."

Ms. Brachman listed several suggested ways to bring about local governance reform. First, creation of a Governance Reform Commission, which would collect data and monitor the growth and needs of those governments. Second, she suggested the creation of a framework for pooling resources regionally, a form of revenue sharing in which "the state needs to be playing a much bigger role. We also need to make mergers, consolidation, shared services, and alternative governance structures more 'permissive.'" In many cases, she said, even if mergers of small government entities were shown to be desirable, as between a city and county. They are not permitted under state law. Finally, she suggested that more data needs to be collected on local government costs. All of these steps, she said, must be taken "in the service of creating a more

innovative environment and reducing the costs that undercut our competitiveness."

Governments also have a larger role to play in creating a fertile environment for clusters. This process can begin with public-private partnerships. Here the private sector needs to lead the way, but public intervention by government needs to create the right conditions to encourage cluster growth.

Doing this, Ms. Brachman said, requires a "multilayered" approach, with public policy restructuring at local, state, and Federal levels, as well as better and more agile partnerships across organizations and across government, business, and nonprofit sectors. She offered Pittsburgh as a nearby example, in its ability to bridge some gaps by creating a regional organization that is "not too large to function."

Another way to promote cluster development is to create a culture of innovation. Key components of such a culture are that it led by the private sector and promotes a productive blend of competition and cooperation; this would more closely resemble the collaboration commonly seen in Silicon Valley than the more hierarchical and secretive behaviors of Route 128 near Boston. This culture must also remove obstacles and inefficiencies, and encourage public investments in education and training. Create a culture of innovation is a major challenge. It may begin with anchor institutions that try hard to leverage their research capacity. Questions remain about the best ways to generate commercialize new products.

The Role of Anchor Institutions

The role of anchors, such as universities, in generating new knowledge is critical in advancing innovation, but universities cannot do this alone. They have their own challenges, such as decentralization. Also, anchor institutions may be beneficial at a broad macro level, but many moving parts must be addressed at local and regional levels, such as knowledge transfer, community revitalization, and education and training. An emphasis on anchors is consistent with putting knowledge first, she said, instead of incentive and financial packages.

When considering the role of anchors in weak market economies, Ms. Brachman said, community transformation cannot be overlooked while generating cluster growth. Community transformation is pivotal to economic transformation—a realization that Akron, Cincinnati, and other cities have faced fully. The efforts of employers, purchasers, developers, educators, and neighborhood groups must be fully engaged and coordinated. As an example, she pointed to the home ownership incentive program of Ohio State University and forgivable loans for the neighborhood by the University of Akron and Case Western Reserve.

Ohio, Ms. Brachman continued, is uniquely positioned with multiple anchor institutions that are rooted by place. These have the potential to bring

growing positive impact to local economies. This impact can be increased by linking the anchors with clusters and business growth. As examples she listed the University of Toledo, University of Akron, University of Cincinnati, OSU, Case Western Reserve, Wright State, Youngstown State, and Ohio University.

Ms. Brachman said that a recognition that Ohio needs to take a different approach to economic growth dated roughly from 2005, when a report by Deloitte was published.[12] This report identified several clusters, and while they were not truly place-based, the ensuing discussion "certainly moved the concept along." The report not only identified areas of economic strength, such as motor vehicles, polymers, and clinical medicine, but also institutions with crucial roles, such as the Ohio Third Frontier and the Hubs of innovation. While the seven Hubs, she said, were products of the previous state administration, their objective of encouraging regional growth by connecting anchors with downtowns and with promising business clusters was a step "in the right direction."

"This kind of economic restructuring and cluster development does not happen on its own," Ms. Brachman concluded, "and you need to be thinking how to organize it for success. It seems to us need that we need to leverage the best of democracy, and do it both from the top down and the bottom up. Finally, I'd like to assert that regions are laboratories of democracy, and that they are best approached by a placed-based strategy. It doesn't work to just spread resources around like peanut butter."

INFRASTRUCTURE FOR THE 21ST CENTURY: HOW EDA MIGHT HELP

John Fernandez
Economic Development Administration

Mr. Fernandez began by saying he is a native of Ohio, and a former mayor of Bloomington, Indiana, who understands the challenges of the Midwestern states and regions from personal experience. He said that President Obama understands them as well, and is "very committed to the notion of winning the future by out-innovating, out-educating, and out-building" the competition. He added that "in my world, the concept of investing in our future is not at odds with the notion of a sound fiscal policy. It requires tough choices, it requires prioritization of investments. That's certainly what all of us have been charged to do within our own agencies."

Mr. Fernandez said that for the EDA, which sits within the Department of Commerce, this charge means "taking hard looks at things that have been around forever, and may not perform as well as they used to." The better course, he said, was "a government that's actually organized around performance and around the challenges of the 21st-century economy."

[12]Deloitte.

Mr. Fernandez defined EDA's role as providing "the ground troops that try to build up these regional environments." He said that since its founding in the 1960s, the EDA had evolved considerably from an economic development organization focused primarily on basic infrastructure to one that is focused on how to build an innovation economy. "We talk almost every day about how you have to have competitive regions if you're going to have a strong national innovation agenda. And we have to focus what we do in my agency on the regions, and on innovation ecosystem development."

The Power of Regional Collaboration

Mr. Fernandez said that he had been working in economic development for about 20 years, and that during his time as mayor of Bloomington IN, "I was involved in the 20th-century economic development game as fully as anybody." The shortcoming of the old model, he said, was that it treated economic development as a zero-sum process. Rather than focusing on the competition in China or Brazil or other places around the world, "we were competing with Ohio or Indiana or just down the highway within Indiana. That focus on inter-state squabbles is really dated."

If the U.S. is going to win the future, he said, it has to collaborate regionally. Normally this is done well in the Midwest, he said, but there are "lapses." Members of the Great Lakes Commission, he noted, generally collaborate and pool resources for the benefit of the region. But when fiscal pressures build, the states may decide to raise taxes a little and suddenly "the surrounding governors pounce on them and try to steal their businesses because they now have lower taxes. I think that's the wrong model. Our country won't out-innovate in the long term if we just try to steal from our neighbors."

From 'Grant Mill' to 'Network Broker'

The way to win the future, he said, is to build an "ecosystem" where organic companies are born, where new companies thrive, and where long-term investment can create jobs locally and regionally. EDA is focused on collaboration models, which means "doing economic development differently. I tell everyone that we're trying to move away from being a 'grant mill' to being a 'network broker,' where our work is to connect people, line up resources, and be a catalyst in the investments we make."

Key Characteristics	20th Century Economic Development	21st Century Economic Development
Focus	Domestic competition; Zero sum game	Global competition & collaboration; Positive sum game
Goal	Growth of jobs	Increasing productivity & per capita income; Growth of jobs
Approach	Incentives to attract or retain cost-driven firms & industries	Investments in talent & infrastructure to support innovation-driven clusters
Role of Economic Development Practitioners	Lead industry attraction and marketing efforts to firms & industries	Broker innovation networks, connecting inventors, financiers, & transformers, to produce results
Performance Metrics	Quantity of jobs, number of firms attracted/retained	Quality of jobs, wage and income growth, innovation

FIGURE 3 A new economic development model.
SOURCE: John Fernandez, Presentation at the April 25-26, 2011, National Academies Symposium on "Building the Ohio Innovation Economy."

If the EDA can leverage economic assets on a regional basis, Mr. Fernandez said, they can help sustain growth. "I don't think you can be just about low cost; that only gets you so far. It's got to be about high talent, innovation, leverage, and public-private partnerships. Those are the resources our agency and this administration tries to seed and encourage." The agency's "leverage points" for sustainable and inclusive prosperity are to (1) enhance regional concentrations, (2) deploy human capital aligned with job pools, (3) develop innovation-enabling infrastructure, (4) increase spatial efficiency, and (5) create effective public and civic culture and institutions.

As the agency tries to change course toward more effective innovation, he said, it develops a framework around jobs and innovation partnerships. EDA is a small agency, he reminded his audience, with a budget of only about $300 million—a mere "rounding error" for a large agency. "We aren't going to move the macro-economic needle of the country's GDP," he said. "But what we can do is be selective and effective with the investments we make. We've tried to target our money at key sectors of innovation ecosystems, to use best practices, and to use competitions to drive demonstration projects. Included in the Jobs and Innovation Partnership are the following:

- Jobs and Innovation Accelerator Competition.
- i6 Green Challenge.
- Regional Innovation Acceleration Network.
- National Economic Cluster Map.
- 21st Century Innovation Infrastructure.

Making Selective Investments

For the i6 challenge, Mr. Fernandez said, which is open to proof-of-concept centers, the Austen Bio-Innovation Institute in Akron was one of the recent winners. EDA also invested in a modeling simulation pilot project for advanced manufacturing in the Midwest. "Those are the kinds of selective investments we want to make that can help demonstrate best practices and be catalytic. We've also learned listening to our stakeholders that you need a lot of persistence and dedication to get through the maze in applying for Federal resources. We need an easier interface and from the Federal side a common framework to bring these fragmented programs together. This is a model the stakeholders and the customer want." He said that EDA was working with 15 other Federal agencies on a Jobs Innovation Accelerator, a $30 million competition for 20 pilot sites to develop locally chosen public-private partnerships around specific cluster initiatives.

Mr. Fernandez closed by reaffirming that "the solutions we need to drive innovation in our economy aren't going to be born in Washington. They're going to be born in communities like Cleveland, like my hometown of Bloomington, Indiana, and other places where the ideas are. That's why these bottom-up strategies really matter, and why the work you do every day is important to the nation's success at innovation. We look forward to being your partner in that."

DISCUSSION

Dr. Lefton affirmed the value of "growing the pie rather than competing with one another." This, he said, is a central element of what clusters are designed to do. "If we create regional, statewide clusters, we can grow the pie, and that means developing ecosystems and leveraging what we have to our best advantage." He agreed with Ms. Brachman's conclusion that "it may mean getting rid of some government bureaucracy and divisions that hold back rather than facilitate cluster development." He then turned to the example of the Cleveland Foundation and its role in facilitating cluster development.

ECONOMIC DEVELOPMENT IN OHIO: THE ROLE OF COMMUNITY FOUNDATIONS

Ronn Richard
Cleveland Foundation

Mr. Richard said he would describe the Cleveland Foundation's overall approach, its key programs, and its progress to date. He added that "You may be surprised by the breadth and depth of our efforts."

The Cleveland Foundation, he began, was the world's first community foundation and Ohio's largest grant making organization. It was created in 1914, and since then its assets have grown to $1.9 billion. Last year it disbursed about $85 million to Greater Cleveland, primarily to nonprofit programs and organizations. "But we also leveraged a lot of money from national foundations and provided leadership," he said, "so I think our results exceed that figure."

Mr. Richard said that when he arrived at the Cleveland Foundation from Washington, DC, eight years ago, virtually all of its grants supported education, social services, and civic affairs. "Those are all wonderful and important recipients," he said. "But we felt that a big piece was missing—economic development. The foundation's board agreed that if we didn't do something about economic development, there might not be an art museum to give money to in 30 years. So we made this a major priority, if not *the* major priority, for the Cleveland Foundation."

A Shift From Responsive to Proactive

Historically, some two-thirds of the foundation's grantmaking was "purely responsive," he said. "The remainder was proactive, where we would see a need or opportunity and create something. Today, two-thirds of our grants are proactive programs that we start. This allows us to make a meaningful impact on our community, and again, economic development is at the top of the list."

The foundation has a multi-pronged approach. One is to increase Cleveland's global standing by attracting foreign operations and helping local companies find new markets overseas. Another tack is to nurture new companies and growth industries. Toward that end, it plays a significant role in helping Cleveland gain a stronger position in the advanced energy and bioscience industries. To accomplish this, it involves itself with "public policy, launching new programs and organizations, and pursuing strategic partnerships with existing stakeholders locally, especially our large anchor institutions."

Mr. Richard said that the foundation's economic development efforts are designed to align with important issues facing the country, especially energy, education, and national security. "And when we strengthen one of those, we strengthen all of them." For example, he said, the efforts to strengthen education, at both local and state levels, also help create a home-grown work

force, which is necessary for the economy to thrive. This work force helps sustain the talent to staff the military, operate high-tech national security systems, and staff private sector companies.

A New Focus on Energy

Mr. Richard said that he regarded energy as "the most important issue facing our country today," and that advanced energy development was a top priority because of its direct effects on every major sector, including transportation, food supply, the environment, and jobs. Given Cleveland's manufacturing history and expertise and its location on the Great Lakes, the region has the potential to assume a leadership position in advanced energy. "This is a $10 billion industry that's growing by double digits and creating tens of thousands of jobs worldwide," he said. "But we have to act swiftly and boldly if we're to win the race and realize the potential of advanced energy." Unfortunately, he said, Cleveland is where it is today "because we totally missed the IT revolution. We cannot afford to miss the next one." Therefore, the foundation has been very active in attempting to ensure that Cleveland is "a green city on a blue lake" and a national player in advanced energy.

To capture this opportunity, the foundation's board agreed to make energy a major focus, hiring Richard Stuebi and becoming the "first and only community foundation out of 717 in the U.S. to have a full-time senior person for economic development and for energy." An early project was to create a map that showed the wind on Lake Erie to be sufficient for a major wind farm. With partners, it helped erect a windmill in front of the Great Lakes Science Center "to remind people that there was a new industry a-comin'," and hired its first lobbyist, who helped pass a renewable energy portfolio standard, or RPS, bill in the legislature, which was signed by the governor. With these steps, Mr. Richard acknowledged, "public policy became important to us." He added that because Ohio ranks fourth in the nation in power consumption, policy measures like an RPS bill, which now requires one-quarter of the state's energy to come from renewable sources by 2025, are vitally important.

The foundation also played a key role in the passage of Ohio House Bill 1, which enables municipalities to create Special Improvement Districts, or SIDs, for solar energy projects. Cleveland and 16 suburban municipalities established the first such SID in Ohio, and businesses are also installing solar projects. Most importantly, he said, the foundation secured backing from the city and the county to build an offshore wind demonstration project in Lake Erie. In September 2010, GE, Bechtel, and Cavallo Energy became partners in an initial 20-Mw project. "We hope to have the first turbines in the water by 2013," he said, "and, hopefully, we'll have hundreds if not thousands of turbines in the lake by 2030."

The foundation has also worked to create a strong network of support for the renewables industry. It gave a $3.6 million grant to Case Western Reserve University to start the Great Lakes Energy Institute, with a focus on

energy storage. "This is critical to make solar and wind more competitive," he said. Foundation support also goes to WIRE-Net to strengthen the nation's supply chain for wind energy; to NorTech, a $700,000 grant to help create its Energy Enterprise initiative; and to the Lake Erie Energy Development Corporation (LEEDCo), to lead the wind project. The foundation also helped launch Ohio Cooperative Solar, which is providing solar energy on the rooftops of major regional anchor institutions.

Support for a Bioscience Industry

Mr. Richard turned to the foundation's emphasis on the bioscience industry "that, like energy, has the potential for rapid growth and job creation." Along with Cleveland Clinic, University Hospitals, and Case Western Reserve, the foundation helped launch BioEnterprise, whose mission is to commercialize biomedical research and launch young companies by connecting them to investors and expertise. So far, BioEnterprise has helped recruit 100 companies in Northeast Ohio and attracted more than $1 billion in investment capital. The foundation also supports BioEnterprise in launching a Health Tech Corridor, planned as a concentration of biomedical, health care, and other technology companies hoping to benefit from proximity to health care institutions and academic centers. The foundation gave a $5 million grant, the largest single grant in its history, to Case Western Reserve to start the Center for Proteomic Medicine, and in 2005 helped launch JumpStart, an organization that provides entrepreneurs with mentors as well as money and financing connections. The Cleveland Foundation also played a key role in starting a Fund for the Economic Future, and remains as one of its funders.

A Partnership with Anchor Institutions

The foundation partners with existing anchor institutions to help them meet their needs and to help the economy. These include Case Western Reserve, Cleveland Clinic, and University Hospitals. "This is part of our place-based strategy," Mr. Richard said. "We think another thing we need to do is help these large anchor institutions create jobs and spin off companies with their intellectual property rights and purchasing power of $3 billion a year, most of which goes outside the state at present. So we've been starting a series of new companies called the Evergreen Cooperative Companies that offer good-paying jobs to local residents, who also have the opportunity to build an ownership stake in these companies. The Evergreen Laundry is up and running, the solar collaborative I mentioned earlier is up and running, and soon we'll have the largest commercial greenhouse in the country."

The foundation has helped start 11 innovative, high-performing schools with the Cleveland public school system, including the Cleveland School of Science and Medicine, where he chairs the board. The school has a 100 percent

graduation rate, with many entering top universities, and Mr. Richard hopes that many will return to Cleveland to work in the anchor institution hospitals.

"We have a long way to go," Mr. Richard said in summary, "and now we're looking at what more we can do, given our balance sheet. We have about $2 billion, we're looking to see how we can invest that money in local institutions and efforts that will give us a good return on investment but also have a double or triple bottom line for us." Mr. Richard concluded by underlining the importance of philanthropy in the campaign for economic development. "We have wonderful foundations in this region, and they all have their oar in the water," he said. "We're all going in the same direction, and I hope we'll really contribute to the success of the public and private sectors."

DISCUSSION

A questioner asked for a good example of creating a cluster, and Dr. Lefton conceded that much more is known about the value of clusters than about how to create them—"especially in places with traditional economies, like Cleveland and Akron. I would probably point to Pittsburgh as one that is starting to take hold."

Mr. Fernandez added that in addition to the well known examples of Silicon Valley, Research Triangle Park in North Carolina, and others, a successful life sciences and medical device cluster was started early in the 1980s in Indiana and has since grown in healthy fashion. The cluster is driven by an organization called Biocrossroads, a public-private partnership. Likewise, in Kansas is a strong aviation and advanced manufacturing cluster being driven by a several chambers of commerce. He said other solid examples are found, some of them in unexpected places, such as the strong cluster around Virginia Tech that was created with the help of tobacco settlement money. He said the EDA is now mapping many of these, which could make it easier to link to organizations that are building successful cluster initiatives.

Investing Across Borders

Dr. Lefton asked what the optimal size of a cluster is, and whether the area from Pittsburgh to Cleveland and Akron is too large for a viable cluster. Mr. Fernandez said he thought size was less an issue than "some of these archaic jurisdictional borders that get in the way of collaboration. The economy doesn't follow those borders, and yet they often constrain us." What the Federal government could do, he said, through competition and tools, is to "give local officials some 'cover' for co-investing with their neighbors. We all know we don't really care much about borders on maps, especially the private sector, but when you try to co-invest, it is really hard." For example, the mayor of Bloomington, he said, would be chastised for putting money in another county, even when it helped the region. He said that foundations could help overcome such boundaries issues.

Robert Schmidt, of Cleveland Medical Devices, said that one barrier to collaboration was the Ohio code that controls rights to discoveries. This is interpreted differently by and within different universities, he said, but it is often considered to mean that any invention that grows out of an activity within a university, even the use of a library or a laboratory, would be owned by the university. He said this had sometimes prompted his company to takes its business outside Ohio to conduct testing rather than use instrumentation in an Ohio university that might thereby claim ownership. He asked whether this law could be revised so that cluster activity could be promoted.

Dr. Lefton said that in northeast Ohio virtually all universities have a liberal policy that encourages tech transfer by leaving a "piece of the action" to the original investigator and a little to the university, and fosters collaboration between either of them and private business. "I think you'll be seeing a modernization of thinking within universities to allow for smoother tech transfer. It's clearly part of Governor Kasich's plan for universities, and also part of ours."

Keynote Address:

Investing in Ohio

James Leftwich
Ohio Department of Development

Mr. Leftwich, who said he had been on the job for only four weeks, said that his new position came with "some big challenges." The state had lost of 400,000 jobs in the recession, the second highest number in the country, and ranked 47th in economic growth. But he said there were already signs of improvement. A report by Ernst & Young had ranked Ohio third in terms of business climate for new investments. Another report from the Small Business and Entrepreneurship Council ranked Ohio 9th in the quality of tax climate for small businesses and entrepreneurs. "We know that's not enough," he said, "but it's what we're focused on."

One encouraging program, he said, was the Common Sense Initiative, which evaluates regulatory guidelines that make it difficult to do business in Ohio. The department is creating Jobs Ohio, a private nonprofit that will focus on economic development. It will be funded through House Bill 1222 that transfers the assets of the state's wholesale liquor system into the program, where the money is intended to provide a recurring source of revenue and to fund investments in promising opportunities. Jobs Ohio will not only spend locally but also invest in companies wanting to locate to Ohio. And it will develop strategies for delivering long-term returns, he said, establishing an investment portfolio that "feeds itself" by creating sustainable long-term opportunities.

"Jobs Ohio will also give us the opportunity to move at the pace of business," said Mr. Leftwich, "not at the pace of government. I know that makes some folks a little uneasy, and it is a place of natural tension. So we want to move at the pace of business, but we also want to be deliberate, thoughtful, and smart about our investments."

RUNNING 'JOBS OHIO' LIKE A BUSINESS

To run Jobs Ohio like a business, Mr. Leftwich said, would require several conditions. One is that it must be part of a network of regional partners, especially NorTech and Team NEO. This is meant to ensure that all entities share their understandings of market, competition, and risk, and to allow partners to take advantage of the same regional and state strengths.

Another focus is a tool kit designed to make the right investments to grow the state economy. Perhaps the best-known of these tools, the Ohio Third Frontier, has already been a "tremendous asset" to businesses, universities, and local governments, he said, and provides a sound infrastructure to build on. The revenues from the liquor agreement should strengthen the Third Frontier, building on investments already made in technology commercialization infrastructure, networks, and the workforce. A key, he said, is to "be sure we're meeting the workforce demands of businesses in the sectors where we want to grow." One area his office studies is the current patterns of investment, and clues to the best ways to encourage venture capital investment.

A primary need, Mr. Leftwich said, is to ensure that collectively "all these things work together." Jobs Ohio would focus on targeted growth, including the growth high-tech jobs and emerging market opportunities. It would target not just the number of jobs but also the payrolls, per capita income, technology transfer, patents developed, and patents actually reaching the marketplace. "We work very hard with regional partners to make sure we leverage the resources both here and in other regions."

Finally, Mr. Leftwich said, a powerful tool was leveraging opportunities brought by Federal partners. These include the NASA Glenn Research Center in Cleveland; Cincinnati's applied EPA research center; and Wright-Patterson Air Force Base in Dayton. Collectively these organizations represent more than $3 billion in research annually. "While they are producing intellectual capital for their own mission needs," he said, "we need to apply and develop that capital for commercial applications as well. In this way we can grow our own industry base from the same intellectual capital being invested by Federal agencies."

DISCUSSION

Dr. Wessner asked how much he planned to emphasize indigenous innovation—promoting innovation from existing clusters—and how much he would use the classic model of attracting new businesses and jobs. Mr. Leftwich said the state could "grow tremendously without going out to attract other businesses. Between our Federal agencies and university system we probably have $5 to $5.5 billion worth of research being conducted in the state. We first look hard at that, then how to fill in the gaps. Then we try to work with local businesses to grow them, rather than spending money to bring other companies in."

Panel IV

State and Regional Innovation Programs

Moderator:
Richard Bendis
Innovation America

Mr. Bendis said that he talked about innovation-based economic development in many places around the world, and northeast Ohio often served as his model. "When you live here in this place I talk about, northeast Ohio, you might take for granted what you have in your own surroundings. So on this panel we're going to talk about just how remarkable is the work you are doing right here in Cleveland."

He praised the Third Frontier program in particular as a leading state program which many others are trying to emulate. He said that one quality that distinguishes the Third Frontier and other innovation-based economic development (IBED) organizations in northeast Ohio is the quality of their leadership. "You have world-class leaders running the organizations that every region or state would love to have. So don't take those people for granted, thank them for being here." A second outstanding feature of the region, he said, was the effectiveness of its foundations—"a major differential advantage that's not happening in many other places."

The global innovation imperative is changing for all of us, Mr. Bendis said, and leading areas are responding to four conditions of great importance. The first is that an area like northeast Ohio is not competing only against the other U.S. states, but also against every other nation in the world. Second is sustained research and development, leveraging both public and private funds. The Third Frontier, he said, has been providing significant funding for this purpose. The third condition is support for innovative SMEs, and the fourth is new innovation partnerships to help bring new products and services to market. He noted that many countries and regions are investing "very substantial resources" for these purposes—"to create, attract, and retain industries in leading sectors."

LOCATIONAL COMPETITION

Underlying the global imperative, Mr. Bendis said, is the "new locational competition for economic activity. It is apparent that geographical boundaries are no longer relevant in a time of global competition. Basically, you're competing against everybody, everywhere, every day." The bar to entry is lower for countries around the world, he said, because innovation is replacing technology as the driver of economies. He recalled the Ohio Edison programs of a quarter-century ago which focused on industries, technologies and products. Innovation, he said, is more focused on services, processes, ways of communicating, partnering, and working together—"not just about creating the next best widget. That's one of the paradigm shifts." This new paradigm, he added, includes more public investment and risk taking, developing trust through collaboration, ensuring responsiveness to partners' missions, and building consensus among all constituents.

Because innovation is collaborative by nature, he said, regional clusters are key ingredients of innovation. He proposed five key components to consider when defining desirable regional assets. These are the economic base, which includes the kinds of products and services produced; entrepreneurship, including the capability to create companies wholly new or from existing firms; talent, including workforce skills and the human capital base; innovation and ideas; and the basic conditions of the region, including location, infrastructure, amenities, factor costs, and natural resources. He said that northeast Ohio already has good collaborative "interaction fields," including regional clusters and university-industry collaborations, which are needed to power the "innovation ecosystem" and move ideas from the proof of concept stage to the proof of relevance stage. The outputs following the proof of relevance stage include the jobs, new products and services, and commercialization activities that signify wealth creation. He stressed that successful innovation of this kind must be a "triple helix" including education, industry, and government, and that the missions of these three sectors are inseparable.

At the same time, said Mr. Bendis, many states have programs like the Third Frontier, including Pennsylvania and Maryland. The best of these, he said, are both providing early-stage support as seed investors and facilitating collaboration throughout the innovation process. "If you're going to do this," he said, "you have to learn how to collaborate, and during the history of IBED, those who have collaborated most effectively have prevailed. I think that what you've done in northeast Ohio is to build a good architecture for collaboration. With NorTech, Jumpstart, BioEnterprise, and other intermediaries, you are developing a real innovation ecosystem. Just as importantly, these programs know how to attract other people's money into the region."

Mr. Bendis closed by praising the IBED intermediary organizations of northeast Ohio, and reiterating his use of northeast Ohio for audiences elsewhere. "I lead with Cleveland and the organizations represented here as examples of what they need to build if they want to be effective," he said. "And

one of your strengths is that you understand the need for cooperation. No one organization can do everything that needs to be done. You need to be able to leverage strengths and partner with each other."

CURRENT TRENDS AND CHALLENGES IN STATE INNOVATION PROGRAMS

Dan Berglund
State Science and Technology Institute (SSTI)

Mr. Berglund began by introducing the State Science and Technology Institute (SSTI), a 15-year-old national nonprofit organization based in Columbus. With 180 members, including state programs, local programs, and universities, SSTI's mission is to "improve government-industry programs that encourage economic growth through the application of science and technology." Its founding funders include the Carnegie Corporation, Kauffman Foundation, and Manufacturing Extension Program, with additional support from the Economic Development Administration.

