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Advisers to the Nation on Science, Engineering, and Medicine

Strengthening American Manufacturing

The Role of the Manufacturing Extension Partnership

Summary of a Symposium

Charles W. Wessner, Rapporteur

Committee on 21st Century Manufacturing:
The Role of the Manufacturing Extension Partnership Program
of the National Institute of Standards and Technology

Board on Science, Technology, and Economic Policy

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Preface

Manufacturing strength is linked closely to the innovative potential and competitiveness of nations. In many sectors, innovative methods and ideas are generated and perfected through the process of making things. In recognition, a recent Report of the President's Council of Advisors on Science and Technology (PCAST) and the President's Innovation and Technology Advisory Committee (PITAC) emphasized the critical importance of advanced manufacturing in driving knowledge production and innovation in the United States.[1] Manufacturing companies play a vital role in the economic growth, high skill employment, and competitiveness of the United States economy. They are responsible for over two-thirds of business and industrial R&D, employing the majority of domestic scientists and engineers. Furthermore, manufacturing R&D is the dominant source of innovative new service-sector technologies that reach beyond the manufacturing arena.[2]

The Manufacturing Extension Partnership (MEP)—a program of the U.S. Department of Commerce's National Institute of Standards and Technology (NIST)—has sought for more than two decades to strengthen American manufacturing. It is a national network of affiliated manufacturing extension centers and field offices located throughout all fifty states and Puerto Rico. Qualified MEP Centers work directly with small and medium manufacturing firms in their state or sub-state region, providing expertise, services and assistance directed to foster growth, improve supply chain positioning, leverage emerging technologies, upgrade manufacturing processes, develop work force training, and apply and implement new information.

Given the importance of innovation to economic growth and competitiveness, MEP today is seeking to evolve beyond its traditional support

[1]President's Council of Advisors on Science and Technology, "Report to the President on Ensuring American Leadership in Advanced Manufacturing," 2011, *<http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcastadvanced-manufacturing-june2011.pdf>*.

[2]The status of U.S. manufacturing is discussed in detail by a new report by the Department of Commerce, written in consultation with the National Economic Council. This report argues that, despite recent declines, manufacturing remains a vital part of the U.S. economy. U.S. Department of Commerce, "The Competitiveness and Innovative Capacity of the United States," Washington, DC, January 2012.

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for lean manufacturing to increase the innovative capacity of the nation's small and medium manufacturers.

THE STEP BOARD'S RESEARCH ON INNOVATION AND COMPETITIVENESS

The National Research Council, under the auspices of its Board on Science, Technology, and Economic Policy (STEP), has since 1991 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 contributed to increased policy recognition of the importance of technology, innovation, and entrepreneurship to economic growth. This work is in many ways congruent with economic growth theory, which emphasizes the role of technology creation in the generation of significant growth externalities.[3] In addition, many economists have recognized the limitations of traditional trade theory, particularly with respect to the reality of imperfect international competition. Public-private partnerships are increasingly recognized for their contributions to the commercialization of state and national investments in research and development. Such partnerships help address the challenges associated with the transition of research into products ready for the marketplace.[4]

One important element of STEP analysis has concerned the growth and impact of foreign technology programs.[5] U.S. competitors have launched substantial programs to support new technologies, small firm development, innovative production at large companies, 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. 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.[6]

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[3]National Research Council, *Enhancing Productivity Growth in the Information Age*, D. W. Jorgenson and C. W. Wessner, eds., Washington, DC: The National Academies Press, 2007.

[4]National Research Council, *Government-Industry Partnerships for the Development of New Technologies: Summary Report*, C. W. Wessner, ed., Washington, DC: The National Academies Press, 2003.

[5]For a review of the challenges and opportunities faced by the United States in the face of unprecedented global competition for developing, commercializing, and manufacturing the next generation of technologies, see National Research Council, *Rising to the Challenge: U.S. Innovation Policy for the Global Economy*, C. W. Wessner and A. Wm. Wolff, eds., Washington, DC: The National Academies Press, 2012.

[6]For a discussion of Chinese initiatives to support national competitiveness, see National Research Council, *Rising the Challenge: U.S. Innovation Policy for the Global Economy*, Ibid, Chapter 5.