Mr. Berglund said that SSTI believes that there are seven elements required for a vibrant technology-based economy. These include "a good intellectual infrastructure, spillovers of knowledge from universities and networks, a strong physical infrastructure, a technically skilled workforce, sources of capital, a rich entrepreneurial culture, and a desirable quality of life." The last two assets, he said, are the most difficult to measure. He offered one definition of an entrepreneurial culture: "If you gather all your family and friends in a room and tell them you're quitting your job to start a company, and if they all applaud, you're in an entrepreneurial culture." Good quality of life, he said, "is in eye of beholder."

Research Parks: Necessary, But Not Sufficient

Why should states spend so much effort building up these seven elements? Mr. Berglund asked. He told the story of going to Kentucky 10 years ago to help the state start its S&T strategic planning process. When he asked state officials what motivated them to act, they pointed to the success of nearby North Carolina in founding Research Triangle Park. They had seen that in 1955, the year before the founding of RTP, both states were poor, with virtually identical per capita incomes at 66 percent of the national level. By 2000, however, North Carolina had moved far ahead of Kentucky, which did not have a research park.

Mr. Berglund said that he later went back to look at the statistics himself, and drew out the chart showing sharply diverging income levels and North Carolina's relative improvement. "I saw three messages in that chart," he recalled. "The first was the same one they had seen in Kentucky, that North Carolina had moved far ahead. But the second message was that it took 30 years

to do that; not until 1985 could you see all that effort pay off in higher income. And third, by the year 2000, when the improvement was clear, the state as a whole was still only at 92 percent of national average per capita income. So it did extremely well, but was not successful in translating that success to all areas of the state. This is one of the challenges all of us have in this field."

Public Approval of S&T

Mr. Berglund looked back at several other trends. When the SSTI was formed, he said, a large part of the mission was to persuade governors of the importance of S&T. "Today there is widespread acceptance across the country, in both parties, of the importance of investing in S&T&I. As an example he cited the new governor of Maine, who ran as Tea Party candidate. "I was sure that if he was elected, the Maine Technology Institute would be eliminated in his first budget. In fact, it received a budget increase. So this continues a trend of last 30 years that political affiliation of the leadership tends not to make a difference for these programs at the state level."

Mr. Berglund also cited a trend of rising public support for science, technology, and innovation over the past 15 years, but much more recent recognition of the need for commercialization, entrepreneurship, and cluster development. "A number of things have helped correct this," he said, "including the *Rising Storm* report, doubling the NIH budget, the creation of Astra to help lobby for these activities." He said that the Federal budget submitted in February was the most supportive of innovation since SSTI was formed. Fortunately, he said, there was abundant evidence of a political constituency favoring the kinds of investments being made by NIST and EDA. Some 84 percent of Americans believe that more jobs in the future will require math and science skills. In a California state poll, 52 percent said that state policy makers were not making technology and innovation a high enough priority. And 78 percent of Americans think "a national initiative would be effective."

Mr. Berglund said that support for science was even reaching popular culture. The toy company Mattel had held an online vote for what Barbie's next career should be, and respondents voted for computer engineer. He said this trend was also seen at ballot boxes. Ohio had renewed the Third Frontier, Maine has passed several bond issues supportive of science, Arizona passed a sales tax, and California passed a $3 billion embryonic stem cell initiative. "So we see a trend of widespread support for science and engineering."

The Challenge of a Skilled Worker Shortage

Among current challenges, he said, were a predicted shortage of skilled workers and new expectations of higher education. "Teaching students and doing research are no longer the only expectations of higher education," he said. "The university is now expected to be the engine of economic recovery and growth." There is also increasing competition from states that have the same

objectives as Ohio. "Ohio has a good chance with the Third Frontier bond issue of leaping over other states," he said, "but other states are not standing still. Indiana, not a state we typically think of in this area, has spent $238 million in the last decade on TBED, and Michigan has spent $573 million."

Mr. Berglund concluded with several lessons learned. Paramount is the need for committed high-level leaders who understand that economic impact does not occur quickly and that research does not always generate economic payoffs. Second, action should be based on an understanding of the state's needs and capabilities. And finally, a successful TBED program must include long-term sustainability, champions from more than one sector, effective management and staff, and an entrepreneurial approach in responding to change.

THE ROLE OF NORTECH: PROMOTING INNOVATION AND ECONOMIC DEVELOPMENT

Rebecca O. Bagley
NorTech

Ms. Bagley said she would begin with a brief economic sketch of northeast Ohio and the Cleveland metro area. Among positive indicators, she said, was Cleveland's ongoing recovery, which ranks 10th among 50 U.S. metro areas, according to the Brookings Institution. In addition, unemployment in northeast Ohio is dropping, with a year-over-year increase of 30,000 jobs in the fourth quarter of 2010.[13] According to the Milken Institute, Ohio has increased its number of business startups, growth in capital, and support for academic R&D. From February to June 2010, Cleveland metro led the nation's 40 largest Metropolitan Statistical Areas in manufacturing job growth.[14]

This and other is evidence, she said, point to a broader economic transformation that "requires huge shifts in the economy over a long timeframe. It's really a 20-year process, and we think we're about halfway through that. The fact that we have this growing innovation ecosystem has become extremely important in continuing this momentum."

Ms. Bagley said that NorTech works under a regional infrastructure called Advance Northeast Ohio, adopted by the members of the Fund for Our Economic Future and regional business community. This agenda functions on the premise that business growth, talent development, racial and economic inclusion, and government collaboration and efficiency are the key pillars of a stronger regional economy.

[13]Source: Team Neo.
[14]Pittsburgh Today and Fund for Our Economic Future.

A Transition into New, Innovative Products

"Over a year ago, the Fund, NorTech, and other regional partners took Advance Northeast Ohio agenda and structured it in line with a Brookings business plan," Ms. Bagley said. "There are only three regions in the country with these Brookings plans. The two others are Minneapolis/St. Paul and Seattle/Puget Sound. The strategy is to look at the characteristics and capabilities of the region and set out the things you want to accomplish. The region also started a detailed development initiative, the Partnership for Regional Innovation Services to Manufacturers (PRISM) in partnership with MAGNET. Our key challenge was to accelerate a transition of manufacturing into new innovative products by capitalizing on the existing potentials of the region's economic ecosystem."

NorTech, Ms. Bagley said, is a nonprofit technology-based economic development organization (TBED) serving 21 counties in northeast Ohio. Among its funders, a little more than half are foundations, a little less than a quarter are businesses, and about a quarter comes from Federal support. "It's a partnership that has worked smoothly," she said.

NorTech develops regional innovation clusters by attracting new members, building relationships, creating market-driven roadmaps, engaging with government, and utilizing data and metrics. "The important point," she said, "is that we develop a model that operationalizes the desire to accelerate emerging industry clusters." This is done by a partnership of companies, including larger companies, and the goal is to reduce the time required to strengthen a given sector.

Ms. Bagley said that NorTech defines a cluster as an economic ecosystem that is interconnected and geographically bound, and includes the entire value chain of technological innovation: research institutions, materials suppliers, equipment manufacturers, service providers, sub-component manufacturers, product developers. This value chain is facilitated by other participants, especially the media. "Every time we have another news story about flexible electronics, we have another call from a company working in that space. This public exposure is critical, and so are public and private funding, associations, work force development, economic development, and cooperation with all levels of government."

Clearer Vision Through Roadmaps

One of the key tools, Ms. Bagley said, is a cluster roadmap, which "gives us a clear vision of our assets and where we're going in a given sector. It puts everybody in the cluster on the same page." The roadmap process is to (1) identify existing and potential assets, including companies, researchers, and research dollars; (2) understand the global market opportunity in a sector; and (3) benchmark the national (and in some cases international) competition. The cluster members come together and try to describe, based on this information,

their vision for seven years forward. This includes a vision statement, definition of expected jobs, and the leverage "for what's going to come out of that."

She said that NorTech's roadmaps were distinctive in two ways. First, it starts with assessing the global market opportunity. And second, this is followed by a real action plan. "We really think 18 months is a good time frame for the action plan. "We really think 18 months is the limit for an action plan; you can't go much past that. What are the roles and responsibilities of each member of the cluster, or the cluster as a whole? What's NorTech's role? We work out how we do that, and which elements are most important in moving the cluster toward the seven-year goals."

Partnerships with Governments

A principal feature of NorTech's work is its engagement with local, state, and Federal governments to seek essential funding that is not otherwise available. "We've been very organized in the region around a government strategy that includes all the partners: Jumpstart, BioEnterprise, MAGNET, Team NEO, and NorTech. Basically we defined specific areas for which we need outside funding: advanced energy, innovation entrepreneurism, manufacturers in transition, and business incubation. And of course we need a strong voice in the State of Ohio Third Frontier program as well."

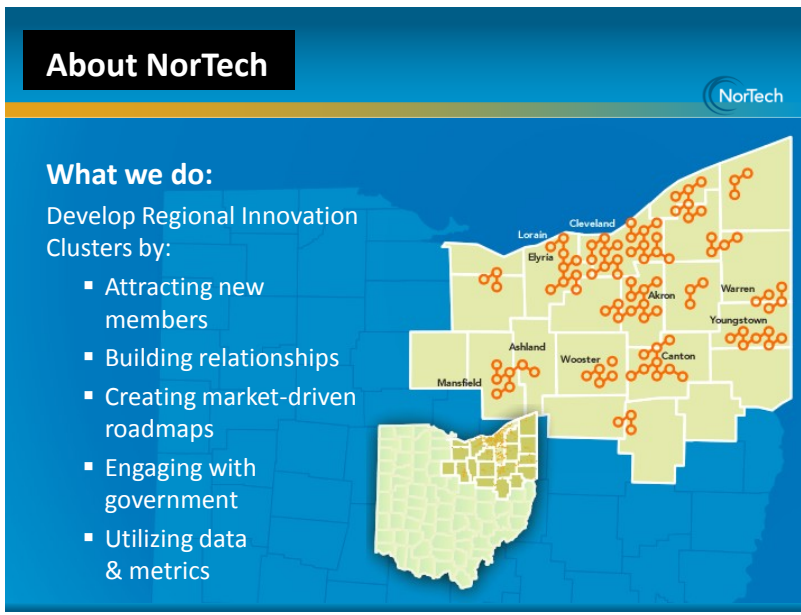


FIGURE 4 NorTech drives the development of regional innovation clusters. SOURCE: Rebecca O. Bagley, Presentation at the April 25-26, 2011, National Academies Symposium on "Building the Ohio Innovation Economy."

Emphasizing the importance of metrics Ms. Bagley, said they are "a critical piece in not only how you talk about the cluster but how you talk about your organization." NorTech tracks the success of each cluster member. Each member signs an MOU stating what NorTech will provide, with a focus on potential revenue, funding, and collaboration opportunities. Those MOUs are intended to turn into "funded opportunities," or actual capital attracted, including Federal funding, state funding, private funds, philanthropic, and revenue.

'Convening, Connecting, Educating'

A final set of priorities for NorTech is to "convene, connect, and educate." These begin with building relationships and attracting new members. They include education sessions, often by bringing industry experts to conferences to discuss new developments and opportunities in priority areas such as advanced energy and flexible electronics. Typical of this approach is the "synergy sessions with cluster members," which involves characterizing a market opportunity and identifying the current barriers to that opportunity. An example is the electronic greeting cards, including singing cards, being marketed by American Greetings. This opportunity fits with the existing flexible electronics cluster, including flexible batteries, flexible LCDs, and other technologies that might produce new products for American Greetings markets.

In reviewing the distribution of the region's specific clusters, Ms. Bagley showed a map portraying about 400 energy-related companies that had self-registered on the NorTech website. The energy space for northeast Ohio includes 11 "areas of opportunity," with four of them targeted for the first roadmaps: waste & biomass to energy, energy storage, electric transport, and smart grid. A priority for NorTech is to help firms in Northeast Ohio connect with others elsewhere, creating, for example, a node for solar innovation in the Toledo area. The region also has significant assets in fuel cells, which we are trying to connect with others. For offshore wind energy, NorTech's partners include the Cleveland Foundation and the Lake Erie Energy Development Corporation (LEEDCo). The goal is to develop the first fresh water wind farm in Lake Erie. This project is being led by LEEDCo. "The reason we care about offshore wind," she said, "is not only the deployment and transformation of our energy sector, but the jobs and economic impact this sector can have on Northeast Ohio."

NorTech is also developing a "FlexMatters" cluster whose vision is "to emerge as a leading producer of flexible electronics sold globally," and specifically to "attract customers, investors, talent, and commercialization partners from around the world." FlexMatters' seven-year goal is to raise $100 million in capital from 100 cluster organizations and to produce 1,500 jobs generating a payroll of $75 million.

Ms. Bagley concluded by saying that the first four roadmaps would be finished within a few months. She said the region could emerge as a leading

global producer of flexible electronics. "We've been working in this area for a very long time, and between the University of Akron and Kent State University, we have a critical mass in research assets. Moreover, we have companies that make products and the various markets in flexible electronics. If we can capitalize on that and make the cluster as interconnected and 'sticky' as possible over the next three years, we can be known internationally as a premier focus of innovation in flexible electronics. This will take a lot of focus from the community, and buy-in from the stakeholders, but the markets are already forming."

DISCUSSION

Dr. Singerman commented that as a long-term observer of the region, he saw its strategy as distinctive in several ways. First was the critical role played by the philanthropic community in organizing and energizing the economic development community. He said that only a few other places, including Pittsburgh with the Heinz Foundation and St. Louis with the Danforth Foundation, had benefited from this degree of philanthropic leadership. The region had also gained visibility through its programs with the Brookings Institution and the Center for American Progress, and now the National Academies. "This is not an accident," he said. "It's a result of a lot of hard work. Also, it's no accident that the President came to Cleveland a month ago, and I'm sure the newspaper articles and phone calls had incalculable value."

Mr. Bendis said that regional strengths and visibility run in cycles, and that northeast Ohio was in an up-cycle. "This is your day, northeast Ohio. Enjoy it, but don't rest on your laurels. It takes continual renewal and reinvestment to maintain the leadership position you now have. Others will study you and emulate what you are doing."

Dr. Wessner asked whether there were visible gaps in the model, and whether it was sustainable as presently formed. Mr. Berglund said that SSTI, his organization, had a high opinion of the region, and that it had selected Cleveland for its annual conference several years previously. Those locations are chosen because they are "select places we think have a good story to tell, and a place where people will learn from."

Good Communication Among NGOs

A questioner noted that with several NGOs working in the same region, it would be helpful to understand the distinction between their missions. Mr. Berglund agreed, saying that good communication and personal relationships among the organizations had much to do with the region's success. Some other regions, he said, had had difficulties in this respect. In Pennsylvania and New York, he said, new administrations had seen what appeared to be redundant development organizations and proposed replacing them with block grants for the regions. "Part of the reason why that happened in those states," he said, "is

that the development organizations didn't play together as well there as they do here."

Mr. Bendis responded to that issue by mentioning the "three C's" that can cause conflict among organizations. One, who gets the most cash; two, who's in control, and of what; and three, who is getting the credit for positive results. "Some symptoms of these problems can be mission creep from one organization to another; funders starting to balk at different organizations lining up at the door for similar missions, rather than coming in together; and the cash barrier that challenges not-for-profits at the state and regional levels. "One of the greatest challenges is that all the NGOs have to demonstrate that they are doing an effective job on providing a return on investment for stakeholders in order to keep them happy."

Panel V

The New Energy Economy in Ohio

Moderator:
Gary Leidich
FirstEnergy

Mr. Leidich said at the outset that the recent acquisition of Allegheny Energy in Pennsylvania had made FirstEnergy the largest utility in the United States by customer count. "What's even better," he said, "is that we're right down the street, headquartered in Akron, Ohio, and we're not going anywhere."

Mr. Leidich said that when he started working for what was then the Cleveland Electric Illuminating Company more than 35 years ago, one of its slogans was The Best Location in the Nation, "and that still applies." He also said that for a complex energy company such as FirstEnergy, innovation had to be part of the culture. "We do not have an option but to innovate. We manufacture a product that everyone has to have, electricity, and yet most people think it falls out of the sky. We actually manufacture it, and we have to do it safely, reliably, and cheaply." He said that the FirstEnergy grid was reliable 99.98 percent of the time, "and that still doesn't satisfy you." The utility also has to do it very cleanly, and finally, to do it cost-effectively.

The company is heavily involved in renewables, he said, in both Pennsylvania and Ohio. It had recently announced a wind farm in Erin, Ohio, which is planned to produce 100 Mw of power. It is the largest wind provider in Pennsylvania, making use of the steady winds along the Allegheny Ridge. The company also strongly supports the solar research being done in Ohio, and he said that solar "has to be part of the portfolio going forward."

Complementary to renewables is storage, he added, and FirstEnergy is developing that sector in partnership with Case Western Reserve "because we think it is a big part of the future challenge. Our duty cycle differs between night and day, and we want to smooth that out, either through storage or smart metering and smart grids." Finally, Mr. Leidich said, the company partners with the University of Akron in advanced fuel cell research.

THE OHIO ENERGY ECONOMY: NEEDS, OPPORTUNITIES, AND INITIATIVES

David Wilhelm
Woodland Venture Management

Mr. Wilhelm discussed his desire to build up an alternative energy industry in the southern Ohio region where he grew up, and where few economic opportunities are available on land ravaged by decades of mining. He then described ambitious plans to develop a solar project "that will be the largest ever constructed east of the Rockies when it is finished in 2014."

He began with the dramatic story of how he had come to this vision with virtually no prior experience in solar energy. He grew up in Athens County, in Appalachian Ohio, and had spent much of his life trying to find a way to stimulate economic growth there. "If you grow up there," he said, "you know the economic history and it is a sometimes painful history," beginning in the days when southern Ohio became the leading source of iron produced in the U.S. "In order to produce that iron," he said, "we cut down every tree in the region to create charcoal for the furnaces. That iron "allowed the North to win the Civil War," Mr. Wilhelm continued, and "built wealth and mansions in places like Pittsburgh and New York City. But at the end of the day, that industry was not sustainable; there were no trees left, and the people of southeast Ohio, as hard as they worked, did not share in the wealth that was created."

Hoping to Heal a Degraded Region

Then came the era of coal, which further degraded the region. "No people worked harder than the people of southeast Ohio to build this country. They worked themselves sick, and at the end of the day, the nation prospered, more mansions were built, and industrial growth was assured. God bless those people who worked in those mines, but it was not sustainable. So as a child of southeast Ohio I've thought about this a lot, and wondered what we could do to make things different."

The first answer he came up with was to generate economic benefits through entrepreneurial capacity building, taking Ohio-based ideas and turning them into Ohio-based businesses run by Ohio workers. Mr. Wilhelm founded a venture capital fund called Adena Ventures, which worked closely with Ohio State University and the University of Akron. It produced seed funds, early-stage funds, emerging angel networks, and operational assistance providers in southeast Ohio. "There are new small businesses," Mr. Wilhelm said, "and many people now aspire to be entrepreneurs. That was one answer."

Another answer was to build on local assets. He recalled talking with a friend about those assets, which amounted to 80,000 acres of reclaimed mine land. In pondering how they could create value from that land, they thought of planting mixed prairie grasses to regenerate the soil and absorb carbon dioxide.

But the idea drew no interest from a large utility and potential partner, the American Electric Power Company (AEP).

Winning the Interest of AEP

Mr. Wilhelm said that he thought some more and realized that to run the huge shovels that strip-mined the coal, the coal companies had erected a vast electricity infrastructure, most of which was still in place. "It was a utility-scale solar project waiting to happen," he realized. He went back to AEP with this idea. "This time you could see that people were starting to sit up and listen." At the end of the meeting he had an agreement: if he could build a solar plant, the utility would buy its entire output for the next 20 years.

A key objective of the project, Mr. Wilhelm said, is to maximize job creation in the state of Ohio. He said that he planned to buy 250,000 solar panels, and that the likely European manufacturer would base its permanent North American operation in Ohio, creating 350 manufacturing jobs. "We are absolutely building out an Ohio-based supply chain in every instance we can," he said. "We are a state of steel vendors: we'll get a supplier to build the racking system to mount these things. Then silver paste: a fundamental ingredient of solar panels. A company in Jackson, Ohio, is the largest silver recycler in the world. Already in Cleveland is a manufacturer of silver paste supplying the solar industry in the U.S. We are going to create a total of at least 650 direct jobs, and probably four times as many indirect jobs."

Mr. Wilhelm recalled many technologies in which Ohio had been a national leader. The first U.S. oil derrick was built in Ohio; more coal was transported out of Nelsonville, Ohio, than any other train station. "Today," he said, "when you study this transitional energy economy, you see the opportunities that exist here. We can build nuclear containment vessels; for natural gas, we have the Marcellus shale and the Utica shale; for carbon sequestration, the Mount Simon formation covers much of western Ohio."

"Just as we once led the world innovating in the old form of energy," Mr. Wilhelm concluded, "I guarantee you that with the Third Frontier and other current programs this transitional energy period is going to be an exciting new phase in our state's history."

ARPA-E INITIATIVES

Jonathan Burbaum
ARPA-e

Dr. Burbaum said that he grew up during the years of the "space race" when he learned to believe in the good that can come from Federal programs in advanced science and technology. After earning a PhD in chemistry from Harvard University, where he worked on biochemical energetics, he spent the first two decades of his career in pharmaceutical and biotech companies, "which

was the way you went in those days." He had founded two companies and was working in San Diego as a consultant when he felt the need to do something more challenging. That challenge presented itself in the ARPA-e program, which "completely turned him on" and drew him to Washington in August 2010.

As part of the "wake-up call" he felt at the time was realizing how quickly the U.S. had lost its global leadership in high-technology industries. For example, the technology for lithium-ion batteries was developed at the University of Texas by John Goodenough, who received the Department of Energy's highest award in 2009. But in that same year, the U.S. produced only about 1 percent of the world's consumption of lithium-ion batteries, vs. 46 percent by Japan, 27 percent by South Korea, and 25 percent by China. "We developed the technology here, and the manufacturing went elsewhere," he said. "The same is true for solar photovoltaics. We came up with it; the rest of the world passed us by."

This realization, Dr. Burbaum said, is what underpins the activities of ARPA-e. It is a small group whose core mission is to support the energy technologies that underlie national security, economic security, and environmental security. The agency was proposed in 2006 in the *Rising Above the Gathering Storm* report by the National Academies and created in 2007 under the Bush administration. It was not funded at first, but in 2009 the Recovery Act was passed, and Steven Chu, one of the authors of the Academies' report, argued successfully in favor of funding ARPA-e.[15]

A Mission to Fill Technical Gaps

ARPA-e was created to fill technical gaps between science and commercialization—to bridge the Valley of Death. It seeks high-impact science and engineering projects that may have high technical risk, investing in the best ideas and teams. "If more research is needed at the end of an ARPA-e project, we say it was not successful. At same time, we don't want to take technologies already proven out and just figure out how to implement them. We're looking for disruptive technologies, things that get our technologies onto new learning curves."

The agency's mission, as specified in legislation, is to "reduce energy imports, improve energy efficiency, and reduce energy-related emissions." These objectives, in turn, are designed to enhance the economic and energy security of the U.S. and ensure U.S. technological leadership in advanced energy technologies. "A successful ARPA-e outcome," he said, "is something that finds a commercial home after we're done with it. We're not looking to support these for the long term."

Organizationally, the agency is distinct from main body of DoE, reporting directly to the secretary. "We try to do things at the speed of business,"

[15]Dr. Chu is now secretary of energy.

Dr. Burbaum said. "Our goal is to get from conception of an idea to beginning execution of the program in six to eight months. That is very fast, and we do that by a particular process. We go through a 'deep dive' into the work, then run a workshop to gather ideas and calibrate whether this is a realistic program. This is followed by internal debate, and then a funding opportunity. We evaluate proposals, and then offer a rebuttal stage, letting people with novel ideas come back and explain to us again why the idea will be revolutionary. Then we select projects and negotiate payments in the form of contracts, not grants."

An ARPA-e project has four parts:

- Impact: "We ask not will this project work, but if it works, will it matter. We are looking for high impact on ARPA-e mission areas or large commercial application."
- Breakthrough technology: "We look for technologies that do not exist in today's energy market, and may be not just incremental but game-changing, making today's technologies obsolete.
- People: "Projects that have attracted the best-in-class people, teams with scientists, engineers, and business people; teams that bring new people, talent, and skill sets to energy R&D."
- Additionality: "Projects that are not already being done by others, but are difficult to move forward without DoE funding and able to attract cost share and follow-on funding."

The funding opportunity process, Dr. Burbaum added, is fast-paced, but it is deliberative. The agency starts with a concept paper that is sent out for review. Full applications come back, and are reviewed internally. Then questions are posed to the applicant, who has a chance to answer them before final selections are made. Selections are made by consensus and defense—not by the ranking system used for grants.

Once selection is announced, it is followed by a negotiation that sets aggressive milestones for the project. In the words of one ARPA-e performer, "ARPA-e has consistently impressed and surprised us with the speed of their evaluation and contracting process and the high caliber of their staff…We wish all R&D programs could adopt this degree of efficiency and professionalism." Dr. Burbaum added, "We want performers to get that sense of urgency. We're the 'urgency agency.'"

ARPA-e's Active Management Tools

The program also uses active management tools to promote eventual project success. "It's not just a matter of putting the money out and saying get back to us and tell us when you've achieved your milestones," Dr. Burbaum said. "We go in and actively manage projects. We look for synergies, make introductions, and try to get these projects to a commercial milestone at the end

of the funding period. We make at least two site visits per year, and hold formal quarterly reviews. This helps identify and resolve technical issues."

When ARPA-e began operation, it issued a broad solicitation that drew 3,700 concept papers. It requested 350 full proposals, and funded 37 of them for about a 1 percent success rate. Projects were supported in 10 energy areas: renewable power, vehicle technologies, solar fuels, carbon capture, biomass, energy storage, conventional energy, water, waste heat capture, and building efficiency.

After that first solicitation, it set out to create more targeted portfolios, beginning with transportation. It asked for proposals in electrofuels, a way of using biology to form carbon-carbon bonds and fix carbon efficiently, combined with direct current electricity to generate liquid fuels. It also asked for proposals on Battery Efficiency and Electrical Storage (BEEST). This focuses on novel ways of, for example, air conditioning buildings, "an energy-inefficient process that hasn't been much improved in the last 80 years." The next focus was three projects on stationary power. Another, called IMPACCT, is a project to bring the cost of carbon capture down to the price of carbon dioxide on the open market. Finally, GRIDS is an expandable storage process for renewable fuels.

"We fund universities, small and large businesses, national labs, and nonprofits," said Dr. Burbaum. "We've made 121 awards to date from seven FOAs with a total value of $366 million."

Funding Opportunities at ARPA-e

At present, four different funding opportunities have been placed on the ARPA-e website since late 2010. The first is power electronics in photovoltaic systems (2/8/11). This is called Agile Delivery of Electronic Power Technology (ADEPT), and seeks to use silicon chips to miniaturize the electronics that have been traditionally done by large transformers. "All portions of the system are being adjusted; the inverter, the transformer, the associated power. We're looking at 5 to 6 cents/kWh installed at the megawatt scale by 2020."

The second program is High-Density Advanced Thermal Storage (1/31/11). Much thermal energy is presently produced and wasted as heat, and the project is searching for new uses for waste heat in vehicles and buildings, and synergies between solar and high-temperature nuclear energy.

Third, Green Energy Network Integration (12/13/10) seeks to make the electrical grid "look more like the Internet." The grid suffers from congested lines, aging infrastructure, unreliability, unpredictability, and increasing outages. In theory, energy transported around the world in "packets" would be more reliable and flexible than present systems, and able to absorb electricity at different points in the system.

The Critical Materials Technology (12/6/10) program has several projects. One of them, the Rare Earth Alternative Critical Technologies, tries to address the threat of lost access to rare materials by looking for new sources and replacements.

Dr. Burbaum closed with a brief description of his own project, Plants Engineered To Replace Oil, or PETRO. "In using biofuels today, we create biomass which is hard to digest and then use biology to convert it to fuel," he said. "We're trying to shortcut that and engineer the plants to produce fuel directly and use their energy more efficiently. There are three ways to do that: adjust absorption by making the leaves darker or black; adjust metabolism so plants make fuel directly; and harvest plants as we do in agriculture but optimize them genetically to develop crops that are competitive with corn and sugar cane."

BUILDING CLEAN ENERGY COMPANIES IN OHIO: WHAT NEEDS TO BE DONE

Lorry Wagner
LEEDCo

LEEDCo, the Lake Erie Energy Development Corporation, is a private, nonprofit enterprise dedicated to making Cleveland a national and perhaps international leader in offshore wind power. Dr. Wagner, a former nuclear engineer, confessed that when he first heard about the project, he was more than skeptical that offshore wind could ever be meaningful in the Midwest. In the last several years, however, he has become not only a believer, but a leader.

Dr. Wagner recalled his early conversations with Ronn Richard, CEO of the Cleveland Foundation. "I admit that when he told me about offshore wind, I thought he was crazy. But in 2005 he put up the wind turbine outside the science center, and I began to pay attention. Today I know that Ronn had a great vision. It's going to take everything in our power to generate the electricity we need, and this can be one source. The Great Lakes have the potential to provide enough offshore wind to power the entire country. That isn't going to happen, but it gives an idea of the vast potential we have. Maybe we'll tap one percent of that, or 10 percent, but the resource is available."

Dr. Wagner was in London the previous week, he continued, "the epicenter of the world's offshore wind industry," and found high interest LEEDCo. "They admire the Midwest," he said, "they admire Ohio, and they admire our ability to get the job done. That's why I still live here. This place is amazing."

LEEDCo has been created by the Great Lakes Energy Development Task Force, a large partnership including the Cleveland Foundation, NorTech, Lake County, Ashtabula County, Cuyahoga County, Lorrain County, and the city of Cleveland. If it is successful in building and installing its initial 20- to 30-megawatt pilot project, it will be the first offshore freshwater wind energy project in North America.

A True Public-private Partnership

"We are that true public-private partnership that we've been talking about at this meeting," said Dr. Wagner. "I started out as a nuclear engineer. I had a lot of dreams, and I still believe in nuclear, but I don't see it filling the need. It will take everything in our power just to maintain the nuclear share of 20 percent. The effort required to replace 100 aging nuclear plants is monumental. And unfortunately the cost of nuclear went up significantly with the crisis in Japan. What will happen with natural gas and coal, I can't predict. But there is a great opportunity for renewables, and that's why we're here. We need secure power, and it has to be affordable."

If Ohio is new to offshore wind, it did set the pace in onshore wind as long ago as the 1876, when local inventor Charles Brush erected the first electric wind turbine on downtown Euclid Avenue. It was not until In the 1970s that NASA Glenn in Ohio advanced the technology further, and in 1979 built the largest wind turbine in the world. But the Federal government did not fund wind technology, and leadership moved abroad to Denmark, England, and elsewhere.

Offshore Wind 'Is the Next Big Thing'

"This is the next big thing," asserted Dr. Wagner. "It is happening right now in Europe. If I were to suggest to any VC here that they should fund a $100 billion industry that has created over 40,000 jobs and been incubated for the last 20 years, I would think it would have a chance if we get the cost right."

Offshore wind is happening in Asia as well, he continued, where governments have invested some $30 billion. "That's a lot more than we're doing," he said. He added that "the most fascinating number I've heard" is that France, which provides more than 70 percent of its electricity from nuclear power, and has no real need for offshore wind, has just decided to invest $13.6 billion in the technology. "Do you think they're doing this to be green? I think it's because they don't want to be left out of the industrial revolution happening in Europe."

Dr. Wagner said that Asian countries plan to dominate the industry by 2015, and that Sinovel, part of a large heavy industry company in China, has vowed to be number one in the world. In the past five years China has surpassed 30 years of U.S. investment in onshore wind, and by 2015 plans to have built nine times our current capacity. "Why are they doing this?" he asked. "Econ 101: the technology is proven, sales go to North and South America, and jobs and profits stay at home." Similarly, he said, South Korea plans to build an $8.2 billion offshore wind farm.

World-class Partners

Dr. Wagner asked why, in the face of such competition, should Cleveland be of interest. A lot of work had been done before he came to

LEEDCo 11 months earlier, he said, with the vision laid out in 2004. "A lot of great people have done a lot of good work, and our partners are world class. They are GE, Bechtel, which is the largest engineering construction firm in the U.S., Cavallo Energy, Great Lakes Wind Energy, and a host of others."

In addition to the large industrials, LEEDCo has a research consortium that is scheduled to grow over time, and some 100 strategic advisors. One of these is Great Lakes Towing, for example, which has been operating for more than a century and understands the safety and navigational issues of Lake Erie better than any organization.

"There's a true advantage in being the first mover," Dr. Wagner said. "The primary infrastructure is going to be built where the first wind farms go. We want to capture the majority of the jobs, using the talents we have. We want Ohio to become the epicenter. Once the industry starts operating we will learn how to cut costs. We're going to take something that is growing in the rest of the world, bring it here, and make it happen."

The Potential for Job-creation

Dr. Wagner said that a NorTech-funded impact study by Kleinhenz & Associates estimated that LEEDCo could create about 8,000 jobs by 2030 if it developed 5 GW of power. That amount, he said, is approximately 10 percent of the potential for the Ohio waters of Lake Erie, or about 1 percent of what's available in the entire Great Lakes. Currently, he said, Ohio is second or third in the country in manufacturing jobs for onshore wind, totaling about 7500 jobs in the state. When that total was compiled, the only wind farms were near Bowling Green, which is now being supplemented by additional activity in western Ohio.

Mr. Wagner said that the Cleveland region was "really good at doing this kind of work," with good facilities for ports, large-scale construction, project fabrication, and staging. This would provide jobs for hundreds of Clevelanders, while later projects should employ thousands of Ohioans. More than half the jobs would come from associated services outside manufacturing, jobs that cannot be exported.

"For the current project," he concluded, "we're starting small, about seven miles off downtown Cleveland, with about five wind turbines. We received our submerged land lease option last January. The project will be three nautical miles long." He showed a picture of an offshore nacelle, weighing 220 tons, presently the world's largest offshore turbine blade, now used in a GE machine off Norway. "The new ones will be 50 percent larger than this," he said in closing. "These cannot be hauled on the highways, so everything is going to have to be done in or near the ports. And we are ready for that."

DISCUSSION

Dr. Wessner asked Mr. Leidich of FirstEnergy if he would invest in wind power or solar power, given the uncertainties of forward pricing. Mr. Leidich said his company was very active in renewables, but agreed that the economics were a significant challenge. "You have to look at the long term," he said. "We would invest nothing if we looked at just the spot price of oil or gas. We're not inactive in renewables, but we're not doing everything people want us to do. We are active on the LEEDCo board, and trying to help work through the process."

Dr. Wessner also asked Dr. Wagner how he would be able to compete with Chinese industry on price, given the lower costs and lighter regulations in China. Dr. Wagner said that an offshore industry did not necessarily have to be competitive on price from the outset. "The first nuclear plant at Shippingport, Pennsylvania, cost 50 cents/kwHr in 1957, while the cost of nuclear today is arguably 3 to 4 cents. The offshore wind industry is in its infancy. The machines will become so large that they cannot be transported from China. The question is: Will the companies that are making offshore wind turbines be American owned or Chinese owned. They will be built here." He agreed that the price of offshore wind has to come down; "we have to be at least half of where we are now to even be in the game."

An 'Incredibly Collaborative' Process

A questioner asked about the experience of Cape Wind, in Massachusetts, which has gone through 12 to 15 years of regulatory and permitting problems. Dr. Wagner said that the Ohio regulatory experience had been different so far, with much more engagement at every level. "This has been a public engagement process since the beginning, a bottoms-up approach. The community, business leaders, the state, regulatory groups, and power siting board have been incredibly collaborative. We met with the Council on Environmental Quality, and at the end of the discussion, they said we were the first group that came to us and said that government is doing something right."

Mr. Wilhelm said that, as someone who is still new to new energy development, he felt it would be possible to meet renewable power standards and do little of lasting benefit for Ohio. For example, the renewable portfolio standard could be met while buying equipment from abroad, which would not help local businesses. He praised AEP, First Energy, and others for focusing on such issues and trying hard to maximize the local and regional economic benefit associated with these projects.

DAY 2

Welcome and Introduction

David Morgenthaler
Morgenthaler Ventures

Mr. Morgenthaler welcomed participants to the second day of the symposium. He said that in addition to his own work as a venture capitalist, he is a member of President's Circle of the National Academies, which advises the presidents of the National Academy of Sciences, the National Academy of Engineering, and the Institute of Medicine, and a member of the Academies' STEP Board, where he has served for many years. "My own interest," he said, "is that what happened to the Rust Belt cities of the U.S. should not happen to the U.S. I'm trying to make sure that does not happen, and this conference is part of that effort."

Mr. Morgenthaler reminded the audience that the National Academies study on state and regional innovation policy is taking place in various locations around the country. "We're reviewing the state, regional, and Federal efforts to once again develop a manufacturing base in the Rust Belt cities and address critical national needs, such as those of renewable energy." The study is also identifying best practices among state and regional innovation programs to develop and reinforce high-tech clusters. "We've all realized that once we've gotten all the food we need to eat, we eagerly go out and buy the new iPads and iPods and other innovations of the world. This is driving our economy, and we want to make sure our regions are in the lead as innovators."

Mr. Morgenthaler offered a brief review of his own productive career, in which he began as a mechanical engineer at MIT and evolved through numerous entrepreneurial activities to founding the Cleveland venture capital firm he still leads, Morgenthaler Ventures.

"In 1950," he recalled, "Cleveland was king of world. It had world-class manufacturing facilities. In 1957, when I was involved with a company headquartered in Birmingham, England, Cleveland was treated by these people

with great respect and as an equal. We had 50 of the Fortune 500 headquarters, and were one of the leading manufacturing centers of the world."

MISSING TWO INDUSTRIAL REVOLUTIONS

Cleveland was so strong during the 1940s and 1950s, he suggested, that it was slow to respond when change came. The area had a powerful economic driver in the automobile, from 1900 to 1960, "and unfortunately the region rode it for another 40 years without recognizing that we had missed two new industrial revolutions, the electronics revolution and the biotech revolution. We are trying belatedly but very sensibly to make up for that now. We're making investments to maintain the level of economic activity that we've become accustomed to, and to adapt to the changing global economy. I'm pleased with the commitment shown in this meeting to develop the strategies and policies to restore Ohio as an economic engine and a leader in innovation."

Mr. Morgenthaler thanked the sponsors of the meeting, including the Department of Energy, the Economic Development Administration, the Technology Innovation Program of NIST, and especially the Cleveland Foundation, the lead sponsor. "We in this region can give profound thanks to our foundations who have stepped up as our corporations have gradually slid away. The foundations have done far more than could have been expected from them, and the Cleveland Foundation has been the leader." They had been joined by the George Gund Foundation, he said, "and a great many additional supporting sponsors and organizers."

Panel VI

21st Century Universities: Drivers of Regional Growth & Employment

Moderator:
William Harris
Science Foundation Arizona

Dr. Harris echoed Mr. Morgenthaler's comment that "what happened to the Rust Belt cities should not happen to the rest of the U.S. This thought is one of the drivers of the National Academies study of state and regional innovation policy and of leaders throughout the country holding meetings like this. You only have to come here and see how much the population has declined, and then feel the energy and determination of the leadership here that is working to turn this situation around."

Dr. Harris proposed a thought to start the panel's conversation: the difficulty experienced by many U.S. businesses in dealing with the academic community. "The university community often says they are easy to deal with," he said, "but to the average citizen, the universities have a wall around them and it is hard to make contact. I have seen that in Arizona, where I work, and in South Carolina where I also worked, and other places."

By contrast, he said, he had worked in Ireland where he found the opposite—"an academic community with a hunger to be more successful in working with the business community. The Irish recognized that if academia didn't find a way to work with industry, it was likely that their industry was going to move to China, or Eastern Europe, where they could find cheaper manufacturing." While Ireland had major banking and real estate problems, they were still sustained by a serious biotechnology industry, he said, which manufactured nine of the ten top-selling drugs in the world. They also manufactured more software than any other country. "The presidents of the universities, in particular, were willing to try new things to help bolster their manufacturing. They had to try to protect that technology base. And they have done so, by creating friendly approaches to IP and making it easy to contact and work with the faculty."

Dr. Harris said that his challenge to the next speakers was to suggest ways to break down some of these perceived walls around academia. "If we can, we're going to find that the capacity to change in this part of the state is enormous. You have talent; it's a matter of releasing that talent and creating an open pathway to economic success. Many universities have a lot of people who are in the middle of that process, none of them with the right incentives to be successful. You have to develop new models and more effective incentives to break down barriers and do this."

RELEVANCE, CONNECTIVITY, AND PRODUCTIVITY: THE AKRON MODEL

Luis Proenza
The University of Akron

The world is actually not flat but rather spiky, said Dr. Proenza, who began his presentation with a nighttime satellite view of the United States, and the state of Ohio. "We see none of the traditional geographical boundaries we cling to even though they are no longer functional. We see that Ohio, especially northeast Ohio, is not composed of separate entities. Our population is neatly distributed in a bull's head pattern, with horns along Lake Erie and the center of gravity at Akron. Economies today are agglomerated into major regions like this. Some extend over great geographical distances, such as from Boston to Philadelphia to Washington. We need to overcome some of those old geographical and political biases we once had."

The Akron Model

Dr. Proenza said northern Ohio's current economic climate is improving and although some challenges remain, the region is beginning to grasp and take advantage of many opportunities. The Akron Model is based on three guiding principles: relevance, connectivity, and productivity. First, universities will not survive if they do not become relevant in their communities. Second, universities cannot be isolated as ivory towers, but must be connected with other sectors of the community. And third, to prosper, they have to be more involved in innovation with community partners.

Dr. Proenza also criticized the current method of ranking universities "by their size and by how many people they exclude. This is an inefficient model, and it doesn't help." The Akron Model is different, he said, and is based on a desire to be a broad-based and robust platform for economic engagement. At The University of Akron, he said, this engagement is part of everything done in every discipline. The university tries to implement that vision through a number of initiatives.

FIGURE 5 The shape of our regional economy.
SOURCE: Luis Proenza, Presentation at the April 25-26, 2011, National Academies Symposium on "Building the Ohio Innovation Economy."

"Over the last 12 years, we have undertaken a major renovation of our campus into a new landscape for learning. This has generated great energy, and transformed the facilities for the betterment of the community. For the first time, governmental entities in Akron recognized that the university is a significant asset in the community—not just because we created many construction jobs, but because our ability to attract students, researchers, and others is collectively making an economic impact."

'An Island of Beauty Surrounded by a Sea of Decline'

An essential realization was that the neighborhood surrounding the university needed revitalization, and if the university did not take an interest, it would eventually suffer. "We could not build an island of beauty surrounded by a sea of decline," Dr. Proenza said. The university joined with the Knight Foundation and began a University-Park Alliance to revitalize a 50-block, 1,000-acre area. To date, outcomes include more than $300 million in private-sector investment, some 920 new jobs, 80 new housing units, and 34 acres of new green space.

Dr. Proenza then outlined one of the university's other major initiatives. "With the support of the Knight Foundation, we joined with three hospitals and a medical school to create the Austen BioInnovation Institute," he said. "The objective was to bridge the expertise in materials science, particularly in biomaterials, at the University of Akron with the orthopedic and wound-healing skills at the hospitals. The goal of this $100 million partnership is to establish Akron as the world's leading biomaterials and orthopedic research program within 10 years."

Other initiatives include an Innovation Alliance, in partnership with two community colleges. Also, with the National Inventors Hall of Fame, the university has helped form a STEM high school. And in conjunction with the National Association of Corrosion Engineers and the Department of Defense, it has created the first BS program in corrosion engineering, forming research partnerships with half a dozen other universities. Finally, the university is forming a Regional Innovation Alliance to better support all these activities.

A 'Broad-based, Robust Platform'

The core of these programs, Dr. Proenza said, is the University of Akron Research Foundation (UARF). "We see it as a boundary-spanning organization," he said, noting further that its central attribute of community involvement distinguishes it from other institutions that have adopted the Bayh-Dole model, but focus primarily on traditional licensing and commercialization. Instead, he repeated, the UARF is a "broad-based, robust platform for economic development."

Dr. Proenza said the foundation began by taking inventory of regional assets left over from the Rust Belt era and began to assemble them in ways that could be more productive. Technical libraries were donated by companies to the university; "we manage them, which saves the industry a lot of money, and we have access to much broader set of resources." Similarly, they found space and equipment that was being underutilized. The UARF inventoried the university's robust patent portfolio to make it more productive; as a result, the university has typically ranked first, second or third nationally on patents issued per million dollars of research input and also in companies formed per million dollars. The university also joined with companies to develop non-core technologies. They began, in cooperation with the companies, to commercialize the IP, license it, or create new companies. The UARF has formed more than 46 companies in the last six years, 23 from University of Akron technology and the balance in cooperation with industries.

The University of Akron Research Foundation also entered into a series of partnerships for research and technologies developed with companies, including Fortune 500 firms that needed new insights into their core areas. It also helped form a series of networks to stimulate the entrepreneurial climate, including an Archangel Network, a women's Archangel Network, and more recently, with the help of many partners, a student-based venture network. It has

partnered with Lorain County Community College and others to make grants to small companies that also become educational opportunities for students. The Foundation formed a series of for-profit and not-for-profit companies to support this activity; it also offers services to others, helping with technology commercialization by other colleges and universities. Dr. Proenza said that because others are sometimes reluctant to say they are contracting with the University of Akron Research Foundation, the foundation is evolving into the Ohio Research Foundation so as to be "place-neutral."

These activities have attracted awards and recognition from a variety of organizations, including the Ohio Board of Regents, Innovation Associates, the University Economic Development Association, Milken Institute, and the Economic Development Administration, which awarded The University of Akron one of its six i6 Challenge Awards, in partnership with the Austen BioInnovation Institute. "We think this recognition is because the model frames the university in a new way—not as an ivory tower, but as a platform across all of its disciplines, with potential opportunities to engage with the community."

Lessons the University has Learned

Among the lessons the university has learned, Dr. Proenza said, are the following:

- Transform "weak" assets into strengths;
- Utilize the "guerilla" entrepreneurial talent of experienced people who have retired or been displaced;
- Identify and form unlikely partnerships that experience unexpected synergies;
- Involve the city and community as integral partners who become allies and advocates;
- Coordinate closely with economic development entities, such as NorTech, Jumpstart and BioEnterprise;
- Expand the university offerings and tool chest into a broader base to focus on relevance, connectivity, and productivity;
- Recognize and resolve :
  - Conflict of egos when participants compete for credit;
  - Partnering paranoia;
  - Relationship fatigue.

"You have to be committed to relinquishing short-term control to gain long-term leverage," Dr. Proenza said.

Finally, universities have to become vigorous "silo busters" to fully engage outreach and partnerships. He said that his university "just happens to own the quintessential example of silo busting, the old Quaker Square silo

FIGURE 6 Silo busting.
SOURCE: Luis Proenza, Presentation at the April 25-26, 2011, National Academies Symposium on "Building the Ohio Innovation Economy."

facility. We have literally broken through the silos while renovating the complex into a functional modern building."

Dr. Proenza concluded by proposing a new role for the university of the 21st century. It must be:

- A convener.
- A developer.
- An anchor institution for clusters of innovation.

"The universities now face common challenges and unique opportunities. The University of Akron is building a bridge to the future through innovative approaches, and that depends on partnerships with visionaries and innovators."

THE ECONOMIC IMPACT OF A MAJOR COMPREHENSIVE RESEARCH UNIVERSITY: THE CASE WESTERN RESERVE UNIVERSITY MODEL

W. A. "Bud" Baeslack III
Case Western Reserve University

Dr. Baeslack suggested the "fundamental premise" that the primary driver of the future economy and job creation "will be innovation largely led by science, discovery and engineering." Global economic competitiveness, he went on, requires the confluence of scientific discovery, which creates knowledge and leads to technological opportunity, with work force talent and an enabling environment. "Put all that together, and you have the ingredients for economic success, as the second National Academies *Gathering Storm* report described."[16]

Modern universities contribute to all these components, he said. Over the past decade, northeast Ohio has embraced this concept, as does Case Western Reserve University (CWRU) and its partners. "Certainly there must be a strong partnership among sectors, and a willingness to work together."

Like other major comprehensive research universities around the country, he said, Case Western Reserve has a broad base of activities that contribute to the U.S. economy. Universities nationwide received about 3,300 patents in 2009, and accounted for more than $40 billion in salaries and 270,000 jobs added annually to the U.S. economy. More than 500 companies form annually around university discoveries, leading to important products and inventions, such as Google and the drug Rituxan, developed from the work of Case Western Reserve scientists.

A Focus on the Priorities

CWRU's approach to economic development, Dr. Baeslack said, is consistent with ingredients described by the National Academies. A key is its institutional strategic focus and prioritization. "We are large; we educate thousands of talented students annually in disciplines tied to growth sector opportunities. That said, we can't be everything to everyone. We have decided we must focus on where we are: health, advanced materials, and energy are our three priority areas. With our expertise there, we can align strongly with the technological community and needs in this region."

Another aspect of its mission is educating the leaders of tomorrow with an innovation and entrepreneurial mindset, he said. Case Western Reserve University has a base of about 10,000 undergraduate and graduate students, with nationally ranked programs in medicine, engineering, and business. It devoted more than $385 million to research in 2009-2010, primarily in the form of grants

[16]Members of the 2005 "Rising Above the Gathering Storm" Committee, *Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5,* op. cit.

from the Federal government. Many of its professional degree programs are interdisciplinary, coupled with training at premier health care and corporate partner sites, including Great Lakes Energy Institute, Advanced Materials Institute, and the schools of medicine, business, engineering, and law. The Innovation Alliance Program teams students and faculty to learn about entrepreneurial and experiential learning, including innovation and commercialization of products.

From such interdisciplinary activities, for example, more than 20 active life science companies have been spun off in the past decade, said Dr. Baeslack. The NSF Center for Layered Polymer Systems, or CLPS, is one of 17 NSF Science and Technology Centers. It has received more than $10 million over its first five years, and has been renewed for five more years. The program, led by CWRU, partners with the Office of Naval Research and University of Texas at Austin. The program uses techniques of extrusion to develop very fine layers of polymers with different structures that create useful new materials for aerospace, electronics, biomedical, and other applications. This has led to the spinoff of Polymer Plus LLC, which works with faculty to translate their basic research. "The reason we were renewed," he said, "is because we are transforming the research into viable technologies and products. This is a great example of a major investment by the Federal government that has seen effective commercialization of research."

Another activity that supports entrepreneurial and commercial activities is the Swagelok Center for Surface Analysis of Materials. This is a multi-user analytical facility providing access to a wide range of materials and surface characterization techniques for both academic and industrial clients. It is also home to a myriad of northeast Ohio clients, enabling commercial access to cutting-edge technical infrastructure.

Collaboration between the CWRU Medical School and its clinical partners has led to the formation of 20 active life-science companies. The medical school also supports regional firms that have imported biotech opportunities to northeast Ohio. Areas of particular activity include biomedical imaging, cellular therapies, and neural engineering. The school is now developing a cluster of small companies in these areas.

Entrepreneurial Support for Faculty

In tandem with the R&D effort are a program of "enabling resources," led by more than 40 professionals who expand and capitalize on the research activities, and the technology transfer office. The tech transfer office supports faculty and links them not only with the community and with corporations, but also with regional organizations, foundations, and governments that provide technology resources.

"This is the key," said Dr. Braeslak. "From a faculty standpoint, it takes that whole team to bring enough support to the faculty. When we hire new faculty, we find they are entrepreneurial. They no longer just want to write

grants and publish papers—they're interested in patenting, even starting businesses. That's what we're trying to support." The tech transfer office now ranks in the top 20 in its national peer group in company creation, revenue, invention disclosures, licenses and options, revenue, and cumulative licenses. It also manages the university's pre-seed fund, Case Tech Ventures, which since 2003 has provided first capital to eight regional technology startups.

He summarized some of the successes in innovation and commercialization, including: A stable of more than 20 for-profit companies active in the region; more than 200 active licenses with industry; novel multi-party collaborations in advanced energy, clinical translation and imaging; and many "first-in-man" clinical interventions based on CWRU technologies and executed by spinoffs and clinical partners.

Among continuing challenges he cited the increasing global competition, the complexity of value creation and economic growth, and the difficulty of anticipating new trends. "As an administrator of a university," he said, "you're trying to project how much new investment you'll need to enable this process and support this infrastructure. It's difficult to predict, yet we have to make that investment."

Aligning Faculty Rewards with Entrepreneurial Goals

Dr. Baeslack added that the university support and reward system for faculty is still poorly aligned with entrepreneurial goals. "We are hiring more faculty who come out of environments and grad school experiences where they had advisors who didn't just do research, but were interested in transferring it into commercial products. We need to encourage more of that, and in some cases to clarify and revise the tenure reward process. We need to recognize not just writing a paper and getting a grant but developing intellectual property and ultimately products."

Finally, Dr. Baeslack said, universities, as key partners in innovation systems, must be more efficient and flexible in supporting the innovation enterprise. "Universities can tend to be insular," he concluded. "We're doing self-study on how we can be more user-friendly and to take a less rigid approach to IP."

DISCUSSION

Tony Dennis of BioOhio said that many universities were adding entrepreneurial training as either graduate or post-graduate programs. He asked whether students should be exposed to this world earlier. Dr. Proenza agreed enthusiastically, citing the University of Akron's program with The National Inventors' Hall of Fame, which works with high school students. The university also has an undergraduate program for entrepreneurism across the curriculum so that students begin to understand not only how new knowledge is created, but also how it is used. He cited a close linkage between the colleges of business,

engineering, and science, as well as an IP program that offers young people more knowledge about how to navigate these environments.

Dr. Baeslack said that one could certainly learn something about innovation and entrepreneurship in the classroom, but that young students might gain even more by spending a few weeks, a summer, or a semester with a startup company. "That's how they really get excited, when they work in the real world."

Mr. Morgenthaler asked the panel's response to a comment by an earlier president of Case Western Reserve that "commercialization and technology transfer should only come through the minds of our graduates." He asked why universities in the past had not been more commercialization minded. Dr. Proenza suggested three points. The first, he said, was historical. American universities had engaged with commercial enterprises in agriculture and the mechanical arts since 1862, when the Morill Land Grant Colleges Act set up the mechanism. It took another century for universities to do that for other areas. Second, most university presidents as late as 1990 disapproved of working with industry in any way. Third, only recently have people come to see that being strategic partners with industry can be in universities'—as well as the country's—interest.

Universities' Responsibility to the Community

Dr. Baeslack said he agreed with those three points, and added that public universities had more sense of responsibility to serve the community than many private universities. At private universities, he said, many faculty members have learned that their role is to do research, make discoveries, and publish results. "It comes back to the reward system, how strongly it defines the culture, and how difficult it is to change." In recent years, he noted, it has changed at some private universities, notably MIT and Stanford. "I think that the importance of strategic partnerships with industry and the community is driving changes in the reward system and the expectations placed on faculty. But it's been slow in coming. My goal is to see that accelerate much more rapidly."

A questioner asked about the extent to which major research universities collaborate on issues of economic development. Dr. Proenza said there was a great deal more collaboration than may be apparent from the "outside." In defined areas of expertise, such as in polymer science, were long-standing partnerships, and "we are increasingly seeing other opportunities."

Dr. Harris pursued the question of collaboration, asking if there were any advantage to greater cooperation on IP issues, perhaps by bringing legal staffs together or creating a single point of contact. Dr. Proenza said that the greatest benefit might be in gaining contacts outside one's area of expertise. Dr. Braeslak agreed that universities do collaborate widely, certainly in materials sciences, health sciences, cancer research, and energy. With the growing emphasis on interdisciplinary research, different universities can bring different strengths, and help in searching for third-party funding and partnerships.

Dr. Singerman asked which activities or policies of Federal funders either hinder or help commercialization activities. Dr. Proenza noted that certain tax policies, such as how tax-exempt facilities can be used, were too restrictive and that it was time to make the R&D tax credit for industry permanent. He added that the mutual finger-pointing by universities and industries over technology transfer issues should stop.

"Of course there are cultural differences, but there are no data to suggest that industry does any better at commercializing technologies than academia," Dr. Proenza said. There's plenty of non-core but useful technology sitting on shelves; we can actually help some industries use it if they take the time to talk with us."

Panel VII

Biomedical Growth Opportunities

Moderator:
Baiju Shah
BioEnterprise

Mr. Shah introduced himself as the CEO of BioEnterprise, "northeast Ohio's development catalyst for growing the biomedical sector." He said that health care had been the leading growth sector of the Cleveland region for most of the past decade. He included not just health care delivery, led by the Cleveland Clinic, but industry as well.

"Nor is this an accident," he said. "In 2001, our health care leadership and civic leadership came together and established the goal of making northeast Ohio a nationally recognized center for health care innovation. Those leaders recognized that this could not be the role of any single institution, but had to be a collective commitment, including investments in translational research capabilities, the identification of capital sources, and supportive state policy in the form of the Third Frontier program. It required investments in talent to help professional service firms reposition themselves and allow manufacturing firms to realign the supply chains. It required changed perspectives of clinicians and clinical institutions in their willingness to work with new innovations.

There was also recognition, he said, that a collaborative spirit was essential to connect those elements and develop an innovation environment. "That's the essential ingredient in any thriving cluster, in any sector." Substantial and aligned investments were made across all of those initiatives toward this common goal, he said—investments by health care institutions, regional foundations, the public sector, the business community. Today, he went on, 10 years later, the success of that aligned community has become apparent. Over the last six years, northeast Ohio is averaging $150 million a year in private investment into biomedical ventures, up from $30 million a year six years prior to 2001. The funding is fed from all around the country, and today there are more than 600 health care companies in the region, up from 250 companies in 2001. "Most importantly," he said, "the region's self-identity and

to some extent our national identity now includes health care innovation as a component."

Mr. Shah introduced the panelists as "three experts on the topic of translating research and clinical insights into innovations," beginning with Dr. Frank Douglas. Dr. Douglas had recently arrived in Ohio from Boston, where he was the founder and executive director of MIT's Center for Biomedical Innovation.

BIOMEDICAL RESEARCH AND THE HEALTH CARE INDUSTRY

Frank Douglas
Austen BioInnovation Institute in Akron

Dr. Douglas acknowledged at the outset that "this is actually a very broad and difficult topic," so that instead of trying to cover all its aspects, he would focus on one movement that has "everything to do with biomedical research and everything to do with how we manage our health." That movement has been called "personalized health," and includes a greater emphasis on prediction and prevention. He said he was one of a group of experts who participated in preparing a "Personalized Health Manifesto," written by David Ewing Duncan, director of the Center for Life Science Policy at the University of California at Berkeley. This "manifesto," and Dr. Douglas' talk, both emphasized some of the "gaps" that exist in current health care, and the need to implement a new epoch of personalized health.

Toward a More Integrative Approach

Some of those gaps derive from our custom of looking at patients from an illness perspective, said Dr. Douglas, rather than a wellness perspective. He said that it was the historic strategy of the pharmaceutical industry to look for "one-pill-fits-all" solutions, a reductionist approach as opposed to an integrative approach.

A major gap, he said, is the mismatch between the "biological space and the chemical space." Scientists have become very skillful in chemistry—making many kinds of small organic molecules that can be used to "fill any structure space you can think of." On the biological side, however, especially concerning proteins and other large molecules, much less is known; definitive molecular structures are elusive because it is so difficult to discern the crystal structure of large molecules. "So although genomics has enabled us to identify potential targets for therapy," he said, "without knowing the structure of these enzymes or proteins and often membranes, it's very difficult to develop and market small organic molecules as agonists or antagonists to those targets."

A second gap in biomedical research, Dr. Douglas said, is the activity of pathways. We now know much more about biochemical pathways and signaling pathways, he said, but we have barely begun to put together the maps

that show us when particular enzymes or receptors and "various other players within a pathway come together through activity or feedback action." Part of the reason for both of these gaps, he said, is the isolation of specialists in "professional silos" that impede collaboration.

A result of this reductionism, he said, is that we know little about basic disease questions: What is the normal natural course of a disease? How does that normal natural course change under certain situations and environmental conditions? "We do not know in a real sense what the progress of disease is." Nor, he said, do we have biomarkers that indicate treatment failures—for example, in a particular patient sub-population—and we do not have good predictive models of diseases or how to halt them. A familiar case is when a healing agent works well in a mouse model but not in a human patient, or in one patient but not another.

Filling Biomedical 'Gaps' Through Interdisciplinary Platforms

Many of these gaps, Dr. Douglas said, could be corrected by using a more integrative approach. For example, wider use of chemical and biological "platforms," studied in interdisciplinary fashion, would raise the chances of identifying disease targets, understanding the targets, and finding drugs to use against them. Such platforms have been introduced in basic research, he said, and "I think the time has come to do something similar within the transformational medicine space, to develop transformational medicine platforms."

Since he left the pharmaceutical industry, he said, where he managed the R&D program of Aventis, he has thought hard about how to bring the industry into closer engagement with personalized medicine. He concluded that every large pharmaceutical company, instead of supporting its own massive research enterprise, would benefit by reaching out to clusters of academic and bio-tech company researchers in approaching large research questions. These might resemble the clusters northeast Ohio was forming in flexible electronics, photovoltaics, and other technologies. A pharmaceutical company could investigate much broader phenomena, such as the pathways of disease, by enlisting a diversity points of view and expertise.

Moving Closer to Personalized Medicine

Dr. Douglas suggested that other fundamental changes in biomedical research and health care could make the field more predictive and move it closer to personalized medicine. These included shifting budgets away from sales and marketing toward R&D, not granting intellectual property rights until later in the clinical trial process, and more emphasis on partnerships for pre-competitive research problems that no one institution can resolve. "If these changes were to happen," he said, "then pharma would look more like integrators of many small specialty players. The VC companies would become true translators, and more

directly help translate research into products. And of course you will have more academic/industry/government collaborations."

Finally, he said, external forces, notably the Federal government, could help give new shape to the bio/pharma space. "What if the government and other players said they will only fund certain conditions, such as Alzheimer's, some cancers, and some orphan diseases, and not the rest? What if they mandated the use of generics by drug class? What if proof of efficacy and identification of side effects were required for approval of all non-generics? What if preventive health measures were preferentially reimbursed? What if we gave approval at Phase 2, and in Phase 3 you do large, normal-use trials to confirm the efficacy or widen the knowledge about side effects?"

Not every therapy lends itself to personalized medicine, Dr. Douglas emphasized. But merely shifting the balance away from "one-size-fits-all" toward prediction, prevention, and individualized care can capitalize on vast new stores of knowledge about human biology. He reiterated some of the major points of the "Personalized Health Manifesto," asserting that "a reordering of priorities is required to stress the application and translation of what has been learned to improve health and to reduce health care costs. If you think about these kinds of changes in a major industry," he concluded, "I think you begin to see tremendous opportunities for innovation and job creation."

BRINGING MEDICAL INNOVATIONS TO MARKET

Delos "Toby" Cosgrove
Cleveland Clinic

Dr. Cosgrove, a heart surgeon, began with the development three decades ago of a closed-loop system for delivering a drug that controlled blood pressure. The system got FDA approval, and eventually received a patent and a contract with a company. "That process resulted in my walking into the office of the CEO of the Cleveland Clinic and giving him a check for $50,000. That was the first time that the Clinic had ever patented anything or received any royalty. I remember the look of amazement on the CEO's face that I could do anything other than find my way out of the operating room. He said, 'Well, perhaps we could make a business out of this,' and gave me probably the greatest gift an innovator could have. He assigned David Morgenthaler to try to tutor me."

The Need for Incentives and Support

Dr. Cosgrove recalled the process of reviewing the Clinic's activities with Mr. Morgenthaler, trying to understand where intellectual property of value might be. After many early failures, they tried in 2000 a two-pronged approach: first, a free-standing venture capital firm, and second, a tech-transfer organization they called Cleveland Clinic Innovations. After hiring a director, they began to realize all the things that were required to make technology

transfer happen. First, they had to encourage doctors to bring forth their innovative ideas. Second, they had to provide some financial and support resources for them, including legal advice, space, and other forms of encouragement.

Over time, Cleveland Clinic Innovation became successful. Looking back on the past 10 years, he said, he could count some 352 patents granted and 1,600 filed—"a slow, laborious process." The group has attracted $450 million in equity investments and another $148 million in commercialization grants, mostly from the state. It has returned $46 million to the Clinic inventors, and created 740 jobs, 528 of which are in Ohio.

Aside from receiving royalties, he said, the organization had begun to spin off companies. It had formed 36 of them, 30 of which are still active. One of them, IntElect, had recently been sold for $28 million to the Cleveland Clinic. "This has been a profitable endeavor for us," he said, "and continues to gather momentum." One of the catalysts for encouraging doctors to participate was the Sones Award, a $50,000 award named after F. Mason Sones, a pioneer of coronary angiography. This award, given annually for any type of innovation, and an equal share of royalties for the inventor has brought increasing attention to the importance of innovation at the Clinic, he said.

In the beginning, Dr. Cosgrove and Mr. Morgenthaler thought they would find potential new companies only based on medical devices. While it is true that only a single diagnostic company had been formed, the Cleveland Heart, more healthcare IT companies are appearing as younger physicians generate new ideas in this field. This requires special expertise to handle the intellectual property and patenting, and to judge which ideas have commercial potential.

Commercializing New Devices: The Need for New Skills

Dr. Cosgrove summarized their progress under two headings. First, they have learned that they sit on a "reservoir of intellect" that can produce new products and devices, and they have developed a procedure to commercialize them. Several medical organizations have asked if they will serve as their tech transfer entity, recognizing that it does take an investment of time, effort, and money to develop these capabilities. They currently have a relationship with MedStar, one of the largest medical systems in the Mid-Atlantic States, and are discussing the issue with several other organizations. Secondly, they have succeeded in closing major sales of startup companies.

Dr. Cosgrove concluded that "it's been a long trip of trial and error," and said that he and Mr. Morgenthaler had learned that the process has more than one stage. "It is essential to encourage physicians to bring their ideas and their inventions forward," he said, "but it is just as important to stay with them all the way through to commercialization."

ADVANCING CANCER RESEARCH

Anna Barker
National Cancer Institute, ret.

Dr. Barker began by saying that "we are probably at an inflection point in biomedicine and cancer, and I think this will be the century when a lot of these diseases are conquered. But this will require a redefinition of the way we do medicine." She agreed with her fellow panelists that the journey toward personalized medicine had begun, and that it would be and difficult though ultimately rewarding one.

Dr. Barker said that when she arrived at the National Cancer Institute in 2002, her goal was to "see if one could actually innovate in the government," and if one could help advance the field toward personalized medicine. She also noted that the 40th anniversary of the National Cancer Act has arrived, the act which launched the "war on cancer." Even after those decades of hard work, one in three people still die from the disease, a reality so familiar that "people often accept it as inevitable." She made this reality more specific by pointing out that Ohio this year would have 65,000 new cases of cancer.

Mortality Rates Have Remained the Same

Dr. Barker pointed to a graph that showed that unlike heart diseases and cerebro-vascular diseases, where mortality has fallen by more than half in the last 50 years, the mortality rates for cancer have remained virtually the same. This creates crushing personal and financial burdens not only in the U.S., but around the world. The global scourge of cancer currently includes some 7.6 million deaths (2008) and $895 billion in spending. Deaths are projected to rise to 10.3 million by 2020. "I would argue that it will become almost destabilizing in terms of these costs," she said. For example, in China, there are 350 million smokers. They are not likely to quit soon, she said, because the tobacco industry is a national industry. By 2035 about 23 percent of their population will be over 65, when the chance of getting cancer goes up "quite dramatically."

Referring to the talks of both Dr. Douglas and Dr. Cosgrove, she said that 21st-century medicine is likely to be as different for cancer as it will be for diseases generally. At its base, she said, "personalized medicine" was molecularly based medicine. It would focus on identifying the particular genomic changes of each person—either genetic changes inherited from parents or somatic changes acquired after birth. "The genes begin to be the basis for how we actually diagnose, treat, and ultimately prevent disease. And I would argue that this whole continuum has got to move further and faster toward prevention. We tend to focus on treating established disease, not preventing it. We will have the tools to prevent cancer, we will have the tools to prevent other diseases; the issue is how we change the mindset."

We are living in an era of convergence, Dr. Barker said, among the molecular sciences, bioinformatics and computational sciences, physics, and engineering. "Now that's a mouthful, but that's exactly what's happening. And it's happening as we speak, and I think it will drive a new wave of disruptive innovation. We are beginning to sort out genomic changes in all these diseases, and how they affect the pathways. We're modeling that; we're bringing in the bioengineers to figure out metastasis. That's all moving quickly into patients and into communities in ways we can't envision. And social networking is going to have a huge impact on medicine, because consumers will be as informed or more informed than their physicians."

Changing the NCI: 'Not for the Faint of Heart'

Dr. Barker cautioned that bringing change to a place like the NCI, however, "is not for the faint of heart. It's very difficult to do innovation in the government, and there is a lot of push-back." She recalled setting out to improve protocols for biospecimens—biological materials, such as blood, tissue, cells, and DNA to be stored for future research. "We had no rules for biospecimens in this country, no standards, no protocols for stewardship, no approach for access. That is the stuff of personalized medicine. We are beginning to change that."

Another gap of modern medicine, she said, is that "research is not connected to the bedside in any meaningful way. We talked in the first panel this morning about the silos, and we have to break through them."

In the area of cancer, Dr. Barker said, the human genome has now been sequenced, and that has given scientists the tools they need to sequence cancer genomes. "Francis Collins and I started a program called the Cancer Genome Atlas," she said, "and that's one of the places we had to start with personalized medicine. When we finished the human genome, we had a normal genome to compare with an abnormal genome. I'm going to let you look under the tent with me at some science, and you can see why I'm so excited about this."

Cancer as a Disease of the Genome

"Cancer is a disease of the genome," Dr. Barker continued. "You inherit these mutations or you get them after you're born. We set out to identify all of the genomic changes in all the cancers. That's a big undertaking, so we started with 20 cancers, most of the major ones. The specimens flow to the characterization centers, the sequencing centers and the data comes out the other end—a lot of data. We are currently approaching generating petabytes of data."

The first cancer was glioblastoma, a brain tumor, and they were able to characterize this tumor into three different subtypes. "I can tell you [the atlas] is already changing practice for brain tumors. Now we can actually look at a patient and say: you shouldn't have this treatment, you should have that treatment based on your subtype. The other thing the project has done is drive

technology development. We are moving toward technology that can sequence a genome for $1,000."

Cancer as a Complex System

Dr. Barker said that cancer is not going to be easily defined. "It is an emergent, complex system. The sum of the parts is actually much different than the parts *per se*, so we have to look at it differently. We try to bring people together from the intersections of fields. We have to start thinking about research differently. We have been stuck with just empiricism for a long time, sort of developing a parts list for cancer, cardiovascular disease. Now we need unifying theories for these diseases."

She said that the snowflake is a good analogy for the complexity of cancer, "the kind of complexity that physicists understand." Just as no two snowflakes are alike, she said, it now appears that no two patients' cancers are alike. The cancers show up in these patterns like snowflakes, "and you don't have to be a scientist to see that the cancers are different. It's a little discouraging. We've got all these communities that live in silos, and we need them to work together."

In summary, Dr. Barker said that creating a system of personalized cancer medicine will require the IT infrastructure, a system of handling biospecimens, a compendium of all the genomic changes, and a responsive translational research infrastructure. All this will require new funding. "We can't afford this amount of innovation," she concluded. "But in fact we can't afford not to innovate. I think you're at the inflection point, and it's the right time to enter this space."

DISCUSSION

A questioner asked what preventive tools should be used for cancer, and how successful they might be. Dr. Barker said that the most important prevention is to not smoke, to eat a healthy diet, and to avoid being overweight. However, for the approximately 28 percent of those who, despite their best preventive efforts, get cancer based on "a whole range of genetic issues, we will be able to identify those genes." She noted that the industry "has never really been able to embrace chemo prevention—that is, making drugs that people can take every day." She said she would argue that Lipitor is a chemo preventive, and that the issue of chemo prevention is on the horizon. "So I think if you add up all the factors that are controllable to what can be done through research, you could prevent most of these diseases, with certain exceptions. And I think we have to do that, because the cost of treating cancer with a drug from the pharmaceutical industry today is about $250,000 per an additional year of life. That's staggering."

Mr. Bendis said that an impediment to better translational research is the conflict of interest policies set by the Federal agencies for Human Genome

Sciences and MedImmune. This evolved out of NIH when conflict of interest policies were different, he said, but the government may have gone too far in the other direction. "What do we have to do to convince Congress and everybody else to come back to the middle so we can open up some pathways." Dr. Barker said she had had to deal with such ethics issues at NCI, and went to a lot of Congressional hearings, "and we did have some problems. I think you're absolutely right it's swung too far back the other way. If you have investigators who can work on nothing that they've developed, especially the trials, then you're not going to move anything forward." Dr. Cosgrove said he would second that, and that the Cleveland Clinic had "tried to take a fairly aggressive policy, where all our physicians list all their financial relationships and make them public on the Internet. I think that's the first and a very reasonable step to take."

Robert Schmidt, of Cleveland Medical Devices, asked about some major medical trends, including the Internet and miniaturization. "Things that used to fill up a room and cost millions of dollars are now a few thousand dollars and then $49 at CVS." With cutbacks in Medicare and Medicaid and higher insurance costs, he asked, will more medical devices be moving into the homes, and what other changes could be anticipated? Dr. Cosgrove agreed that technologies are changing, as are disease distributions. "We're no longer seeing acute diseases in hospitals like we used to; now the majority are chronic diseases. And over the last 25 years, we have 200,000 fewer beds for 70 million more people. So healthcare is moving from inpatient to outpatient and eventually to homecare. In terms of the recent legislation and changes in government programs, hospitals are going to come together in systems. I think there will be fewer independent hospitals simply because of the complexity that is required in the back office to manage a hospital. I think there will probably be 500 to 1000 fewer hospitals across the U.S., as well as hospitals rolling up into systems."

Towards a More Open, Holistic Research Model

Dr. Wessner asked what Federal or state investments the panel members would wish for. Dr. Barker said that "the short answer is everything," but that she would begin by directing Federal money into regional public-private partnerships and clusters. "The emphasis could be IT or centralized biospecimens or networks for doing clinical trials, all are needed. I would start with measures that have promise in the personalized medicine space. Frankly, I don't see this entire system developing quickly absent some Federal investment." Dr. Douglas agreed on the priority of clusters. "You could insist on having a number of clusters, and those clusters would include IT, engineering, and biotech companies able to take innovations rapidly to commercialization. This would not require new money; the government could support a regional cluster with money already there." Implicit in support for clusters, he added, is support for shifting toward a multidisciplinary, holistic approach. Dr. Cosgrove

said he was concerned about inadequate funding for research or innovation in a more and more constrained economy. "One thing I see coming may be more open research projects. Michael Milken has suggested that he will fund research around prostate cancer if in fact results are shared openly and immediately. That's a huge step in the right direction. Rather than hoarding information in hopes it will be published in *Nature*, we speed up the efficiency. There has been a very interesting proposal to put problems on the Internet and reward people who come up with solutions regardless of where they are in the world. That draws in the best brainpower and mobilizes more diverse resources."

Panel VIII

Growing the Ohio Flexible Electronics Industry

Moderator:
Byron Clayton
NorTech

Dr. Clayton said that the discussion of regional clusters by the previous panel constituted a good introduction to this panel, with the growing importance of clusters to the northeast Ohio region. He said that the presentations would be brief so as to leave time for more general discussion on what collaboration can do for a region and an industry.

He began with a "quick definition" of flexible electronics as "simply electronic devices that are printed on flexible materials." This includes plastics, paper, and even fabrics, he said, and any other ways of making electronic devices "flexible, rollable, wearable, or formable." It also makes devices less costly to manufacture than traditional forms of electronics, as well as more durable and more energy-efficient.

"If you think of all the ways electronics touch you today," Dr. Clayton said, "just wait a few years, when electronics, specifically flexible electronics, will be in virtually everything you do. It will be in clothing, walls, and architecture. My personal favorite is electronic wallpaper. For those who hate to paint, imagine the time when you're ready for a new wallpaper and all you have to do is press a button; there are different colors, different patterns." The appeal of such products, he said, is why experts predict that the market for flexible electronic products may reach $250 billion by the year 2025.

"The good news for Ohio," he said, "is that we have established world-class core competencies in not only the materials and the technology, but also in the manufacturing of flex electronics. And more good news is that there's time for us to position ourselves to compete globally. The bad news is that even our world-class capabilities are still not going to be enough." He referred to Dr. Wessner's comments about how hard other countries are working. "We're going to have to be even smarter about how we go about building our industries."

ADVANTAGES OF A CLUSTER APPROACH

One of the ways to be smarter, he said, is to use the cluster approach. The northeast Ohio cluster created through NorTech is called FlexMatters, a term coined by Dr. West in 2006. The cluster includes partnerships throughout the value chain among universities, community colleges, small businesses, large businesses, potential end users, economic development organizations, and others. FlexMatters focuses specifically on five areas: technology innovation, capital attraction, supply chain building and networking, talent development, and market development. "Collaborating around all those areas," he said, "is what it will take for us to compete on the world stage."

Dr. Clayton characterized the mix of panel members as "a core subset of the FlexMatters cluster," including representatives of two universities and two manufacturing companies. "This is an example of real-world industry-university collaboration," he said. "I'm not talking about just a collaboration that comes together when it's time to go after a grant. This is a collaboration of organizations that have been working together for years on projects from basic research through technology development all the way to commercialization. This kind of core can drive the prosperity of entire regions."

THE GENESIS OF A NEW CLUSTER

John West
Kent State University

Dr. West began by summarizing several themes already addressed in the symposium, notably the extent of regional collaboration and the effectiveness of the cluster in building on innovation. He said that the region is presently the leader in flexible electronics—"we're simply the best in polymers and liquid crystals."[17] Logically, he continued, northeast Ohio should be "leading this new economic engine for the future." The first companies in the world to do roll-to-roll manufacturing of liquid crystal displays are in northeast Ohio, he said and "LCDs are everywhere. It is the display of choice. I invite you to count the number of LCDs you use in your personal life."

The downside, he continued, is that "none of those LCDs are made in northeast OH; none are made in the U.S. The next generation is going to be flexible displays, and flexible electronics. We have to make sure this doesn't happen again. We have the leadership now, and we should claim it, hold it, and have the vision for the future."

[17]He also cited Ken Werner, editor of *Information Display*, who wrote: "The only world-class center—in my opinion, at least—is Kent State University's Liquid Crystal Institute."

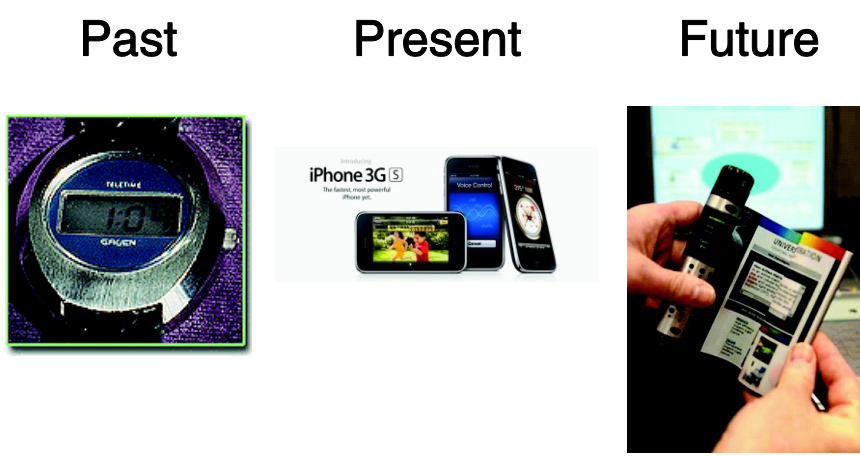


FIGURE 7 Liquid crystal displays.
SOURCE: John West, Presentation at the April 25-26, 2011, National Academies Symposium on "Building the Ohio Innovation Economy."

In reviewing the evolution of LCDs, he showed a slide of an early LCD watch display, which was made by a spin-off company of a researcher from the Liquid Crystal Institute. The researcher patented the technology, formed a startup company, and made the first LCD display in Kent, Ohio, and put it in the first digital wristwatch. That watch, now in the Smithsonian Institution, was "one of the top inventions of the last century in leading our new IT industry," he said. "But we didn't keep that lead. The visionaries in the year 1970 were talking about the TV on the wall. They didn't have a clue about the iPhone." The way technologies are going to come together and blend, he said, is through collaborations, which will be the mechanism that allows northeast Ohio to stay in control of this industry and build on its natural lead. "We are the MIT; we are the Stanford of this industry."

Leadership in Flex Electronics Through Collaboration

Dr. West expressed how fortunate he was as a young researcher to be at the Liquid Crystal Institute, "the best place in the world for liquid crystal displays when it was still an industrial curiosity." It has now become an industrial powerhouse, he said. "If you go anywhere in the world that is making LCDs, they'll tell you that the Liquid Crystal Institute at Kent State is simply the best. We have the best researchers. We know how to translate technology from the laboratory to the marketplace. A number of the companies that are sitting here today used the resources of the Liquid Crystal Institute to get started." He also emphasized the collaborations with the polymer expertise of the University of Akron and the Center for Layered Polymer Systems (CLPS) at Case Western Reserve. "We have the academic lead, we have the innovation, and we have the

ability to translate our research from laboratory curiosity into the reality of new companies. The challenges are some of the things we've been talking about today: How do we recognize this regional cluster? How does the Federal government make sure that it is supported? How do we attract enough venture capital support for the companies that are coming?"

Dr. West said that his biggest concern was that northeast Ohio should not miss the current inflection point as it missed the IT boom. "We shouldn't let that happen again. And I think the point at the table today is that the ring is coming around again. We have the new startup companies. We have the innovation within the universities. We need to strengthen this cluster with a collaborative approach and build this into an industry."

Dr. West closed by praising the expertise of his fellow panelists, and describing the breadth of the expertise they represented, from basic research to manufacturing and the next stages of innovation. "This is a collaboration that works," he concluded. "The next steps will be to take our innovation skills to the next level in the form of this cluster, and be sure that we are the ones who grab the brass ring this time."

ROLE OF REGIONAL ACADEMIC INSTITUTIONS IN FLEXIBLE ELECTRONICS DEVELOPMENT

Miko Cakmak
The University of Akron

Dr. Cakmak said he would begin with "a small sketch of what the academic institutions are doing to help promote the flexible electronics technologies in northeastern Ohio." These institutions in partnership with regional companies, he said, have been working for almost seven years to develop the technologies and have collaborated on nearly $60 million worth of funding, primarily from the Ohio Third Frontier program.

He followed Dr. West's discussion in saying flexible displays are highly useful in a range of new devices, such as soft sensors for prostheses and other biomedical devices. Devices are made flexible through the use of polymers; in the case of biomedical devices, the demands are stringent, because the devices may have to be not only functional but also soft, stretchable, comfortable, and perhaps even biodegradable. "You may want the latter devices to perform a function for desired length of time and then disappear," he said. "But that is still over the horizon."

A typical path to commercialization, he said, begins with a functional material sub-component. That includes the polymer, the primary base that will provide the flexibility, as well as other functionalities, such as electrical conductivity, piezo-electric capabilities, and magnetic properties magnetic properties in nanostructure form with functional materials. These materials can be produced by roll-to-roll manufacturing, "the bread and butter of polymer science and polymer engineering." The state of the art today, he said, is to put

the components into a device form in a much more precise way, requiring skilled people who assemble devices and eventually take them to market. A high priority is to reduce the impediments in technologies and in tech transfer processes in universities to commercializing these devices.

New Materials: The Most Urgent Need

The most urgent needs for the field, Dr. Cakmak said, are new materials. He said that many of his industrial colleagues had to compromise by using off-the-shelf materials. Finding materials for small-volume production was the most difficult. As an example, he cited the need for photo-functional materials for processing with light.

He noted that roll-to-roll manufacturing, despite its promise to lower production costs, also involves expensive techniques, such as vacuum deposition that need to be eliminated in future generations through advances in material science that will allow direct atmospheric printing. Also, it will soon need shaping and forming operations for displays or devices with a double curvature or spherical devices that cover a face. This will require devices such as those made by Kent Displays and AlphaMicron and then stretching them into two-dimensional objects. "The materials will have to be able to take that reasonable amount of deformation," he said. "You also need precision molding and a range of printing techniques and then roll to roll manufacturing technique to assemble the final devices.

The Priority of Work Force Development

Academia's major contribution to this technology, Dr. Cakmak said, was workforce development, from the technician to the PhD level. "Flexible electronics companies are going to use fully automated machines that will be operated by people with advanced degrees." He said that academic scientists in the region were already participating at the highest level. The technology would need photochemicals, he reiterated, and Scientists and Bowling Green State University, Center for Photochemical Sciences together with other regional institutions such as College of Polymer Science and Polymer Engineering at the Univ. of Akron, Liquid Crystal Institute of Kent State University are capable of designing new photocurable polymer precursors. This is a critical component, and one of the anchors that feeds into this technology." He say that Dr. West had already described the contributions being made by Kent State in liquid crystals and other functional molecules, and that Case Western Reserve University had a polymer program that together with the University of Akron's program was "literally the largest in the world." The University of Akron specifically provides monomers and polymers in special designs, and the University of Akron has National Polymer Innovation Center for the roll-to-roll manufacturing.

Bottom-up Partnerships Between Academia and Business

Obviously, Dr. Cakmak added, the academic programs need to be connected to the companies, and he specified KDI, AlphaMicron, Akron Polymer Systems, and Orbital Research, Parker Hanifin in Cleveland as existing R&D partners that take advantage of these linkages. He clarified that Akron Polymer Systems (APS) is a spin-off from the University of Akron which custom-designs molecules for new applications of liquid crystal displays. "They can turn on a dime to produce new molecules when someone needs them, unlike the large companies." An additional component is Akron Polymer Training Center, specifically designed to educate technicians and engineers at the University of Akron campus. "Global Polymer Academy," he said, "has an even a bigger vision that focuses on K-12 students and high school teachers. They also actually come to our campus for summer practices and interact with our graduate students."

The University of Akron has also invested matching funds in a new facility called the National Polymer Innovation Center, in partnership with Ohio State University and the University of Dayton, together with 85 companies. This center was part of an attempt to fill a specific technical need at commercial scale in roll-to roll-manufacturing. "We are literally providing this capability, which is called an electromagnetic processing line, to the industry and to anyone who would like to use our facilities. In this center science and engineering research R2R manufacturing is being carried out to enable these technologies through partnerships with regional institutions including NASA Glen and local industry.

In closing, Dr. Cakmak reiterated that "our continuing priority in regional economic development through our academic institutions is work force development." The university is changing its curricula to put more advanced elements, such as roll-to-roll manufacturing and photovoltaics, and flexible electronics, into advanced-level courses. A second priority is "to continue to identify and eliminate scientific and technological barriers to commercialization," he said, "particularly for new material design, process design, and process modeling. Ultimately, what we need is hierarchical modeling from a molecular scale all the way to the end of the process. That's an ultimate we are all striving for as academicians."

"This has all been a bottom-up approach," he concluded. "We have just naturally reached out to each other and created these research and commercialization programs, led either by a company or a university."

ROLL-TO-ROLL MANUFACTURING OF FLEXIBLE DISPLAYS

Albert Green
Kent Displays

Dr. Green, the chair of the FlexMatters steering committee, began by describing what may have been the most unusual product line discussed at the

symposium, an LCD-based device called a "Boogie Board." This is the first and best-known commercial product of Kent Displays, a company that was spun out of Kent State University's Liquid Crystal Institute. The Boogie Board is an iPad-sized paperless writing tablet which lets the user make lists, draw doodles, or jot down thoughts using the included stylus, a fingernail, or any non-sharp object. It erases with the touch of a button, and the internal battery is rated at about 50,000 erasures. With virtually unlimited applications, it has appealed to users of every interest and is now inspiring a rush of sister products from Kent Displays. The Boogie Board was introduced in January 2010 and quickly became a hot seller around the world.

Dr. Green said that Kent Displays would soon introduce a product line known as Reflex LCD Electronic Skins, which is also aimed at new markets. The electronic skins are ultra-thin, durable, single-pixel plastic displays that can be cut to a custom shape and conformed to a personal electronic device, such as an iPod, MP3 player, clothing, computers and peripherals, toys, and vehicles. No power is required from the host device to retain a displayed color image almost indefinitely. It is based on the company's "Reflex" technology that allows for "no-power image retention." According to the company, some Reflex displays have retained the same image without power for over 10 years with no degradation.

New Products from Flex Electronics

A new product introduced in the summer of 2011 is the Skin Flik LCD Color Changing Case, designed for the iPod Touch. Skin Flik changes the color and design of the case with a swipe of the finger. "We're really excited about that and a roll-out of a few others in 2011 and then into 2012," said Dr. Green. "This is a material that changes color depending on what you do to it electronically. That's what all the Skin Flik and the e-skins products are able to do."

The company's other products are equally high-tech, though aimed at more traditional existing markets. One is a color e-reader product, which is typically made under license to companies in Asia, and the other an e-card display used in credit cards.

"It really has been an exciting year for us," Dr. Green continued. "Within the next few weeks, we're introducing three more products along these same lines. For anyone who thinks you can't manufacture a consumer electronics product in northeast OH and sell it around the world, my response is: 'Boogie Board.' The U.S. is our largest market, and Japan is a close second. We have a lot of activities right now in Europe and all over."

The company is proud of its location in Kent, Ohio, where it now has about 100 employees. All of its products are based on RTR manufacturing, which, Dr. Green said, is fundamental to its success to date. "In many ways," he said, "RTR manufacturing of displays is the holy grail of the display industry, and we're happy to be a pioneer in that space, along with Bahman Taheri and

AlphaMicron." The bottom line, Dr. Green said, is that the technology keeps both production and set-up costs very low. While a traditional LCD manufacturing plant typically costs a billion dollars or more, the Kent Displays production facility was built with a capital investment of several million dollars.

MANUFACTURING OF CURVED LIQUID CRYSTAL DEVICES

Bahman Taheri
AlphaMicron

Dr. Taheri said that while AlphaMicron and Kent Displays have a "very, very close working relationship," their products and business models were "basically on the other side of the spectrum," He said that while AlphaMicron and Kent Displays both work with liquid crystals, their approach is different. Kent Displays works on reflective systems, with the product able to reflect what is written on it. AlphaMicron works with transmissive systems, which control the light as it passes through them. The product line of his company extended across the consumer market, and into medical, military, automotive, and other sectors. The company was founded by a few faculty members at Kent State "and initially was more of a way to let us play around with the LCD technology." As the company evolved, it changed its business model toward an infrastructure that could support different kinds of scientific research. It now has facilities for performing chemistry, lasers science, and optical physics, as well as processing, manufacturing, and design, including fashion design. The manufacturing capability was essential to "move into the next level of our world," he said. The company is not funded by VCs; "we continuously support ourselves through this program, probably because they wouldn't fund a bunch of physicists doing goofy work, but partly because we wanted to be able to do what we wanted to do." That made for a long path to market for their products.

Doing its Own In-house Research

Its program started for the benefit of Air Force pilots, whose vision was affected when they flew into and out of clouds. Traditional windows and other translucent structures are made of flat glass, which was the company's starting point. The Air Force needed a way to electronically control ambient light on a curved plastic visors. This was not yet available in eyewear or any other commercial product, so AlphaMicron had to develop new liquid crystal based functional film that could be applied to an existing pilots' visors. The company had to do its own in-house chemistry and materials development, design its roll-to-roll production, and finally develop the ability to thermoform a liquid crystal device. This technology is now patented, said Dr. Taheri, and likely to have many applications.

"This is a pretty big thing," Dr. Taheri said. "Nobody in the world can put liquid crystals on curved by thermoforming without going through our patents."

The company's development was supported by SBIR grants and 6.1 and 6.2 funding from the military, followed by a transition to Third Frontier programs in Ohio. Now it is supported by commercial partners who want development, licensing or an aspect of the technology. The company is developing eyewear for the Special Forces, who need to go in and out of buildings without changing goggles, and Navy jets that go in and out of clouds. They have made ski goggles with the same ability, as well as a motorcycle helmet. They were negotiating a contract with an automobile manufacturer to develop auto-dimming mirrors for cars, and hoped to develop car windows and architectural windows.

"The point here is that this type of development has been collaborative," Dr. Taheri concluded. "Our employees all came from Kent State University, and if they do leave, which they don't, they would go to Al Green's company, and anyone who leaves Al's company comes to us."

DISCUSSION

Sujai Shivakumar of the National Academies asked what the U.S. needs to do— given the sizeable flexible electronics programs in countries such as Germany, Korea, and Japan—to grow this technology in the U.S. and to develop a large domestic manufacturing industry around it. Dr. West said that the size of investments in the technology is an indicator that the next brass ring will be important. "Manufacturing is going to be the key issue," he said. "We do have a lead, but that doesn't mean we can sit on it." He noted significant investments through the Third Frontier and the Federal government for basic research and early product development, but emphasized the need to invest in manufacturing. "Who controls the RTR manufacturing," he said, "is going to control flexible electronics."

Dr. Taheri said that early progress had been made from the bottom up, and now it was time for top-down creation of a system that will "connect the individual parts that are distributive. The distributive knowledge base needs to be networked, both academically and industrially." This could be done by a regional organization with reasonable funding, he said, so that when somebody comes in with an idea to create a business, he can be guided through the maze of complexities: material development, process development, process design, and skills. Through NorTech and the other regional institutions, he noted, a sufficient knowledge base exists.

'What We Don't Have is Money'

Dr. Clayton said that other countries are moving rapidly toward the cluster approach, specifically Germany and Taiwan. "I just spent five days in

Taiwan going through exactly what they're doing," he said. "They were gracious enough at ITRI to lead me through their entire process. I had 15 different meetings, and what we're doing is the right thing. What we don't have is the money. They are putting $600 million a year into different things, one of which is flexible electronics."

Dr. Wessner asked Dr Albert Green of Kent Displays how the small firms here could hope to compete with East Asia, given the vigor of government investments. Dr. Green said that his company was in the process of negotiating a joint venture with Taiwan, and that he knew the flexible electronics leaders at ITRI very well. He said he had also negotiated many contracts in this technology with Samsung and LG in South Korea. He said that Taiwan was currently the more formidable competitor, with Korea somewhat "distracted by their own LCD industry." He said that the innovation culture in northeast Ohio, being "particularly American, does not translate well elsewhere, and they really do look to the U.S., and amazingly, to northeast Ohio, for leadership in these areas. It's really staggering. So I agree that the challenge for us is to realize it's not just the innovation part, which we do really well, but to translate that innovation into manufacturing and the expertise that goes out into the marketplace."

Dr. Taheri added that nobody can truly control the ultimate disposition of industries. "All these companies are evolving," he said, "and you don't know. Oakley is now owned by an Italian company, but the notion is that they're still located here." The issue, he said, "is not so much whether a foreign firm can come and buy us. If you create certain parts of a firm, then logistically it doesn't make sense for some of those to move." He said that AlphaMicron was working with a German-Canadian mirror company which plans to situate its plant near Michigan to save the expense of sending materials to Germany and back to the American market. "Those are market issues," he said. "Who knows what they will do. The notion is to create opportunities, and then allow the market to decide which way it goes."

'A Window of Opportunity is Open, and We Could Seize This Industry'

Dr. West referred to his second slide, which showed the LCD digital wristwatch when it was first made, and pre-LCD televisions. "Think about companies that made TVs at that point. You won't buy them from those companies today. It is the companies that had the patience and the diligence to see a new technology and to stick with it long enough to walk up the manufacturing curve. When that tipping point came, it was too late. I think we have an opportunity in RTR manufacturing, particularly if we have a few more years, to be quite a way down that innovation curve. We are the first doing the manufacturing. Our companies are learning how to do yields, put the product out into the marketplace at a low cost, manufacturing know-how that will be the basis of this industry. A window of opportunity is open, and we could seize this industry."

Dr. Clayton agreed that the market for flexible electronics was still "pre-demand. The bulk of the demand has not hit yet. But when it hits, people will be looking for which companies have the knowledge to actually manufacture these products. We want them to end up here."

A questioner asked whether the flexible electronics companies represented on the panel were joint ventures with the universities, and how the growth of the companies had been financed. Dr. Green said that Kent Displays raised early funding from many sources, primarily Manning Ventures, a VC firm in Rochester, New York. The company is now owned primarily by Manning Ventures, with Kent State University a small minority owner.

Dr. Taheri said that AlphaMicron was not a joint venture with the university, although it was affiliated with it, and it does not have venture capital funding. "We actually raise funding and sell products," he said.

A Need for 'Patience and Continued Investment'

Dr. Harris asked Dr. West if any valuable lessons had been learned from the first time Ohio missed the "inflection point" of the information technology boom. And he asked the panel more generally how the U.S. could compete with, for example, Taiwan, where the government simply invests in a technology if it wants to capture a market. Dr. West said several lessons had been learned. He said he had worked in two different industries, learning two different lessons. The first was the compact disc industry, where "a revolution happened overnight," and major companies took over the industry in a year or two. The second was the LCD industry, where there were many opportunities in small markets, niche markets, and unexpected applications developed over the course of 40 years." He said he thought the flexible electronics industry would follow this second course, "and I think we have to have that patience and continued investment."

Dr. Taheri agreed, and said that what was holding the industry back now was "purely money. We're bootstrapping our way to get there, starting with niche markets. If there were a concerted effort to say this is important, I think you'd be surprised at how fast you could grow and what you could dominate."

Panel IX

Early-Stage Finance and Entrepreneurship in Ohio

Moderator:
Lisa Delp
Ohio Department of Development

Ms. Delp said that she and her fellow panelists anticipated "the most valuable session of the day" in addressing the essential process of early funding. She began by saying that she manages the entrepreneurial assistance, capital access, and incubation program of the Ohio Department of Development (ODOD). "The collaborative nature of the organizations here is frankly phenomenal. We encourage that at ODOD, certainly with the Entrepreneurial Signature Program (ESP). In fact, in some parts of the state, we held what we referred to as 'shotgun weddings' to make sure everyone played nicely together." That, she added, was not necessary in northeast Ohio, where partnerships have already formed.

MAKING OHIO A PLACE TO 'LAUNCH, BUILD, AND GROW YOUR BUSINESS'

The broader goal of the Third Frontier program, which falls under the ODOD, is to build the innovation ecosystem in Ohio, including early-stage activities and early-stage funding. The ~~E~~ntrepreneurial Signature Program~~s~~ in northeast Ohio are represented primarily by Jumpstart. ~~T~~he ESP programs are designed to help entrepreneurs by offering support packaging them for later stage investment activities, and ~~help~~ preparing them to be growth-oriented organizations that bring high value, high quality jobs, and remain focused in their communities. This all helps to keep jobs in the state and helps build supply chains—a "continual, aggressive, concentrated effort to make Ohio a good place to launch, build, and grow your business," Ms. Delp said.

The other programs she manages are the Edison Incubators, which include the University of Toledo, the Youngstown Business Incubator, GLIDE at the Lorain County Community College, and other organizations in and around the state. She also manages Ohio Third Frontier supported angel capital funds, her first role when she came to the state about three years ago. "We try to

provide incentives for our angels to make investments in Ohio companies. We want to make sure that all of our money stays in Ohio, so we've provided grant funding to the angel capital organizations. These organizations professionally manage funds to help the angels by providing money that matches their own investments. So, in a sense, our angels are playing with 50-cent dollars when they make their investments. And about 50 percent of the angel funds in the state have received capital from the Ohio Third Frontier."

The Innovation Fund at Lorain County Community College is a good example of that, Ms. Delp said. The fund started in the ESP program and then moved on to start its own fund, receiving grant money from the state. Ohio also provides a 25 percent investment tax credit from the Ohio Technology Investment Tax Credit program when angels invest farther down the road. The tax credit carries forward for 15 years, and does not have to be used against a specific investment, so if the investors have a good exit at a later date, they can use their credit to offset the profits from other investments. This further reduces the risks and barriers for those early-stage angel investors.

STIMULATING ENTREPRENEURSHIP: THE LORAIN COUNTY MODEL

Roy Church
Lorain County Community College

Dr. Church said that one reason for Lorain County Community College's deep involvement in economic development was that "Lorain County for the last 30 years has had the highest percentage of its work force directly involved in manufacturing of any county in northern Ohio." In 1980, 43 percent of the work force was in manufacturing, but today that figure has shrunk to about 14 percent. "Our county has epitomized the transformation that has taken place from traditional assembly line manufacturing to whatever is evolving in the knowledge economy of the 21st century. As a community college, we have to be responsive to the needs of the local community, and that means rejuvenating the entrepreneurial spirit of the manufacturing economy."

The effort began, he said, with a focus on work force development, but it quickly became apparent that this effort was directly connected to the larger economic development milieu. "We knew that if people were going to be able to live in our county and enjoy the quality of life, they had to have jobs." The county has always had limited resources, he said, "So we knew we'd have to learn how to partner with others and create synergies." The college started by forming the Great Lakes Innovation and Development Enterprise, GLIDE, as a business incubator, in partnership with the Lorain County commissioners and chamber of commerce. "The goal was to try to wrap good business processes around entrepreneurs who had good product or business ideas." The project began in 2001, at the beginning of the recession. The first step was to go to the Third Frontier program at the Ohio Department of Development and ask for

support as an Edison technology incubator. The director of development, Bruce Johnson, said he was then cutting funds to technology incubators, and to come back again "when you've got a track record."

Learning How to 'Wrap a Good Business Around Their Idea'

In 2006 Dr. Church and his partners returned to share their early success. By then the GLIDE business incubator had placed third out of twelve then existing in the state, and Third Frontier agreed to take them on. "It really was a teaching and learning process consistent with the role of higher education," he said. "We discovered that most of the entrepreneurs had great business ideas, technology ideas, and passion for what they were doing, but they were not trained in business. They didn't know how to wrap a good business around their idea and breathe life into it."

Since 2001, GLIDE has worked with more than 1,900 entrepreneurs and incubated 65 companies, about 45 of them on the Lorain campus and the others "virtually" in the community. "The exciting news is that 62 or those 65 are still in business."

However, Dr. Church found that most of the young companies ran into the Valley of Death as soon as they had exhausted friends and family, second mortgages, and credit cards. "We knew we had to figure out a way to bring in some pre-seed capital that would enable them to move their ideas to market." The team assembled by GLIDE came up with the notion of using the foundation to raise some funds philanthropically that could then be invested at that earliest stage.

Using Philanthropy to Support Business

Here they encountered a legal roadblock. "We knew that if we were going to use philanthropic dollars, the IRS would have to agree that the donation was tax deductible—even though invested in a private business. It took us three and a half years and five IRS reviewers, but we won. We have the only private letter ruling in the country allowing those contributions to be tax deductible, and for us to invest them in private enterprise." The IRS ruled in 2006 that a "public good" was served if the entrepreneur receiving the award provided one or more students with a work-based learning experience. This brought a "triple win"—for the college in gaining educational value, for the community in building a business, and for the entrepreneur in reducing financial risk.

Dr. Church realized, however, that if the fund were going to be successful, it would need to draw great ideas from across northeast Ohio. Rather than restricting it to Lorain County, it now serves 21 counties. A first natural step was for form alliances with other educational partners. The first was the University of Akron. The two institutions began to raise funds together to provide matching dollars and bring eligibility for the Ohio Third Frontier pre-seed funds. They added Youngstown State University, and have now added

Cleveland State University, NEOUCOM,[18] and Stark State College as partners. "So this is in fact a partnership of the state, higher education, and business, utilizing philanthropic dollars to drive that earliest pre-seed investment."

He said that GLIDE makes investments at two levels: $25,000 for the "imagining stage," to help finish the research, build a prototype, or prove a concept, and $100,000 to mature the business, which must be matched 1:1 by the entrepreneur. And the entrepreneur must agree to replenish the fund after five years. "Our notion was to create something that is sustainable," he said, "certainly for a decade or more."

Success of the Innovation Fund

With state funding and favorable tax status now secured, the Innovation Fund was rechristened the Ohio Innovation Fund and officially launched in July 2007. Since then, the Innovation Fund has received almost 4,000 on-line inquiries, and 424 completed applications—including a business plan, financial figures, and a rigorous due diligence process staffed by volunteer entrepreneurs. It has made 71 awards to 60 companies, each of $300,000 or more, totaling $4.3 million. Applications have come from 17 of the 21 counties, "so it truly is a regional fund." These come from professors, students, and citizens from the community. "We provide the support and just a little funding to get them started."

Dr. Church added that "the most exciting aspect part to me is the return on investment. If you look at the performance metrics required by Third Frontier, and add follow-on investments, earnings, other kinds of investments, we've experienced an 11 times return on investment." The $3.8 million invested by the end of September 2010, he said, drew $42 million in follow-on investments. "So this is a good indication that these companies are going to be successful, launch, and move forward. The whole notion behind the Innovation Fund was to help reinvent and rejuvenate the entrepreneurial spirit of northeast Ohio."

ANGEL INVESTING: THE ARCHANGEL EXPERIENCE

Barry Rosenbaum
The University of Akron Research Foundation

Dr. Rosenbaum said he had come to Akron in 1990 as vice-president for technology of a joint venture between Exxon and Monsanto, and finally he had the opportunity to "learn to be an entrepreneur." For the last five years he had worked with the University of Akron Research Foundation, helping small businesses. "My passion in life," he said, "is to engage higher education in the

[18]Northeast Ohio Universities and Colleges of Medicine and Pharmacy.

TBED[19] ecosystem, and to take the Akron model and spread it not only in northeast Ohio, but across the U.S., and even in a venture we're developing with the University of Le Mans in France."

The priorities of the University of Akron strategy, he said, are not only excellent student education and world class research, but also societal impact—a concept accentuated by Dr. Proenza. This concept includes fostering innovation and entrepreneurship, engaging in regional economic development, and providing leadership and assistance in technology commercialization.

Dr. Rosenbaum said that his office is dedicated to excellence in technology transfer and commercialization of research; outperforming national benchmarks for the number of startup companies; partnering with industry to create jobs and increase business profitability; and strategic partnerships with industry, government, other educational institutions, and the VC community. "My point is," he said, "that the ARCHAngel experience is a natural part of the strategy of the University of Akron and its Akron model."

He noted that Dr. Proenza highlighted the University of Akron Research Foundation, which has the responsibility of managing the intellectual property of the University of Akron. "But it's not about the University of Akron," he said, "it's about the community, about northeast Ohio, about the state of Ohio. So we get involved in translating intellectual property into real products across the community."

Creating Networks to Leverage Market-ready Technology

The ARCHAngel network was formed in 2005 as an angel network. "To get it started," Dr. Rosenbaum said, "we gathered the Rolodexes of some of the people in this room and brought together about 30 accredited investors from the greater Akron community." The network was sponsored by the University of Akron Research Foundation, and the initial leaders were Baiju Shah of BioEnterprise and Ray Leach from Jumpstart. "The vision that we had was to create wealth in the northeast Ohio community. The strategy was to create intimate networks and partnerships among universities, industry, the business leadership and regional government, and to leverage leading-edge market-ready technologies. We wanted the ARCHAngel experience to be primarily market-driven."

At the outset there were 30 investors, and the initial vision was "rather conventional." After conversations with Dr. George Newkome of the University of Akron, its role has expanded and changed. The membership has grown to about 550 people who are primarily business leaders and service providers from all sectors of the community. About 20 percent are accredited investors, "but money is not the goal of what is required to create that ecosystem for entrepreneurs to be successful," he said. "We ask three or four companies to present at our quarterly network meetings, along with a keynote speaker. We

[19]Technology-based economic development.

invite active core of mentors and service providers to startup companies. Many members are people in the community who want to give back, to help the entrepreneurs, who want to provide the services and support. So the network substitutes invaluable service, mentorship, and support for just financial aid." The network is also strongly allied with the Lorain County Innovation Program. Most of the companies presented at the regular meetings are technology-based companies in the area which are supported by the Ohio Third Frontier; those companies, in turn, tend to advance to the Lorain County Innovation Fund and often to "pre-Jumpstart."

A Strong Interest From Students

An interesting development of ARCHAngel is the strong interest it has drawn from students. About 125 people attend the quarterly meetings, and of those typically about 50 are students from across northeast Ohio. "The educational experience these students get is quite important," Dr. Rosenbaum said. "We've even spun off a student venture fund which is now expanding beyond the University of Akron into northeast Ohio."

ARCHAngel is strongly allied with the Austen Bioinnovation Institute, the Akron Global Business Accelerator, and GLIDE in Lorain County. ARCHAngels has become syndicated with all the angel groups in Ohio "because we want to strengthen the role of universities as participants in the ecosystem. That includes supporting early-stage companies. We've become an advocate for university engagement in SBIR and STTR programs, trying to get universities more involved with SBIR companies. We also work with the educational foundation of the Angel Capital Association to develop tools for improving education across the boundary between angel investors and tech transfer offices."

Leaders Who Give Back

Most of those who have worked for the ARCHAngels, he noted, have done so pro bono. Many of them are community leaders who want to give back to future entrepreneurs and innovators. The network has engaged about 65 companies in its five years of existence, and generated an estimated $80 million in follow-on funding. "This is not surprising," he said, "because a lot of those companies moving through the ecosystem are supported by Jumpstart in the region and by the Third Frontier in the state."

Dr. Rosenbaum offered several conclusions from his experience to date. "The most important," he said, "is that research universities can be strategically vital to regional economic development. Some do this better than others, and we are fortunate to have some of the best. Also, the culture of the community is critical. We work hard at improving the economic development culture in Akron. Third, the creation, attraction, and retention of entrepreneurial talent are vital. And finally, early-stage funding will always be precious, but it's

not the only thing that drives entrepreneurship. The other is successful community engagement in the economic development ecosystem."

INNOVATION CAPITAL AND ENTREPRENEURSHIP IN OHIO

Ray Leach
Jumpstart

Mr. Leach began by saying that JumpStart, which was founded by NorTech and Case Western Reserve, was "an incredibly robust and exciting story that had help to achieve a revolution over the last decade." The three themes of JumpStart, he said, were Leadership, Activities, and Outcomes.

"When I came back to northeast Ohio in 2003," he said, "a key reason was the leadership. In philanthropy, the private sector, higher education—everyone was organized and had the same sense that economic development was an urgent need." And the Third Frontier was beginning to focus on not just providing resources for services, but also resources for capital, assisting pre-seed and seed stage companies that typically would not be able to raise private sector capital for another six to 24 months. So I had the good fortune of great timing."

The Commitment and Talent of the Intermediaries

In 2002, Mr. Leach said, a total of five pre-seed stage investments were made. "There wasn't much going on; the region was like scorched earth." Then collaborators across the state demonstrated to Ohio voters the commitment and talent of the intermediaries, NGOs, institutions, private sector, and philanthropic community, and they approved a $500M expansion of the Ohio Third Frontier program in 2005. "Groups had the ability to act on common interests," he said, "even though they did not necessarily know how they were going to execute. But now we've done it, we had a vision, we executed against that vision and then we generated not just a lot of activities—that's easy—but a huge amount of outcomes."

Among the activities, he said, was an overall framework to which the state in 2007 committed $87 million to accelerate the entrepreneurial ecosystems in all six regions of the state. Each region identified a single leading nonprofit entity—sometimes a university, sometimes an NGO—to coordinate entrepreneurial development activities. That original grant, which had to be matched by non-state funding sources and competitively scored and awarded, propelled each region to a great start and showed that these organizations were there not just strengthen themselves but had the mission, ability and competence to help build out the broader innovation and entrepreneurship ecosystem—this was especially in the case of northeast Ohio.

Sharing Knowledge with Others

Since that set of grants in 2007, the innovation ecosystem had raised another $50-60 million across the six regions, again through a competitive process, that have promoted expansion of the ecosystem and helped to identify additional market gaps and opportunities. Starting in 2004, JumpStart focused exclusively on its own outcomes, but over the last three years it has spent more effort and resources trying to help other organizations or funds by providing due diligence, marketing and other back-office services at no cost. It has also become more engaged with higher education institutions at the programmatic level, and with a new set of incubation activities in the nonprofit and private sectors. This kind of evolution has occurred across the state, so the level of collaboration is high. "We meet regularly," Mr. Leach said. "We're excited about the new administration's interest in what we are doing, and in leveraging tools in more significant ways."

As part of this "experiment," he said, resources from the state can be used flexibly to "meet the regions where they are" and enable them to design and develop their own strategies. For example, the program has been able to take the best regional companies to Silicon Valley and other centers of capital to encourage investors there to invest in the best of the Ohio private sector.

Feeding the Pipeline to the Private Sector

In terms of outcomes, Mr. Leach said, 2010 data from northeast Ohio show that in greater Cleveland, an all-time high number of companies, 79, have received investments totaling 234 million from angel and private-sector investors and/or members of the northeast Ohio Entrepreneurial Signature Program. Of those 79, 68 percent received capital and services from one of the four funds in the ESP: Glengarry Ventures, North Coast Angel Fund, the Ohio Innovation Fund, and JumpStart's Evergreen Fund. "We anticipate, for pre-seed and seed stage, that this percentage will exceed 85 percent starting next year. So what we're doing by investing in these companies that are not ready for prime time is feeding the pipeline to the private sector."

Of the 79 companies in northeast Ohio, he said, 57 percent were in health care, 32 percent in IT, and 10 percent in clean tech, energy, or advanced materials. There is also a robust pipeline in instruments, controls, and electronics and in chemistry in the pre-seed and seed stages. In 2010, 42 of the 79 investors were located outside Ohio. "We have an opportunity to do an even better job of attracting capital from outside Ohio."

Looking forward, Mr. Leach saw challenges in finding enough equity for the financing pipeline. He said that Michael Camp of Ohio State estimated that between now and 2018 there will be at least $500 million in seed investment opportunities available across the state, with some 800 companies needing seed capital. In 2010, $22 million were invested in the seed category. The universities

are generating more commercialized technology, and industry is continuing to do so, "so we have a huge amount of capital to raise, a challenge."

Overall, he said, Dr. Camp has estimated a total need for $1.6 billion in growth-stage capital in the state to fund about 200 companies. In the aggregate, all these needs total some $3.5 billion, principally in private sector capital. "I am on the board of the National Venture Capital Association," he concluded, "and one reason my work there is a priority is that we have to do a much better job connecting to large amounts of risk capital, which is likely to be even more highly concentrated on the coasts over the next 10 years."

DISCUSSION

A questioner closed the discussion on capital needs by urging a more ambitious target of $5 billion and greater participation of Ohio pension funds. He said that this amount would constitute only 5 percent of the holdings of those funds, and would constitute an appropriate and patriotic use of Ohio resources. "It's not too much to ask that we invest in ourselves," he said, "because if we don't do that, certainly no one else is going to do it."

Bringing the symposium to a close, Dr. Wessner once again thanked Dr. Mary Good for her leadership of the National Academies study of State and Regional Innovation Policies, thanked the sponsors for their support, and thanked the participants and audience for what he deemed a very informative and successful meeting.

III

APPENDIXES

Appendix A

Agenda

Building The Ohio Innovation Economy

A Symposium Organized by
The U.S. National Academy of Sciences
in cooperation with
The University of Akron, NorTech, Case Western Reserve University,
David Morgenthaler, and Richard Pogue

25-26 April 2011

Founders Ballroom
Intercontinental Hotel
9801 Carnegie Avenue
Cleveland, Ohio

DAY 1: APRIL 25

9:00 AM **Welcome and Introduction**
Richard Pogue, Senior Advisor, Jones Day
Mary Good, Founding Dean, College of Engineering and Information Technology, University of Arkansas at Little Rock

9:30 AM **Keynote Address**
Luis Proenza, President & CEO, The University of Akron

9:45 AM	**Panel I: The Ohio Innovation Economy in the Global Context** *Moderator: Richard A. Stoff, President, Ohio Business Roundtable*
	Challenges and Opportunities for the Ohio Innovation Economy *Ross DeVol, Executive Director of Economic Research, Milken Institute*
	Meeting the Global Innovation Imperative *Charles Wessner, Director, Technology, Innovation, and Entrepreneurship, The National Academies*
11:00 AM	**Coffee Break**
11:15 AM	**Panel II: Stimulating Manufacturing in Ohio** *Moderator: Sridhar Kota, Assistant Director for Advanced Manufacturing, Office of Science and Technology Policy, White House*
	Innovation and U.S.-Based Manufacturing *Sridhar Kota, Assistant Director for Advanced Manufacturing, Office of Science and Technology Policy, White House*
	The State Manufacturing Challenge *Eric Burkland, President, Ohio Manufacturing Association*
	Stimulating Manufacturing in Ohio: An Industry Perspective *James Griffith, President & CEO, Timken Company*
	Reviving Manufacturing: The Role of NIST *Phillip Singerman, Associate Director for Innovation and Industry Services, National Institute of Standards and Technology*
12:30 PM	**Lunch**
1:30PM	**Panel III: Innovation Clusters and Economic Development** *Moderator: Lester Lefton, President, Kent State University*
	Clusters and the Next Ohio Economy: What is Needed *Lavea Brachman, Executive Director, Greater Ohio Policy Center*

Infrastructure for the 21st Century: How EDA Might Help
John Fernandez, Assistant Secretary, Economic Development Administration

Economic Development in Ohio: The Role of Community Foundations
Ronn Richard, President & CEO, Cleveland Foundation

2:45 PM **Coffee Break**

3:00 PM **Keynote Address: Investing in Ohio**
James Leftwich, Director, Ohio Department of Development

3:30 PM **Panel IV: State and Regional Innovation Programs**
Moderator: Richard Bendis, Innovation America

Current Trends and Challenges in State Innovation Programs
Dan Berglund, President & CEO, State Science and Technology Institute (SSTI)

The Role of NorTech: Promoting Innovation and Economic Development
Rebecca O. Bagley, President & CEO, NorTech

4:15 PM **Panel V: The New Energy Economy in Ohio**
Moderator: Gary Leidich, Executive Vice President, FirstEnergy

The Ohio Energy Economy: Needs, Opportunities, and Initiatives
David Wilhelm, Founder & President, Woodland Venture Management

ARPA-e Initiatives
Jonathan Burbaum, ARPA-e

Building Clean Energy Companies in Ohio: What Needs to Be Done
Lorry Wagner, President, LEEDCo

5:00 PM **Adjourn Day 1**

DAY 2: APRIL 26

9:00 AM **Welcome and Introduction**
David Morgenthaler, Founding Partner, Morgenthaler Ventures

9:15 AM **Panel VI: 21st Century Universities: Drivers of Regional Growth & Employment**
Moderator: William Harris, President & CEO, Science Foundation Arizona

Relevance, Connectivity, and Productivity: The Akron Model
Luis Proenza, President & CEO, The University of Akron

The Economic Impact of a Major Comprehensive Research University: The Case Western Reserve University Model
W. A. "Bud" Baeslack III, Provost and Executive Vice President, Case Western Reserve University

10:15 AM **Coffee Break**

10:30 AM **Panel VII: Biomedical Growth Opportunities**
Moderator: Baiju Shah, BioEnterprise

Biomedical Research and the Health Care Industry
Frank Douglas, President & CEO, Austen BioInnovation Institute in Akron

Bringing Medical Innovations to Market
Delos "Toby" Cosgrove, President & CEO, Cleveland Clinic

Advancing Cancer Research
Anna Barker, Deputy Director, National Cancer Institute, ret.

11:30 AM **Panel VIII: Growing the Ohio Flexible Electronics Industry**
Moderator: Byron Clayton, Vice President, NorTech

The Genesis of a New Cluster
John West, Professor of Chemistry, Kent State University

Role of Regional Academic Institutions in Flexible Electronics Development
Miko Cakmak, Distinguished Professor of Polymer Engineering, The University of Akron

Roll-to-Roll Manufacturing of Flexible Displays
Albert Green, CEO, Kent Displays

Manufacturing of Curved Liquid Crystal Devices
Bahman Taheri, CEO, AlphaMicron

12:30 PM **Lunch**

1:00 PM **Luncheon Keynote Address**
The Honorable Rob Portman, United States Senate

1:15 PM **Panel IX: Early-Stage Finance and Entrepreneurship in Ohio**
Moderator: Lisa Delp, Technology Investment Coordinator, Ohio Department of Development

Stimulating Entrepreneurship: The Lorain County Model
Roy Church, President, Lorain County Community College

Angel Investing: The ARCHAngel Experience
Barry Rosenbaum, Senior Fellow, The University of Akron Research Foundation

Innovation Capital and Entrepreneurship in Ohio
Ray Leach, CEO, JumpStart

3:00 PM **Adjourn**

Appendix B

Biographies of Speakers
(as of April 2011)

W. A. "Bud" Baeslack III

William A. "Bud" Baeslack III was appointed Provost and Executive Vice President at Case Western Reserve University on October, 1, 2008, and is responsible for all facets of the academic programs and research of the University. He also holds an appointment as Professor of Materials Science and Engineering.

Prior to joining CWRU, Baeslack served as the Dean of the College of Engineering and Executive Dean of the Professional Colleges at The Ohio State University. Baeslack began his academic career as an Assistant Professor at OSU in 1982. As an academic administrator at OSU from 1991 to 1999, he served as a Department Chair, Associate Dean for Research and College Development, Interim University Vice President for Research, and President of the OSU Research Foundation. From 1999 to 2004, Baeslack served as Dean of the School of Engineering at Rensselaer Polytechnic Institute, during a period in which the Institute created and implemented its highly successful Rensselaer Plan. He returned to OSU in 2004.

Baeslack is internationally recognized for his research on the materials science and engineering aspects of joining advanced aerospace materials, including titanium, aluminum and nickel-base alloys, intermetallics and metal-matrix composites. He has received research funding from the Office of Naval Research, the Army Research Office, the Air Force Office of Scientific Research, the National Science Foundation, the Ohio Edison Program, national laboratories and industry. Baeslack and his students have authored over one hundred and fifty journal and proceedings articles. He has been elected a Fellow of ASM International, The Welding Institute and the American Welding Society. In 1989/90, Baeslack spent a sabbatical leave at The Welding Institute in Cambridge, England.

Baeslack received his B.S. and M.S. degrees in Welding Engineering from The Ohio State University and his Ph.D. degree in Materials Engineering from Rensselaer Polytechnic Institute. Following graduation from RPI, he served four years at the U.S. Air Force Materials Laboratory as a materials engineer and technical area manager.

Rebecca O. Bagley

Rebecca O. Bagley is president and chief executive officer of NorTech, a regional nonprofit technology-based economic development organization that serves 21 counties in Northeast Ohio. As a catalyst for growing Northeast Ohio's technology industries, NorTech is leading an effort to develop regional innovation clusters that will spur job creation, capital attraction, and long-term positive economic impact.

Ms. Bagley joined NorTech in July 2009, bringing a wealth of experience and leadership as a nationally recognized expert in technology-based economic development. Ms. Bagley leads the organization's effort to develop regional technology clusters and make the region's economy more economically diverse by supporting and nurturing Northeast Ohio's most promising technology projects and initiatives. Ms. Bagley connects with regional, state and federal government leaders to raise the visibility of Northeast Ohio's technology assets and drive funding to the region. Recently, Ms. Bagley and her team worked in partnership with the White House to organize the first "Winning the Future Forum on Small Business" with President Obama and five cabinet level officials.

Previously Ms. Bagley served as Deputy Secretary for the Technology Investment Office of the Pennsylvania Department of Community and Economic Development (DCED). In that capacity, she was responsible for the administration of several major state initiatives with a total of $79 million in yearly appropriations, and more than $1.7 billion in investments. She also managed the passage of $650 million for Pennsylvania's Energy Independence Fund. She previously served as Director of Venture Investment for DCED and managed venture and real estate investment programs.

Before joining DCED, Ms. Bagley worked for several investment banks, most notably JPMorgan Chase, where she advised energy and technology companies on merger and acquisitions and raising capital in the high yield-bond group and oil and gas group.

Ms. Bagley is a frequent guest speaker at regional, state and national conferences and meetings on the topics of regional innovation cluster development and measurement for technology-based economic development initiatives and programs. Ms. Bagley serves on several boards and advisory councils including the National Association of Seed and Venture Funds (NASVF); State Science Technology Institute (SSTI) - Finance Committee Chair; BioEnterprise; JumpStart; Sustainable Cleveland 2019 Advisory Council; The Oberlin Project—A Clinton Climate Initiative; OneCommunity; TechBelt

Executive Committee; Ohio Agricultural Research and Development Center Advisory Board; Ohio Wright Center for Sensor Systems Engineering; Cleveland State University Fenn College of Engineering Visiting Committee; and Senator Sherrod Brown's Ohio Export Advisory Group. She is also a member of the Leadership Cleveland Class of 2011. Ms. Bagley holds a Bachelor of Science Degree from the University of Colorado at Boulder.

Anna Barker

Dr. Barker served as the Deputy Director of the National Cancer Institute (NCI) and as the Deputy Director for Strategic Scientific Initiatives for the past eight years—retiring at the end of August, 2010. In this role she developed and implemented multi/trans-disciplinary programs in strategic areas of cancer research and advanced technologies including: the Nanotechnology Alliance for Cancer; The Cancer Genome Atlas (TCGA)—in collaboration with the National Human Genome Research Institute; and the Clinical Proteomics Technologies Initiative for Cancer. Recently she led the development of a new initiative to develop a network of trans-disciplinary centers focused on the elucidation of the "physics" of cancer at all scales through the establishment of Physical Sciences-Oncology Centers (PS-OCs). All of these programs emphasize innovation, trans-disciplinary teams and convergence of scientific disciplines to enable progress against cancer. They also stress the synergy of large scale and individual initiated research, precompetitive research and public databases and translation of discoveries into new targeted interventions to detect prevent and treat cancer more effectively

Dr. Barker has also led and collaborated on NCI's effort to develop contemporary resources for cancer research in the areas of biospecimens and bioinformatics (the Cancer Human Biobank (caHUB) and the Cancer Bioinformatics Grid (caBIG, respectively) to support molecularly based personalized medicine. She served as the founding co-chair of the NCI-FDA Interagency Task Force; founding co-chair of the Cancer Steering Committee of the FNIH Biomarker Consortium; and oversaw the NCI's international cancer research programs, including pilot programs in Latin America and China. Dr. Barker has a long history in research and the leadership and management of research and development in the academic, non-profit and private sectors. She served as a senior scientist and subsequently as a senior executive at Battelle Memorial Institute for 18 years; and co-founded and served as the CEO of a public biotechnology drug development company. She has received a number of awards for her work in support of cancer research, cancer patients, professional and advocacy organizations and the ongoing national effort to prevent and cure cancer. Most recently she received the 2009 AACR Margaret Foti Award for Leadership and Extraordinary Achievements in Cancer Research, AACR 100th Anniversary Meeting; and In 2009 Dr. Barker was named to the list of "The 100 People Changing America" by Rolling Stone Magazine.

Her research interests include experimental therapeutics, tumor immunology, and free-radical biochemistry in cancer etiology and treatment. Dr. Barker completed her M.A. and Ph.D. at the Ohio State University, where she trained in immunology and microbiology.

Richard Bendis

Richard Bendis is a distinguished and successful entrepreneur, corporate executive, venture capitalist, investment banker, innovation and technology based economic development leader, international speaker and consultant in Innovation and Economy Building.

Mr. Bendis currently serves as the founding President and CEO of Innovation America (IA), a Global Innovation Intermediary focused on accelerating the growth of the entrepreneurial innovation economy in America. IA has a fivefold mission: Global advocate for accelerating awareness of Innovation, Entrepreneurship and Early Stage Capital in stimulating Innovation Based Economic Development (IBED); International speaker on Building Innovation and Entrepreneurial Ecosystems (Voted a Top 5 Innovation Speaker by Speakers Platform); International Consulting on IBED; Publishing innovationDAILY and WEEKLY, a daily e-newsletter reporting on Global trends on innovation with a circulation of approximately 500,000 unique visitors in over 185 Countries (Voted The 4th Best Innovation Blogger in The World by Blogging Innovation); Early Stage Capital Fund of Funds Consulting and Formation

Mr. Bendis has been appointed to several national innovation related organizations and committees include the White House U.S. Innovation Partnership (USIP) Advisory Task Force and Co-Chair of the Small Business Innovation Research Committee), the National Governor's Association (NGA) Science and Technology Council of the State's Executive Committee, the State Federal Technology Task Force, the National Academies (NAS) committee on "Competing in the 21st Century: Best Practices in State and Regional Innovation Initiatives"; National Academies National Research Review of "an Assessment of the SBIR Program; National Institute of Standards and Technology Manufacturing Extension Partnership (MEP) National Advisory Board; U.S. Small Business Administration's Angel Capital Electronic Network (ACENET) Board of Directors; American Academy for the Advancement of Science (AAAS) Nominating Committee and the American Association Research Competitiveness Program Advisory Committee; Council on Competitiveness—Clusters of Innovation Committee.

Mr. Bendis is currently or has previously served as a board member and representative to the following organizations: National Association of State Venture Funds (NASVF) Founding Board member and Vice Chairman of the Executive Committee; State Science and Technology Institute (SSTI) Founding Board member: Eisenhower Fellowships Nominating Committee, the Ernst and Young Entrepreneurial Institute Member and as a past EOY winner as well as

a national/regional Judge, Advisory Board member of the Technopolicy Network.

Mr. Bendis has provided global consulting services to over 18 countries and 24 states, several cities and regions, along with international organizations including the United Nations, NATO, UK Trade and Industry, European Commission, French Embassy, the German Marshall Fund, The Canadian Consulate, COTEC, TechnoPolicy, Science Works, METI, AKEA, the International Science Parks and Innovation Expert Group and other global entities. Mr. Bendis is an International speaker, focusing on Innovation , Entrepreneurship, and Developing and implementing Innovation Based Economic Development Strategies.

Mr. Bendis founded the Bendis Investment Group LLC, (BIG), a financial intermediary and consulting firm, along with managing his own angel investment portfolio. Mr. Bendis also founded and served as the founding President and CEO of Innovation Philadelphia (IP), a three state regional public/private partnership dedicated to growing the wealth and workforce of the Greater Philadelphia Region. IP managed a portfolio of programs in four distinct areas: Direct Equity Investment/Financing Assistance; Technology Commercialization; Global/Regional Economic and Workforce Development; and Market Research and Branding. Mr. Bendis currently serves as the Chairman of the innovation Philadelphia, Board of Directors.

Previously, Mr. Bendis successfully leveraged a career in the private sector (with Quaker Oats, Polaroid, Texas Instruments, Marion Laboratories and Kimberly Services) and the venture capital industry (RAB Ventures) to lead the Kansas Technology Enterprise Corporation (KTEC). As its president and CEO, he developed KTEC into a globally recognized model for technology-based economic development. Mr. Bendis also successfully built an Inc. 500 healthcare software company, Continental Healthcare Systems, Inc., which he took public on NASDAQ and later sold to an international conglomerate. He was a nominee for the 2005 Ernst and Young National Entrepreneur Supporter of the Year Award (EOY) and was the 1996 recipient of the Regional Ernst and Young Entrepreneur of the Year Award.

Dan Berglund

Dan Berglund is the President and CEO of SSTI, a non-profit 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.

Lavea Brachman

Lavea Brachman, as Executive Director of Greater Ohio and a Non-Resident Senior Fellow at the Brookings Institution, has been the chief architect of and manages the Restoring Prosperity to Ohio Initiative as well as other related statewide initiatives, including ReBuild Ohio, a statewide vacant property redevelopment coalition. Since coming to the organization, Lavea has been instrumental in shaping the Greater Ohio's organizational and strategic direction, as well as developing policy and programmatic areas of focus and strategic partnerships with other non-profit organizations and private sector leaders. She has also written a number of publications including co-authoring Greater Ohio's recently released report, "Restoring Prosperity: Transforming Ohio's Communities for the Next Economy," and the Brookings publication, "Ohio's Cities at a Turning Point: Finding the Way Forward" on the plight and strengths of Ohio's older industrial "shrinking cities."

After practicing environmental law at a Washington, DC, law firm, Lavea was a partner with a Cambridge, Massachusetts consulting firm advising Fortune 500 companies on brownfield redevelopment strategies. Since then, Lavea has dedicated her work to the non-profit and public sectors. While at the Department of Energy (DoE) during the Clinton Administration, she worked on redevelopment and community involvement strategies for decommissioned DoE sites. As director of Ohio work at the Chicago-based non-profit Delta Institute, Lavea worked with community leaders throughout the Midwest to promote local watershed and brownfield redevelopment projects.

Before returning to Ohio, Lavea was a Visiting Fellow at the Lincoln Institute of Land Policy and taught in the Department of Urban Studies and Planning at MIT, both in Cambridge, Massachusetts, where she developed and taught workshops and wrote about the role of community development organizations in brownfields development and neighborhood revitalization efforts. Lavea graduated from Harvard College and The University of Chicago Law School, and received a master's in city planning from the Massachusetts Institute of Technology.

Eric Burkland

Mr. Burkland, a native of Wheeling, West Virginia, is a 1974 honors graduate of Miami University, where he received a Bachelor of Arts degree in

political science. During 1972 and 1973 he studied at the European Study Center in Luxembourg. Following graduation, Mr. Burkland was a staff writer for the Wheeling News-Register. He then returned to Miami University, to pursue post-graduate work in political science while holding a position as a teaching assistant in the department of political science at the university.

Prior to assuming the presidency of The Ohio Manufacturers' Association in March, 1989, Mr. Burkland served as Vice President, Legislative Relations, Community Mutual Insurance Company, between 1984 and 1989. From 1979 to 1984, Mr. Burkland was on the staff of the Ohio State Medical Association, as the Director of the Department of State Legislation. Mr. Burkland has served also as a Research Assistant for the Ohio Legislative Service Commission.

Miko Cakmak

Distinguished Professor Miko Cakmak joined UA in 1983 as a chief engineer in the Department of Polymer Engineering and was appointed assistant professor in 1985. He earned tenure in 1990, and was awarded the title of professor of polymer engineering in 1995. Before coming to Akron, Cakmak received his B.S. in Chemical Engineering from the Technical University of Istanbul, and earned both his master's and doctoral degrees in polymer engineering from The University of Tennessee.

As an assistant professor, Cakmak received the prestigious Presidential Young Investigator Award from the National Science Foundation for showing strong promise in academic research. Cakmak received three Best Paper awards from the Society of Plastics Engineers and its 1990 Outstanding Achievement Award.

He has led research efforts with external funding of about $19.5 million. In particular, he was co-leader for the effort to bring to campus a Wright Center of Innovation, the "Center for Multifunctional Polymer Nanomaterials and Devices," led by The Ohio State University. Subsequently he was principal investigator for an $8 million Third Frontier Research Project for Commercialization of Functional Polyimide Films and Nanocomposites. This project integrates efforts at UA, the University of Dayton and Kent State University, and 14 high-tech companies to develop very high value-added optical, high strength and conductive polymer films.

Using the technologies developed in these two efforts, Cakmak has made it possible to develop a strong membrane for a novel "artificial pancreas" using polymers originally synthesized by UA's Dr. Joseph Kennedy. For their work on the artificial pancreas technology, the pair recently received the 2009 NorTech Innovation Award in the Biosciences category from the Northeast Ohio Technology Association.

His area of expertise is on Identification, modeling and simulation of complex structural mechanisms particularly stress induced crystallization that take place during the course of polymer processing operations of wide range of

polymers subjected to solution , melt as well as rubbery state deformation. The range of materials includes the high temperature thermoplastics and their blends as well as nano particle filled systems. Of particular interest is the relationship between thermo-mechanical history applied by fiber spinning, film blowing, biaxial stretching and injection molding and evolved structure and properties. Current activities are focused on real time measurements of true mechano-optical and mechano-electrical properties of polymers undergoing uni and biaxial deformation for photonics applications. With the recent CMPND center, he is actively developing novel processes to address the needs of emerging markets. Towards this goal, his group recently developed a hybrid Electrospinning/solution casting multipurpose processing platform to produce functional polymer films including conductive transparent films. He has just received an $8M Third Frontier commercialization grant that integrates University researchers and industrial companies around the concept of "Functional Polyimide films and high performance nanocomposites." This project focuses on commercialization of products including Optical films for LCDs, high strength films for High Altitude Airship, high performance composites to replace jet engine parts and thermal management films for dissipating heat from electronic devices including plasma and liquid crystal television sets.

Roy Church

Dr. Church is currently the President of Lorain County Community College. He has served as a leader in comprehensive community colleges and has led the transformation of Lorain County Community College since 1987.

Hallmark initiatives and accomplishments include: Creating comprehensive community higher education centers for local communities to access education from the K-12 level through graduate studies; building collaborative initiatives with business, organized labor and government to enhance workforce education and economic development; improving the articulation of programs and the transfer of students between secondary schools, community colleges and universities.

Dr. Church is professionally involved in activities to improve access to education, build collaborative initiatives, and improve articulation and transfer at the state, regional and local level. He serves co-Chairs of the Ohio Board of Regents' Articulation and Transfer Council and as a member of the Governor's Workforce Policy Advisory Board, and the State Advisory Committee on Adult Career-Technical Programs. Regionally, he is Vice Chair of the Northeast Ohio Council on Higher Education. He serves on the Fund for Our Economic Future Funders' Steering Committee; the WVIZ/PBS and 90.3 WCPN Ideastream Board; the Innovation Alliance, Co-Chair; the NorTech Board and chairs the Talent Sub-Committee of its Information Technology Initiative. Dr. Church also serves on the boards of The Midwest Consortium for Community College

Development, Business Volunteers Unlimited, the Manufacturing Advocacy and Growth Network (MAGNET), TeamNEO and JumpStart.

Locally, he has chaired the United Way Campaign and served as President of the Board of the United Way of Greater Lorain County. For three years he chaired the Board of Lorain County 2020, a county visioning organization. He also is Secretary-Treasurer of the Great Lakes Organized Labor/Management Council. He is a board member of The Great Lakes Innovation and Development Enterprise, The Center for Leadership in Education, the Lorain County Workforce Institute, Team Lorain County, South Shore Community Development Corporation, Lorain County Port Authority, El Centro de Servicios Sociales, the Lorain County Urban League and the Lorain County Chamber of Commerce.

Byron Clayton

Dr. Byron C. Clayton serves as the Vice President of NorTech, a nonprofit technology-based economic development organization that serves 21 counties in Northeast Ohio. He is responsible for leading NorTech's Flexible Electronics cluster initiative to accelerate commercial activity and jobs in the sector. In this role, he works with cluster companies, research institutions, entrepreneurs, investors, and government officials to catalyze cluster efforts to create economic impact in Northeast Ohio. Dr. Clayton serves on the National Academies Committee on Best Practice in National Innovation Programs for Flexible Electronics.

Dr. Clayton has over 25 years of experience developing new businesses and commercializing high tech systems serving numerous industries including automotive, aerospace, construction, defense (DoD), nuclear (DoE), and space (NASA). For 15 of those years, he served as a senior or executive manager specializing in strategic management, product commercialization, and business development. He has guided or facilitated the commercialization of over 45 high-tech products and systems, been published in both academic and trade journals, and holds patents for manufacturing optimization software used by numerous plants across North America.

Delos "Toby" Cosgrove

Delos M. Cosgrove M.D., is president and chief executive officer of Cleveland Clinic. Under his leadership, Cleveland Clinic has experienced improved clinical outcomes and increased patient satisfaction, and expanded locally, nationally and internationally. Dr. Cosgrove has enacted policies focused on quality improvement, improved patient experience, and greater transparency and accountability at all levels of the organization. He has reaffirmed Cleveland Clinic's dedication to clinical medicine at all levels, and is leading its reorganization into institutes based around specific diseases and organ systems. Dr. Cosgrove has committed Cleveland Clinic to major support

for local schools, hunger centers, and high school apprenticeship programs in nursing and the biological sciences.

As CEO, Dr. Cosgrove presides over a 4.6 billion dollar healthcare system comprised of the Cleveland Clinic, nine community hospitals, 14 family health and ambulatory surgery centers, Cleveland Clinic Florida, Cleveland Clinic Toronto, and the developing Cleveland Clinic Abu Dhabi.

The years since Dr. Cosgrove's appointment as president and CEO in 2004, have been the most successful in Cleveland Clinic history and include Cleveland Clinic being ranked among the top three hospitals in America (U.S. News & World Report); contracts and MOUs to establish Cleveland Clinic medicine in Abu Dhabi, Toronto, Vienna, Singapore and Seattle; and a successful 1.25 billion dollar capital campaign to support over 4 million square feet in new construction and improvement.

Dr. Cosgrove received his medical degree from the University of Virginia School of Medicine in Charlottesville and completed his clinical training at Massachusetts General Hospital, Boston Children's Hospital, and Brook General Hospital in London. His undergraduate work was at Williams College in Williamstown, Massachusetts.

He was a surgeon in the U.S. Air Force and served in Da Nang, Republic of Vietnam as the Chief of U.S. Air Force Casualty Staging Flight. He was awarded the Bronze Star and the Republic of Vietnam Commendation Medal.

Joining Cleveland Clinic in 1975, Dr. Cosgrove was named chairman of the Department of Thoracic and Cardiovascular surgery in 1989. Under his leadership, Cleveland Clinic's heart program was ranked number one in America for ten years in a row (U.S. News & World Report).

He has published nearly 450 journal articles, book chapters, one book and 17 training and continuing medical education films.

Before retiring from surgery in 2006, Dr. Cosgrove achieved one of the most distinguished and accomplished careers in the field of cardiac and thoracic surgery. He performed more than 22,000 operations and earned an international reputation for expertise in all areas of cardiac surgery, especially valve repair. A pioneer and refiner of advanced surgical techniques, Dr. Cosgrove was a pacesetter in the development of minimally invasive valve surgery, and performed the first minimally invasive mitral valve surgery over a worldwide video network in 1996. As an innovator, Dr. Cosgrove has 30 patents filed for developing medical and clinical products used in surgical environments.

He is a member of 16 scientific societies including the Society of Thoracic Surgeons, the American College of Surgeons, the American Heart Association and the American Association of Thoracic Surgery, for which he served as president in 2000. He is an honorary member of six international organizations.

The recipient of Cleveland Clinic's Master Clinician Award, Innovator of the Year Award and Lerner Humanitarian Award, Dr. Cosgrove is also a member of Cleveland Medical Hall of Fame and Cleveland Business Hall of

Fame. In 2007 he was named Cleveland Business Executive of the Year by the Sales and Marketing Executives of Cleveland, and Castle Connolly's National Physician of the Year. He also received the Woodrow Wilson Center Award for Public Service as well as Harvard Business School's Award from HBS Alumni, Cleveland.

Lisa Delp

Lisa Delp is a seasoned entrepreneur and experienced manager of government-led economic development initiatives that provide technical assistance, business support, and risk-capital funding to entrepreneurs and intermediary organizations. Lisa has managed the Ohio Third Frontier (OTF) Risk Capital and Entrepreneurial Assistance programs since joining the Ohio Department of Development in 2008; her portfolio includes the Entrepreneurial Signature Program, Pre-Seed Funds Initiative, Ohio Venture Capital Authority, and the Technology Investment Tax Credit Program. As the newly named Entrepreneurial Services and Incubation Manager, Lisa will focus her business skills and knowledge of state programs to improve entrepreneurial support and growth activities in Ohio. In her new role Lisa will continue to manage the successful Entrepreneurial Signature Program and be given responsibility for Ohio's fourteen Thomas Edison Incubators. Lisa is a primary state contact for information regarding technology investment programs and provides direct consultation, assistance, and referrals to Ohio's economic and business development network.

Lisa is a founder of two consulting companies focused on providing technical assistance to entrepreneurs and is the co-founder of the Delp Mixer Company, a laboratory equipment business she funded through bootstrapping and Angel capital investments. Lisa attended Columbus State Community College and supports entrepreneurial development in Central Ohio through board participation and volunteer activities. She sits on the Economics, and Applied Management Advisory Boards at Franklin University; is an annual judge for the Business Plan Competition at The Ohio State University Fisher College of Business; and is an instructor for Increase Community Development Corporation, an organization assisting Minority Business Owners.

Ross DeVol

Ross DeVol is Executive Director of Economic Research as well as Executive Director of the Centers for Health Economics, Regional Economics and California at the Milken Institute. He oversees the Institute's research on the dynamics of comparative regional growth performance, technology and its impact on regional and national economies and health-related topics such as chronic disease. He is an expert on the intangible economy and how regions can prepare themselves to compete in it. He was the principal author of "An Unhealthy America: The Economic Burden of Chronic Disease" which brought

to light for the first time what is often overlooked in the discussion of the impact of chronic disease—the economic loss associated with preventable illness and the cost to the nation's Gross Domestic Product (GDP) and American businesses in lost growth. The study is the first of its kind to estimate the avoidable costs if a serious effort were made to improve Americans' health. He authored the ground-breaking study, America's High-Tech Economy: Growth, Development, and Risks for Metropolitan Areas, an examination of how clusters of high-technology industries across the country affect economic growth in those regions. He also created the Best Performing Cities Index, an annual ranking of U.S. metropolitan areas that shows where jobs are being created and economies are growing. Other recent work involves the study of biotechnology and other life-sciences clusters, and the impact these industries have on regional economies. He was the lead author of Mind-to-Market: A Global Analysis of University Biotechnology Transfer and Commercialization released in September, 2006. This study looked at the transfer and commercialization of university-developed intellectual property on a global basis with particular focus on the field of biotechnology. Prior to joining the Institute, DeVol was senior vice president of Global Insight, Inc. (formerly Wharton Econometric Forecasting), where he supervised their Regional Economic Services group. He was the firm's chief spokesman on international trade. He also served as the head of Global Insight's U.S. Long-Term Macro Service and authored numerous special reports on behalf of the U.S. Macro Group. He is ranked among the "Super Stars" of Think Tank Scholars by International Economy magazine.

Frank Douglas

Frank Douglas is the president and CEO of Austen BioInnovation Institute in Akron, Ohio, a best-in-class model for the future of health care delivery and innovation. Douglas, a former founder and executive director of Massachusetts Institute of Technology's Center of Biomedical Innovation, is an award-winning industry veteran, with more than twenty-four years of experience in health care, pharmaceutical research, and biotechnology.

Douglas joined the Austen BioInnovation Institute in Akron after serving as senior partner, Puretech Ventures and, chief scientific advisor, Bayer Healthcare, AG.

Douglas has received more than fifteen industry awards, including the Global Pharmaceutical Chief Scientific Officer of the Year Award, the Wolfgang von Goethe Medal of Honor, the Associated Black Charities' Black History Makers Award, the Lifetime Achievement Award from the National Organization of Black Chemists and Chemical Engineers, and the Heart of the Year Award from the Chicago Heart Association and the Louis B. Russell Memorial Award from the American Heart Association, both for his development of high blood pressure screening and control programs for African-American churches in Chicago.

After graduating cum laude from Lehigh University, Douglas attended Cornell University where he earned his PhD in physical chemistry and his MD. He completed his internship and residency in internal medicine at The Johns Hopkins Medical Institutions and a fellowship in neuroendocrinology at the National Institutes of Health.

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 thirteen 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 Doctor of Law (J.D.) from Indiana University. He also earned a Master of Public Affairs (M.P.A.) and Bachelor of Science (B.S.) from Indiana University's School of Public and Environmental Affairs.

Mary Good

Dr. Mary L. Good, founding Dean and Donaghey Professor, 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 the 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 was also the first female winner of the AAAS's prestigious Philip Hogue Abelson prize for outstanding achievements in education, research and 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 is also the 6th Annual Heinz Award Winner. During the terms of Presidents Carter and Reagan, Dr. Good served on the National Science Board and chaired it from 1988-1991. She was the Undersecretary 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.

Albert Green

Dr. Albert Green is the CEO of Kent Displays, Inc. and serves on the Board of Directors. He has held this position since joining the company in June 2007.

Prior to joining KDI, Dr. Green was Vice President and Division Manager at Science Applications International Corporation (SAIC) where he worked closely with KDI in jointly developing Reflex™ technology for flexible display applications.

Dr. Green spent 13 years at SAIC and worked in a variety of capacities including Senior Scientist, Program Manager, and Business Unit Chief Scientist. He also holds over 25 patents in the areas of photonic systems, displays, and advanced materials. Dr. Green holds a BS in Physics from The University of Chicago and a PhD in Physics from Stanford University. He has also attended the Executive Training Summer School at MIT's Sloan School of Business Administration.

Dr. Green has had a long history of innovation in applications that involve advanced materials and applications in display and related technologies. He has the unique combinations of skills that allow him to both innovate, market, and manage those technologies and the related products that stem from those innovations. Kent Displays offers the unique opportunity to take a revolutionary technology from the laboratory and pilot manufacturing to large scale production.

Dr. Green is an advisor to President Barrack Obama's Export Council. He is also chair of the FlexMatters steering committee. The FlexMatters

initiative was formed to recognize the flexible electronics cluster in Northeast Ohio and to accelerate its growth.

James Griffith

James W. Griffith is president and chief executive officer of The Timken Company and a member of the company's board of directors.

Since being named president in 1999, Griffith has led a transformation of The Timken Company focused on creating ever-increasing levels of value for customers and shareholders. By harnessing its legendary quality and industry-leading innovation, Timken has pushed beyond its historic leadership in the tapered roller bearing market into a vast global market for technologies to manage the friction generated by moving parts and improve the transmission of power in a wide array of machines.

Griffith joined The Timken Company in 1984 and has held positions as plant manager, vice president of manufacturing in North America and managing director of the company's business in Australia. From 1996 to 1999, he led Timken's automotive business in North America and the company's bearing business activities in Asia and Latin America. He was elected president, chief operating officer and director in 1999 and was named chief executive officer in 2002.

Griffith is president of the World Bearing Association and chairman of the board of directors of the Manufacturing Advocacy and Growth Network (MAGNET). He is vice president of the Management Executives' Society and serves on the boards of directors of the U.S.-China Business Council and Goodrich Corporation (NYSE: GR). He also serves on the board of Mount Union College.

Griffith holds a bachelor's degree in industrial engineering and a Master of Business Administration from Stanford University.

William Harris

Dr. Harris is the President and Chief Executive Officer of Science Foundation Arizona (SFAz). Prior to joining SFAz, Dr. William C. 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 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 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.

Sridhar Kota

Dr. Sridhar Kota is a Professor of Mechanical Engineering at the University of Michigan-Ann Arbor where he has been involved in teaching and research in Design and Manufacturing area for 23 years. He is currently on leave from the U of M serving as the Assistant Director for Advanced Manufacturing at the White House Office of Science and Technology Policy. He has authored over 200 technical papers, holds 25 patents and served as an engineering consultant to numerous organizations in manufacturing, automotive, aerospace and MEMS fields. He is the recipient of the ASME Machine Design Award and the ASME Leonardo Da Vinci award. He is the founding President and CEO of FlexSys Inc.—a small business engaged in bio-inspired design of aircraft wings, wind turbine blades and automotive systems. Kota's research was featured in New York Times, Discovery Channel, Science News, Aviation Week, Popular Science, and other popular press.

In his current role at OSTP, Dr. Kota coordinates Federal advanced manufacturing R&D across agencies and addresses issues related to R&D funding gaps, manufacturing competitiveness, technology development and commercialization.

Ray Leach

Ray Leach is the founding CEO of JumpStart Inc. and under his leadership, the Cleveland-based organization has gained national recognition for its innovative model and economic impact in Northeast Ohio, leading to its recent launch of the JumpStart America Initiative in January 2011. One of the first implementation partners of the Startup America Partnership, Ray is leading JumpStart America's effort to build public, private, and philanthropic partnerships across the country to develop and grow entrepreneurial ecosystems and transform regional economies. Ray began his career at IBM before founding and bootstrapping two startup companies. Both were sold to Multigraphics Inc. in 1997, after which Ray became Vice President of Sales. In 2000, he founded Capella Investments, Inc., an investment and management consulting firm focused on startup IT companies. Prior to JumpStart, Ray taught at the MIT

Sloan School of Management while earning his MBA as a Sloan Fellow. He also served as an Entrepreneur-in-Residence for CommonAngels, Boston's largest angel investor organization. Ray is a member of the U.S. Commerce Department's National Advisory Council on Innovation and Entrepreneurship (NACIE), which supports the national innovation strategy by developing policies that foster entrepreneurship. He also serves on the board of the National Venture Capital Association (NVCA) which has over 400 members and serves as the voice of the United States venture capital community and advocates for policies that encourage innovation and reward long-term investment. Ray also earned a BA in Finance from the University of Akron.

Lester Lefton

Dr. Lester A. Lefton became Kent State University's 11th president in July 2006. As Kent State president and chief executive officer, Dr. Lefton oversees one of the nation's largest university systems. Kent State's eight campuses provide more than 280 academic programs to nearly 42,000 undergraduate and graduate students from throughout Ohio and the nation, and from more than 100 countries. One of the largest employers in Northeast Ohio, the university employs more than 5,000 full- and part-time faculty and staff.

Prior to coming to Kent State, Dr. Lefton was senior vice president for academic affairs and provost at Tulane University, dean of George Washington University's College of Arts and Sciences, and dean of the University of South Carolina's College of Liberal Arts.

Dr. Lefton is respected internationally for his scholarship in the field of experimental psychology. An authority on visual attention and memory, his research has been supported with numerous federal grants and has been published widely in scholarly journals. He was elected a fellow of the American Psychological Association, an honor that recognizes his impact on the field of psychology.

Dr. Lefton has been active in a number of national higher education organizations. He is known nationally as a passionate advocate for undergraduate education. An award-winning teacher with nearly 40 years of university teaching experience, Dr. Lefton's introductory psychology textbook, now in its ninth edition, is used in college classrooms nationwide.

In keeping with Kent State's strong support of regional and state economic development, Dr. Lefton is active on the boards and executive committees of NorTech and the Greater Akron Chamber. A member of Leadership Cleveland's Class of 2008, Dr. Lefton also upholds the university's role as a regional cultural resource through service on the board of the Musical Arts Association of the Cleveland Orchestra.

At the national level, Dr. Lefton serves on the American Council on Education's (ACE) Commission on Effective Leadership. The commission advises the ACE's Center for Effective Leadership, which provides a variety of

leadership and professional-development programs for presidents and other higher education administrators.

A Boston native, Dr. Lefton earned a bachelor's degree in psychology from Northeastern University (1969). He holds a Ph.D. in experimental psychology from the University of Rochester (1974), where he held a U.S. Public Health Service Predoctoral Fellowship.

At the start of his presidency, Dr. Lefton instituted an approach to all university operations that is founded on the pursuit of excellence. He initiated an excellence-driven, university-wide strategic plan (dubbed the Excellence Agenda) to lead Kent State into its next decade. Now nearly five years old, this approach and investment in excellence have yielded accomplishments, contributions and recognition of unprecedented size, scope and real-world relevance. In the last five years, Kent State has set records in student enrollment and student academic quality; created a new vice presidency for Diversity, Equity and Inclusion; provided students on all eight campuses with 21st-century facilities, including the Robert S. Morrison Health and Science Building at Kent State University at Ashtabula, the Performing Arts Center at Kent State University at Tuscarawas and a rejuvenated Kent Campus library and surrounding Risman Plaza; fostered a new era of cooperation with the city of Kent, including collaboration on a project to build a downtown hotel and conference center; entered into a number of mutually beneficial agreements with leading international universities; begun modernizing the curriculum and streamlining the path to graduation for undergraduates; celebrated its centennial year; launched a $250 million fund-raising campaign that to date has raised more than $225 million, including more than $35 million for student scholarships; saw the May 4, 1970, site added to the National Register of Historic Places and launched plans for a May 4 Visitors Center; created a College of Public Health that offers baccalaureate, master's and doctoral degrees to help meet a state and national need for highly trained public-health professionals; set records for federal funding of faculty research; and earned international recognition with its inclusion in The Times Higher Education Rankings list of the world's top 200 universities.

The president and his wife, Linda J. Lefton, have two daughters and three grandsons. Mrs. Lefton's strong support of Kent State takes the form of volunteer work on a variety of university events and activities. She is an attorney who served as a state prosecutor in South Carolina and was an academic advisor for pre-law majors at George Washington and Tulane universities. A graduate of Leadership Portage County, she served on the board of the Pediatric Palliative Care Center at Akron Children's Hospital and on the Women's Committee of the Cleveland Orchestra.

James Leftwich

James Leftwich is the newly appointed director of the Ohio Department of Development. Prior to his current position, he was president and CEO of the

Dayton Development Coalition, the Dayton Region's economic development organization and principal public advocate. Mr. Leftwich was instrumental in securing a successful outcome for the Dayton Region in the 2005 Base Closure and Realignment (BRAC) proceedings which saw the region gain and retain nearly 10000 jobs.

After graduating from the Air Force Academy in 1987, Mr. Leftwich entered the Air Force where he served over 8 years as a logistics officer. He had various assignments and concluded his career as a staff officer at the Pentagon. In 1995 he left the Air Force and joined Synergy Corporation where he served in various roles including program management and business development. In 1999, Jim joined the Rand Corporation as a research analyst where he formulated, conducted and directed research to evaluate new logistics concepts, procedures, and systems needed to support military forces in force projection scenarios. He lead several efforts including the evaluation of organizational structure changes and policies for logistics command and control that today are serving as a guide for logistics command and control transformation.

In 2003 he left Rand and returned to the defense industry where he served as the Director of Logistics Business Development for the GRACAR Corporation. While there, he developed, directed and executed strategic planning and business development activities for Logistics, Commercial, and Enterprise Solution business divisions. He was instrumental in leading growth of company from $6.1M to $12.8M over two years. In 2004, the company was recognized by Inc magazine as number 373 of the fastest growing 500 companies in the country. He remained at GRACAR until 2005 when he assumed his position at the Dayton Development Coalition.

Mr. Leftwich has a B.S. in Political Science from United States Air Force Academy and a Master of Public Administration from University of Dayton. He has also completed Business Graduate Studies at Old Dominion University. Additionally, he completed the Secretary of Defense Executive Leadership Development Program in 1995. Jim has authored several publications and refereed articles in the areas of logistics, command and control and supply chain management. Jim resides in Bellbrook, Oh, with his wife Lynne and their two children, Halie and Drew.

Gary Leidich

Gary R. Leidich is executive vice president for FirstEnergy Corp., currently providing executive oversight for the Allegheny Energy merger integration.

Gary began his career with The Cleveland Electric Illuminating Company (CEI) in 1974 and held various positions during construction of the Perry Nuclear Power Plant from 1975 to 1986. Gary was named director of System Planning for Centerior Energy, the parent company of CEI and Toledo Edison in 1987, and director of Human Resources in 1991. He was elected vice president of Finance and Administration and chief financial officer in 1993, and

president of the Power Generation Group in 1995, a position he held until the 1997 merger of Centerior Energy and Ohio Edison that formed FirstEnergy Corp. In 1998 Gary became executive vice president of the Institute of Nuclear Power Operations. He rejoined FirstEnergy in 2002 and was named president and chief nuclear officer of FirstEnergy Nuclear Operating Company in 2003. In 2007 he was named senior vice president of Operations. In 2008 he was named executive vice president and president, FirstEnergy Generation. He was named to his current position in February 2011.

Gary received his Bachelor of Science Degree in electrical engineering and Master of Science Degree in engineering science from the University of Toledo. He received a Distinguished Alumni award from the University's College of Engineering in 2007. He completed the Public Utilities Executive Program at the University of Michigan in 1988, and was an instructor for the Reactor Technology Program at the Massachusetts Institute of Technology.

Gary is on the Board of Directors of the Electric Power Research Institute and is also a member of the American Nuclear Society, Institute of Electrical and Electronic Engineers, and a Registered Professional Engineer in Ohio. He is a trustee of the Akron Art Museum.

David Morgenthaler

David Morgenthaler founded Morgenthaler Ventures in 1968 and over 31 years has built a national reputation in venture capital. His current investment focus is on biotechnology. He is Chairman of the Board of Ribozyme Pharmaceuticals, Inc., and has been a director of a large number of companies, ranging in size from the startup stage to large public companies. Between 1957 and 1968, he was President of Foseco, Inc., a venture-backed manufacturer of specialty chemicals. From 1950 to 1957, he was Vice President and Director of Sales at Delavan Manufacturing Company, which became the largest manufacturer of jet aircraft fuel injection nozzles in the world. Previously, he was an entrepreneurial manager with several growth companies. He was an Advisor to the Brentwood Associates Fund, and Vice Chairman of the Edison Biotechnology Institute. He is serving or has served as a Trustee of The Cleveland Clinic Foundation, a member of the Visiting Committee of Carnegie Mellon University, the Sloan School of Massachusetts Institute of Technology, and the Weatherhead School of Business at Case Western Reserve University, and a trustee of various philanthropic organizations. He served as Senior Vice President-International for the Young Presidents' Organization and as President of the Chief Executives Organization. Mr. Morganthaler was President of the National Venture Capital Association when the capital gains tax reduction was enacted in 1978, and played a leading role in testifying before Congress for the new legislation. He has frequently been asked to testify before Congress, and to speak before various administrative groups on venture capital and economic development. He is the first recipient of the National Venture Capital

Association's Lifetime Achievement Award, and more recently was inducted into The Private Equity Analysts Venture Capital Hall of Fame. He is a graduate of Massachusetts Institute of Technology (B.S. and M.S. in Mechanical Engineering).

Richard Pogue

Richard W. ("Dick") Pogue is Advisor (i.e., full-time independent consultant) at Jones Day in Cleveland, Ohio. A graduate of Cornell University (1950) and the University of Michigan Law School (1953), he served three years (1954-1957) in the Patents Division, Office of The Judge Advocate General, United States Army, in the Pentagon, and left with the rank of Captain. He holds Honorary Doctorate degrees from the University of Akron and the Cleveland Institute of Music. In 1972 he served for six weeks in the White House as a consultant on antitrust policy.

Mr. Pogue joined the law firm Jones, Day, Cockley & Reavis in Cleveland as an Associate in 1957, and became a Partner in 1961. Over the years his primary fields of practice were antitrust, corporate takeover work, and commercial arbitration/mediation. On 3/1/84, he became Managing Partner of the firm, by then known as Jones, Day, Reavis & Pogue. During his nine years (1984-1992) in that position, the Firm grew from 335 to 1,225 lawyers and from five domestic to 20 worldwide offices, and became the second largest U.S. law firm. Today Jones Day has over 2,500 lawyers in 36 offices around the world.

In 1994, Mr. Pogue retired from Jones Day and became Senior Advisor to (and a Director and major shareholder of) Dix & Eaton, a Cleveland-based regional public relations firm. Then on 1/1/04, he returned to Jones Day in his present capacity, where he assists the Firm's Managing Partner (Stephen J. Brogan) and its Cleveland Office Partner-in-Charge (Lyle G. Ganske) and others in client development, special projects, and civic engagement.

Over the years Mr. Pogue served as a Director of various companies, including Continental Airlines, Derlan Industries (Canada), M.A. Hanna Co., IT Group, KeyCorp, Ohio Bell Telephone Co., Redland PLC (England), and TRW. Today he is a Director of Rotek Incorporated, and a member of the Advisory Committee of SS&G Financial Services.

Mr. Pogue has chaired many major organizations in the civic arena in Cleveland and Northeast Ohio (including The Cleveland Foundation, Business Volunteers Unlimited, University Hospitals Health System, the Greater Cleveland Growth Association ("GCGA"), The City Club of Cleveland, the Presidents' Council Foundation, The 50 Club, Kulas Foundation, the Greater Cleveland Chapter of the American Red Cross, and the successful $52 million United Way Campaign in 1989). He was the principal organizer in 1997 of the Regional Business Council, the predecessor of Team NEO, a Regional marketing group serving the 16-county Northeast Ohio Region. He presently co-chairs the $30 million Gordon Square Arts District project, and chairs the Advisory Committee for the (Ralph) Regula Institute at Mount Union College

and the Greater Cleveland project to honor the late Ohio Chief Justice Tom Moyer at Ohio State University.

He has been active in the field of Higher Education. A former Trustee of Case Western Reserve University, he is currently Vice Chairman of the Board of the University of Akron, and a Trustee of both the Cleveland Institute of Music (where he recently co-chaired a successful $40 million Capital Campaign) and the Northeast Ohio Council on Higher Education (of which he served as Interim Executive Director in 2001). In 1993-94 he designed and taught a course as Visiting Professor at the University of Michigan Law School entitled "The Business of Law." In 2003-04, he chaired the (Ohio) Governor's Commission on Higher Education & the Economy ("CHEE"), a 33- member group of business leaders, college presidents, and State government officials, which publicly reported on 4/29/04 a number of major recommendations relating to Higher Education's role in the State's economic development. This led to his 2005-06 activity in helping the Ohio Business Roundtable to organize the (Ohio) Business Alliance on Higher Education & the Economy ("BAHEE"), a group of active and retired CEOs, to carry on some of the work of CHEE. Since 2007 he has served as the (first) chair of the Dean's Advisory Council at the University of Michigan Law School. As Jones Day's Managing Partner, Mr. Pogue led the Firm's entry into international practice, beginning 1/1/86; during his stint the Firm opened overseas offices in London, Paris, Riyadh, Geneva, Hong Kong, Brussels, Tokyo, Taipei, and Frankfurt. As Chairman of the GCGA he co-founded the Greater Cleveland International Trade Alliance, which acquired World Trade Center status. For several decades he has been a member of the Council on Foreign Relations.

Active in many aspects of the 1980-1996 "Cleveland Comeback," he was called "the most powerful man in Cleveland" by *Cleveland Magazine* in 1988. Years later, in 2005 *Inside Business Magazine* said of him: "Pogue is this region's consummate insider. There isn't much that goes on in this town, or this region, for that matter, that Pogue hasn't been consulted on, is aware of, or approved of." In that Magazine's 2010 "Power 100" for Northeast Ohio he is one of 18 for-profit company representatives out of the 54 listed from Cuyahoga County. Mr. Pogue and his wife Pat have lived in Shaker Heights, Ohio since 2/1/57. They have three children (Mark—Providence, RI, Tracy—Manhattan, and David—Westport, CT), and eight grandchildren.

Rob Portman

Rob Portman is a United States Senator from the state of Ohio. He was elected in 2010, running a campaign that focused on common-sense conservative ideas to help create jobs and get the deficit under control. Rob won with a margin of 57 to 39 percent, winning 82 of Ohio's 88 counties.

Rob was born and raised in Cincinnati, where he lives today with his wife Jane, and their three children, Jed, Will and Sally. He grew up in a small business family, where he learned early on the value of hard work, leadership,

and fiscal responsibility. When Rob was young, his dad, Bill Portman, borrowed money to start Portman Equipment Company, where Rob and his brother and sister all worked while growing up. His father, and then his brother, built the family business from a small forklift truck dealership with five employees, with Rob's mom as the bookkeeper, to one that employed more than 300 people. Rob became a lawyer and developed his own private practice, representing Portman Equipment Company and other small businesses. In 1993, Rob was a partner in the Cincinnati law firm of Graydon, Head and Ritchey when he was elected to Congress, where he represented the diverse, seven county Second District in southern Ohio. He was proud to serve the Second District for twelve years, and in seven elections, he never received less than seventy percent of the vote.

During his time representing the Second District, Rob earned a reputation as a serious leader who focused on results. Rob was actively involved in crafting and promoting the historic welfare reform efforts as a member of the committee that wrote the legislation, and he was a forceful advocate of the balanced budget that passed in 1997. Rob gained the respect of both Republican and Democratic colleagues through his successful, bipartisan legislative initiatives, including several measures he authored to increase retirement savings, reform the IRS and add over fifty new taxpayer rights, curb unfunded mandates, reduce taxes, and expand drug prevention and land conservation efforts.

In 2005, Rob left Congress when he was asked to serve as the United States Trade Representative, the Cabinet-level official responsible for implementing and enforcing U.S. trade policy. In his one year in the job, Rob was successful in reducing barriers to U.S. exports and increasing enforcement of trade laws to help level the playing field for American farmers, workers and service providers. Under his leadership, American exports increased and the U.S. brought successful legal challenges against international trade law violations.

Following his accomplishments as Trade Representative, Rob was asked to serve in another Cabinet post, this time as Director of the Office of Management and Budget. A deficit hawk, Rob made his mark by proposing a balanced budget, fighting irresponsible earmarks, and putting in place new transparency measures for all federal spending.

Rob succeeded George Voinovich as Ohio's U.S. Senator on January 5, 2011 and immediately began fighting for pro-growth, pro-jobs policies to help get Ohio and our nation back on track.

Luis Proenza

Luis M. Proenza is chief executive officer of The University of Akron. He has led its transformation into a powerful engine for regional economic development, a catalyst for collaborative initiatives, and the preeminent public university in Northeast Ohio. In 12 years of his leadership, UA’s revenue and research portfolio more than doubled, and private donations established all-time

records. His initiatives have distinguished the university nationally and internationally and made it a national model for innovation. In 2001, President George W. Bush appointed Dr. Proenza to serve on the President's Council of Advisors on Science and Technology, the nation's highest-level policy advisory group for science and technology. Dr. Proenza also is a member of the executive committee for the Council on Competitiveness and its Manufacturing Competitiveness Steering Committee, the Government-University-Industry Research Roundtable of the National Academies, the Technology Innovation Program Advisory Board for the National Institute of Standards and Technology, and the Council on Foreign Relations. He holds a bachelor's degree from Emory University (1965), a master's from The Ohio State University (1966) and a doctorate from the University of Minnesota (1971).

Ronn Richard

Ronn Richard is the president & CEO of The Cleveland Foundation. Over the past 28 years, Mr. Richard has held a variety of key management positions in government, the private sector and the nonprofit sector. In addition to his responsibilities at the Foundation, in January 2009, Mr. Richard had been appointed by Governor Strickland to the volunteer, temporary post of Infrastructure Czar to oversee the expenditure of the federal stimulus funds for Ohio.

Prior to joining the Foundation, Mr. Richard was the managing director and chief operating officer of In-Q-Tel, the CIA's venture capital fund. In this role, he worked to ensure the prompt and effective delivery of new technologies into the U.S. intelligence community.

Before joining In-Q-Tel, Mr. Richard spent 13 years at Panasonic in senior management positions. Among other assignments, he served as president of Panasonic's North American R&D operations; president of Panasonic Home & Commercial Products Company, a major sales and marketing division of Panasonic USA; president of Panasonic Strategic Ventures Company, in charge of mergers and acquisitions and strategic alliances; vice president for planning, technology and public affairs, which included heading up Panasonic's corporate philanthropy; and vice president for internet business development.

Early in his career, Mr. Richard was a U.S. diplomat serving at the American Consulate General in Osaka/Kobe, Japan and at the U.S. Department of State in Washington, DC, as a desk officer for North Korean, Greek and Turkish affairs, respectively. He also served in San Francisco as a Pearson Program Fellow where he researched and reported on U.S.-East Asian and U.S.-Latin American trade, investment flows and technology transfers.

Mr. Richard began his career at the nonprofit Japan Society in New York City as director of the national public affairs program.

Mr. Richard served for many years on the board of trustees of Spelman College and on the board of advisors of the Landegger Program in International Business Diplomacy at the Georgetown University School of Foreign Service.

He was a visiting professor for international business at Bennett College in North Carolina during the spring 2003 semester. For many years he served as chairman and then as a member of the board of trustees of the International Biomedical Research Alliance (an academic joint venture between NIH-Oxford and Cambridge Universities).

He currently serves on the boards of Council on Foundations, Living Cities, Ohio Grantmakers Forum, Rainbow Babies & Children's Hospital National Leadership Council, and the Finca Vigía Foundation (dedicated to preserving Ernest Hemingway's home in Cuba). Mr. Richard chairs the Ohio Grantmakers Forum's Task Force on educational reform for the State of Ohio, and he also serves on a corporate board in the biotech sector.

Mr. Richard holds a master's degree in international relations from the Johns Hopkins University School of Advanced International Studies, a bachelor's degree in history from Washington University in St. Louis, and honorary doctorates from Notre Dame College and Baldwin-Wallace College. He is a recipient of the African-American President's Council Champion Award for his work in the area of inclusive economic development, and in 2007 he received Wheaton College's Otis Award for Social Justice (previous recipients include Senator Edward Kennedy, Gloria Steinem and Marian Wright Edelman). Mr. Richard was inducted into Hiram College's Garfield Society (the college's highest honor) and was the recipient of the Entrepreneurs for Sustainability's 2007 Champion of Sustainability award.

Barry Rosenbaum

Barry Rosenbaum obtained his PhD in chemical engineering from Northwestern University in 1967. Upon graduation, he joined Exxon Chemical Elastomers Division where he held a number of senior technical and business positions in the specialty polymers industry during a thirty-year career.

In 1991, Dr. Rosenbaum helped to found Advanced Elastomer Systems, a joint venture between Exxon and Monsanto in Santoprene ThermoPlastic Elastomers and was the vice president of technology until 1997. Dr. Rosenbaum became the chief technology officer of GenCorp/OMNOVA Solutions from 1997 until his retirement in 2005 when he became a senior fellow with the University of Akron Research Foundation.

In his new role, Dr. Rosenbaum works closely with The Research Foundation and the Office of Tech Transfer to help commercialize new technologies from the University of Akron in addition to networking across northeast Ohio to promote Innovation: Transforming Knowledge into Wealth. In late 2005, he was a founding member of the Akron based ARCHAngel Investment Network sponsored by the University of Akron to focus on wealth creation in northeast Ohio.

Baiju Shah

Baiju R. Shah is President and CEO and a Founder of BioEnterprise, a partnership of Case Western, Cleveland Clinic, Summa Health, and University Hospitals. BioEnterprise is a business acceleration initiative to support the growth of bioscience companies. Since 2002, it has helped more than 100 Cleveland companies that have collectively attracted more than $1 Billion in new funding. Prior to BioEnterprise, Shah was with McKinsey & Company, where he played a leading role in the Growth and Business Building practice. In the community, Shah is a Founder and has served as Chair of Global Cleveland, TiE (The International Entrepreneurs) Ohio, and Summer on the Cuyahoga. He also serves on the Boards of Great Lakes Science Center, Saint Luke's Foundation, Cleveland International Fund, United Way of Greater Cleveland, and Sustainable Cleveland 2019. Shah has been named an Ernst & Young Entrepreneur of the Year and has been recognized as one of Cleveland's most powerful and influential leaders by several publications. Shah, a Cleveland native, received a J.D. from Harvard and his B.A. from Yale.

Phillip Singerman

Phillip Singerman serves as Associate Director for Innovation and Industry Services at the National Institute of Standards and Technology (NIST). In this capacity he is responsible for the NIST suite of external partnership programs, including the Hollings Manufacturing Extension Partnership, the Technology Innovation Program, the Baldrige Performance Excellence Program, and NIST technology transfer and small business innovation research awards.

The position of Associate Director was established in October 2010 as part of the first major realignment of NIST programs in 20 years; Mr. Singerman was appointed to this position in January 2011. Immediately prior to joining NIST, he was a Senior Vice President at B&D Consulting, a DC-based firm providing strategic advice and technical assistance on federal economic development programs to non-profit organizations, local governments, and universities. Previously he was a managing director of a $120 million seed stage venture fund that invested in early stage technologies.

Mr. Singerman has more than 30 years of experience in tech based economic development; he was the first chief executive of two of the best known public-private partnerships, the Ben Franklin Technology Center of Southeastern Pennsylvania and the Maryland Technology Development Corporation. During the Clinton Administration he served as U.S. Assistant Secretary of Commerce for Economic Development, a Presidential appointment requiring Senate confirmation.

Mr. Singerman has participated on scores of local, state, and national advisory boards and associations, including the State Science and Technology Institute, the Technology Council of Maryland, the International Economic

Development Council, NGA's Advisory Committee on Entrepreneurial Policy, NSF's Small Business Advisory Committee, the Pennsylvania Biotechnology Association, the Strengthening America's Communities Initiative Advisory Committee, and the Editorial Board of the Economic Development Quarterly.

Mr. Singerman received his bachelors degree from Oberlin College and holds a doctorate from Yale University. He has taught at Yale College, Barnard College (Columbia University), and the Fels Institute of Government (University of Pennsylvania). After graduating from college he served as a Peace Corps Volunteer in Colombia, South America, working in rural community development projects.

Mr. Singerman is a co-author of "Beyond Recovery: Moving the Gulf Coast Toward a Sustainable Future" (February 2011), published by the Center for American Progress and Oxfam America, and the "Handbook on Climate Prosperity" (May 2009), published by the International Economic Development Council.

Richard A. Stoff

Richard Stoff is the founding president of the Ohio Business Roundtable, a nonpartisan organization of the chief executive officers of the state's major business enterprises.

In his capacity as Roundtable president, Mr. Stoff provides leadership and support to a number of education-related organizations. He was instrumental in the creation of Ohio's BEST, which is regarded as one of the nation's broadest, deepest and most effective business-education coalitions. He serves as the treasurer of BEST and he co-chairs the Coalition's acclaimed BEST Practices initiative. Mr. Stoff has been especially active in workforce issues, spearheading the Ohio Skill Gap Initiative. He was appointed by Governor Voinovich to the Ohio Workforce Development Board, serves on the national board of directors for Jobs for America's Graduates and is vice-chair of its resource development committee. He is helping to create a world-class Ohio Principal's Leadership Academy and he has helped to start the Ohio Community Schools Center. He works closely with Achieve, the National Alliance of Business, The Business Roundtable and other national groups on a range of education reform issues.

Prior to his appointment as president of the Roundtable, Mr. Stoff spent 16 years as a management consultant. A former partner with Ernst & Young, Mr. Stoff directed the firm's services to state and local government in Ohio. His core competency is organizational change and he has assisted clients in improving quality, productivity, systems and cost management. He has specialized experience in conducting financial feasibility studies for stadiums and arenas. Prior to joining Ernst & Young, Mr. Stoff served as a senior consultant with Touche Ross (now Deloitte & Touche); working with a wide range of clients in manufacturing, real estate, banking, retailing, health care and government. He began his public service career as a budget analyst with the Fairfax County, Virginia Bureau of the Budget and the Ohio Office of Budget and Management.

A native of New York City, Mr. Stoff received his bachelor's degree in political science, with honor, in 1972 from Northeastern University and his master's degree in public affairs in 1975 from Syracuse University's Maxwell Graduate School of Citizenship and Public Affairs.

Bahman Taheri

Bahman Taheri is the CEO and a founder of AlphaMicron Inc. He also holds an adjunct faculty position at the Liquid Crystal Institute. Bahman received his B.S from Cal Poly in San Luis Obispo, and M.S. and Ph.D. in laser Physics from Oklahoma State and is a graduate of the OPM program at Harvard Business School. He has published in the areas of liquid crystals, lasers, optics and condensed matter and hold international patents in a number of device and processing areas. Bahman was the finalist in Ernst and Young's Entrepreneur of the year and one of Crain Business "40 under 40".

Lorry Wagner

Dr. Lorry Wagner, an experienced energy engineer and longstanding member of the Great Lakes Energy Development Task Force became President of the Lake Erie Energy Development Corporation (LEEDCo) in May 2010. Previous energy project experience includes hydroelectric, nuclear, as well as wind. Other relevant work was performed in the fields of adaptive learning, failure analysis, and explosion-proof control systems.

A nuclear engineer with several degrees from Purdue University, Dr. Wagner previously served as president of Azure Energy LLC, a renewable energy development corporation based in Solon, Ohio. At Azure, he played a leading role in the development and installation of several land based wind projects. Dr. Wagner, a lifelong boater and member of Cleveland Underwater Explorers (CLUE), brings extensive knowledge of maritime and subsurface issues, central to the deployment of offshore wind turbines.

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 U. S. 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 National Academy studies centered on government measures to encourage entrepreneurship and support the development of new technologies and cooperation among industry, universities, laboratories, and government to capitalize on the nation's investments 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 $2.5 billion award program for small companies and start-ups. He is also directing a major study on best practice in global innovation programs, entitled Comparative Innovation Policy: Best Practice for the 21st Century. Today's meeting on "Building the Ohio Innovation Economy" 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.

John West

John L. West, professor of chemistry, joined Kent State University in 1984 as a senior research fellow of the Liquid Crystal Institute. He served as Director of the Liquid Crystal Institute and of the National Science Foundation Science and Technology Center, ALCOM from 1996-2002. He served as Vice President for Research and Dean of Graduate Studies at Kent State from 2003-2010. During this time he collaborated with Nortech to establish FLEXMatters, a collaboration designed to support the growth of the flexible electronics industry in Ohio. In the summer of 2010 he returned to full time to the faculty at Kent State. He now splits his time between Kent State University and the University of Central Washington, where he is establishing a research foundation and helping to move innovation from the laboratory to the marketplace.

In parallel with his administrative duties, Dr. West maintains an active and productive research program. He has published over 125 articles and holds thirteen U.S. patents related to liquid crystal materials. He concentrates his research on the development of PDLC and cholesteric materials for use in flexible displays and of responsive liquid crystal fibers.

Dr. West earned a B.S. in chemistry from the College of William and Mary, and M.S and a Ph.D. in chemistry from Carnegie Mellon University.

David Wilhelm

David Wilhelm is the president of Woodland Ventures, a company dedicated to the proposition that entrepreneurial vision and managerial talent may be found anywhere, including the hills of central Appalachia and the prairies of the Midwest. To this end, Wilhelm launched Adena Ventures and Hopewell Ventures, with a combined $140 million under management, bringing investment capital to high growth companies situated in these underserved regions of the country. Today, these venture capital funds have invested millions of dollars in companies located in communities such as Marquette, Michigan; Nelsonville, Ohio; Charleston, West Virginia; and Lansing, Illinois, creating hundreds of jobs for the people who live there and the prospect of strong returns for the investors that backed the basic Woodland premise: the flip side of a capital gap is a market opportunity!

Earlier in his career, Wilhelm led a number of enterprises that could easily be categorized as the ultimate start-ups: political campaigns. He was the national manager of the 1992 presidential campaign of William Jefferson Clinton and has served in similar capacities for Mayor Richard M. Daley, Senator Joseph R. Biden, and the late Senator Paul Simon. Following the election of President Clinton in 1992, Wilhelm was named chair of the Democratic National Committee, becoming the youngest person ever to serve in that role in American history.

Wilhelm is the recipient of a master of public policy degree from Harvard University and a Bachelor of Arts degree from Ohio University. He has been awarded honorary doctorates by Ohio University and the University of Charleston, he has taught classes at the University of Chicago and DePaul University, and he has been a fellow at Harvard University's Institute of Politics and Ohio University's Voinovich Center for Leadership and Public Affairs.

Appendix C

Participants List

(speakers in italics)

Martin Abraham
YSU, College of STEM

Karen Allport
NorTech

Dianne Anderson
Case Western Reserve University

Ziona Austrian
Cleveland State University

W. A. Bud Baeslack III
Case Western Reserve University

Rebecca O. Bagley
NorTech

Dave Baldwin
Aquarian Technology Systems

Marcia Ballinger
Lorain County Community College

Reka Barabas
TiE Ohio

Anna Barker
National Cancer Institute, ret.

Christopher Bauer
BEng

Dorothy Baunach
NorTech

Gina Beim
MCDA Consulting, LLC

David Bell
Case Western Reserve University

Richard Bendis
Innovation America

Dan Berglund
State Science and Technology Institute (SSTI)

Daniel Berry
MAGNET

Phillip Bessler
Baldwin-Wallace College

Nathaniel Blasdel
The University of Akron

Terrie Bonfiglio
Energy Rethink

Lavea Brachman
Greatert Ohio Policy Center

Patrick Bravo
County of Summit

Paul Brentlinger
Retired Partner, Morgenthaler

Rob Briggs
GAR Foundation

Glenn Brown
The Generation Foundation

Jenny Brown
OneCommunity

Pat Brown
E-JET, Inc

Olivia Bulls
NorTech

Jill Bumbu
jb assoc

Jonathan Burbaum
ARPA-e

Eric Burklund
Ohio Manufacturing Association

Miko Cakmak
The University of Akron

Jamie Callender
Kent State University

Heidi Callender
Lake Publishing, Inc

Steve Caminati
Melamed Communications, LLC

Lisa Camp
Case Western Reserve University

Truc Cao
Greater Cleveland Partnership

James Carulas
Meaden & Moore LLP

Robert Chalfant
The University of Akron

Diane Chelsea
BioSciEssence, LLC

Diana Christopherson
DCD International, Inc.

Roy Church
Lorain County Community College

Mary Cierebiej
Team Lorain County

David Ciocca
FirstMerit Bank

McAlister Clabaugh
National Academy of Sciences

Kelley Clarett
LEAP

Byron Clayton
NorTech

Peggy Claytor
The Timken Company

Bob Cohen
Braintree Business Development Center

Daniel Colantone
Greater Akron Chamber

Delos "Toby" Cosgrove
Cleveland Clinic

Michael Cremeans
Neace Lukens

Jim Crowcroft
TCP, Inc.

Charles Daane
Pilot Hill Capital

Jeff Dafler
The Timken Company

Shawn DaVis
The Greater Cleveland Partnership

Brian Davis
Austen BioInnovation Institute in Akron

David Dawson
The National Academies

Jorge De
Case Western Reserve University

John Dearborn
JumpStart Inc.

Lisa Delp
Ohio Department of Development

Tony Dennis
BioOhio

Ross DeVol
Milken Institute

Neil Dick
DickGroup Consultants

Dennis Diemer
Dennis J. Diemer, Attorney-at-Law

Emily Dierig
NorTech

Susan Dollinger
The University of Akron

Frank Douglas
Austen BioInnovation Institute in Akron

Mark Dzurec
CGI Federal Inc.

Jennifer Eaton
Summa Health System

Roger Emerson
Emerson Thomson Bennett

Steve Fening
Austen BioInnovation Institute in Akron

John Fernandez
Economic Development Administration

Charles Fey
The University of Akron

Joel Fox
Great Lakes Science Center

Jon Gallagher
CCBDD

Lydia Gao
CWRU

Nick Gattozzi
Greater Cleveland Partnership

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Global Vision Corp.

Mary Good
University of Arkansas at Little Rock

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David J. Gornik, Esq.

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Lorain County Community College

Albert Green
Kent Displays

John Green
The University of Akron

Jeff Greene
Greene Advisory Services, LLC

James Griffith
Timken Company

Glenn Harbold
Takoda Capital Partners

George Haritos
The University of Akron

William Harris
Science Foundation Arizona

Iris Harvey
Kent State University

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Jet Industries,LLC.

Connie Hawke
Kent State University

Raymond Headen
Bricker & Eckler LLP

Kevin Heigel
ALPHA Performance Group

Steve Hendricks
FirstMerit Bank

Joe Hensel
Polyflow

Stephen Hils
Fisher College, OSU

Sandra Hodge
Oberlin College

Deborah Hoover
The Burton D. Morgan Foundation

Walter E. Horton
Northeastern Ohio Universities Colleges of Medicine and Pharmacy

Michael Hynds
Metropolitan Architecture Studio

Marc Imbrogno
Premix, Inc.

Joseph Jankowski
Case Western Reserve University

Janine Janosky
Austen BioInnovation Institute in Akron

Molly Johnson
Fund for Our Economic Future

Dan Kalynchuk
Orbital Research Inc.

Peter Kasvinsky
Youngstown State University

Maureen Katanic
The University of Akron

Vincent Kazmer
EndoRetics

Shilpa Kedar
The Cleveland Foundation

Daniel Kellogg
Crystal Ventures

Asad Khan
Kent Displays, Inc.

Grif King
Dollar Bank

Lynn Koster
Meaden & Moore

Sridhar Kota
Office of Science and Technology Policy, White House

Harry Lader
microBites- Excel Training and Consulting

Dennis Lafferty
CSU

John LaGuardia
The University of Akron

Beth Lawson
NorTech

Bob Leach
Braintree Business Development Center

Ray Leach
JumpStart

Lester Lefton
Kent State University

James Leftwich
Ohio Department of Development

Gary Leidich
FirstEnergy

Iryna Lendel
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Heavenly Bound Inc.

Ajay Mahajan
The University of Akron

Donald Majcher
Ohio Aerospace Institute

Ted Mallo
The University of Akron

Jeffrey R. Marshall
Independent

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JCU

Chris Mather
Lorain County Community College

Neema Mayhugh
Cleveland Clinic

Grant McGimpsey
Kent State University

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QualiSci

Alan Melamed
Melamed Communications

Bob Miller
The Generation Foundation

Patricia Mintz
Cuyahoga Community College

Dean Mocko
DEM Enterprises

Tim Moerland
Kent State University

Chelsea Monty
The University of Akron

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Team Lorain County

David Morgenthaler
Morgenthaler Ventures

Polly Moss
The University of Akron

John Motley
PPG Industries Inc

John Myers
The University of Akron Research Foundation

Terry Nauck
True North Business Advisors

Leslie Nelson
The Burton D. Morgan Foundation

George Newkome
The University of Akron

Ian Nickey
ToChi Technologies

Frank Nisenboum
Socius

Diane Palmintera
Innovation Associates

Jill Paulsen
Cuyahoga Arts & Culture

Michael Paxton
Summa Health System

Ellen Perduyn
The University of Akron

Richard Pogue
Jones Day

Rob Portman
United States Senate

William Powel III
Summa Health System

Marsha Powers
Powers Financial group of Companies

Ken Preston
The University of Akron

Luis Proenza
The University of Akron

Richard Proeschel
Proe Power Systems, LLC

Peter Ranney
Generation Foundation

Laura Rayburn
Great Lakes Science Center

Tita Reed
City of Oberlin

Frank Ricard
FirstPower Group LLC

Joseph Rich
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Ronn Richard
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Edward Richards
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Barry Rosenbaum
The University of Akron Research Foundation

Mark Roshon
Tornado Technologies

Scot Rourke
OneCommunity

Mark Sabau
ALPHA Performance Group LLC

David Salay
Ohio Aerospace Institute

Frank Samuel
Geauga Growth Partnership, Inc.

Jay Schabel
Polyflow

Al Schiazza
Engineering

Chris Schmid
NorTech

Robert Schmidt
Cleveland Medical Devices Inc.

John Schober
MAGNET

Sonni Senkfor
Gates Pike Consulting

Baiju Shah
BioEnterprise

Ilene Shapiro
Summa

Helen Sheehan
Melamed Communications

Donzel Shepherd
HCA

Andrew Sherman
Powdermet Inc

Sujai Shivakumar
The National Academies

Erin Siebel
County of Summit

Barbara Sinclair
Consultant

Phillip Singerman
National Institute of Standards and Technology

Mark Slanta
Jet Industries LLC

Nilli Sleibi
Linking Employment, Abilities and Potential

Lea Smith
NorTech

Carol Staiger
VANTAGE POINT Enterprises

Ken Stapleton
Ken Stapleton & Associates

Sam Steinhouse
OneCommunity

Thomas Stimson
The Timken Company

Richard A. Stoff
Ohio Business Roundtable

Eugene Stromberg
Closed Loop

Donald Styblo
Valtronic USA, Inc.

Bahman Taheri
AlphaMicron

Kasey Tamosiunas
ESA Automation Services Inc

Jennifer Thomas
John S. and James L. Knight Foundation

Chris Thompson
Fund for Our Economic Future

William Tomko
TGE Associates, Inc

Ronald Traub
City of Mentor

Thomas Tyrrell
Collaborx

Mary Vanac

Neil Veloso
Cleveland Clinic

Bill VerDuin
Wright Center Sensor Sys Engrg

Lorry Wagner
LEEDCo

Thomas Waltermire
Team NEO

Wayne Watkins
The University of Akron

Sherri Waxman
Proactive Ingenuity (tm)

Charles Wessner
The National Academies

John West
Kent State University

Byron White
Ohio Board of Regents

David Wilhelm
Woodland Venture Management

Gregory Wilson
Kent State University

Harvey Wiseberg
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Laura Woods
RAPRA Limited

Brian Wright
Melamed Communications

Ray Yoder
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of Development

Appendix D

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