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THE MEP STUDY

In 2011, MEP requested the National Academies' Board on Science, Technology, and Economy Policy (STEP) to undertake a review of MEP. As noted below, this study seeks to generate a better understanding of the operation, achievements, and challenges of the Manufacturing Extension Partnership (MEP) program in its mission to support, strengthen, and grow U.S. manufacturing.

Project Statement of Task

An ad hoc committee will carry out an evaluation of the operation, achievements, and challenges of the Manufacturing Extension Partnership (MEP) program at the National Institute of Standards and Technology. The committee will hold a series of fact-finding workshops and commission research papers and case studies to review and document the program's current achievements, challenges, and new opportunities; identify and review similar national programs from abroad in order to draw on foreign practices, funding levels, and accomplishments as a point of reference; and discuss current needs and initiatives in light of the global focus on advanced manufacturing. One workshop summary will be prepared in the course of the study. The committee will develop findings and recommendations to improve program operations and impact for inclusion in the committee's final consensus report.

THIS REPORT

To launch this study of MEP, the STEP Board convened a workshop of business leaders, academic experts, and state and federal officials to review current operations and some of the recent MEP initiatives in the broader context of global manufacturing trends and the opportunities for high-value manufacturing companies. The conference also addressed the metrics and impacts of MEP and identified potential areas of improvement. The meeting drew attention to the scale and focuses of MEP, and highlighted the role it plays in supporting and enabling U.S. manufacturers to compete more effectively in the global marketplace. This volume is a summary of this initial workshop.

This report includes an overview of key issues raised at this workshop and a detailed summary of the conference 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

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the views of all workshop participants, the planning committee, or the National Academies.

To further address the Statement of Task, the Committee has commissioned research, reviewed program data, and visited MEP Centers to document the program's current achievements and challenges. In addition, the Committee has reviewed a number of leading national programs to support applied research and manufacturing in order to learn more about foreign practices, funding levels, and accomplishments. This information will contribute to the Committee's final report. The Committee's goal is to inform a wide array of stakeholders, from federal and state policymakers and NIST and other federal agencies to small and large manufacturers, academic researchers, and others concerned about the manufacturing challenge and the role of MEP.

ACKNOWLEDGMENTS

On behalf of the National Academies, we express our appreciation and recognition for the insights, experiences, and perspectives made available by the participants of this meeting. We are indebted to Alan Anderson for summarizing the proceedings of the meeting. We are also indebted to Dr. Sujai Shivakumar for his important contributions to the quality of the report and the review process. We also wish to acknowledge McAlister Clabaugh and David Dawson for their contributions to the organization of the symposium.

ACKNOWLEDGMENT OF REVIEWERS

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: Yoram Koren, University of Michigan; Diane Palmintera, Innovation Associates; Jan Youtie, Georgia Institute of Technology; and Jose Zayas-Castro, University of South Florida.

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.

Philip Shapira Charles W. Wessner

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I

OVERVIEW

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Overview

The Hollings Manufacturing Extension Partnership (MEP) traces its origins to the establishment of the Manufacturing Technology Centers Program in 1989.[1] This program was developed as a part of the nation's response to the perceived decline in position of the United States vis-à-vis Japan as a leading manufacturer of high-technology goods. Located within the National Institute of Standards and Technology (NIST), MEP has offered technical and business support primarily to the nation's small and medium-sized manufacturers. Two decades later, the rapid rise of China as a global locus of manufacturing is once again raising concerns about U.S. competitiveness.[2] To address these concerns, MEP is seeking to refine and adapt its mission to encourage product innovation and commercial development among the nation's manufacturers. In its own words, it has begun a transition from "reactive" strategies to the "proactive pursuit of increased profits and overall growth."[3]

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[1]Senator "Fritz" Hollings of South Carolina introduced legislation that led to the establishment of the Manufacturing Technology Centers (MTC) Program through the National Institute of Standards and Technology (NIST). This program started in 1989 with regional centers in three states—South Carolina, Ohio, and New York. The mission of these regional centers was to support the transfer of manufacturing technology to improve the productivity and technological capabilities of America's small manufacturers. The number of centers grew rapidly to provide services to all 50 states and Puerto Rico, and, in 1998, the program was re-named the Manufacturing Extension Partnership (MEP). Senator Hollings maintained his support for the MEP Program through his retirement in 2004 when, in his honor, it was re-designated the Hollings Manufacturing Extension Partnership. Source SC-MEP at *<http://www.scmep.org/history/>*.

[2]President's Council of Advisors on Science and Technology, *Report to the President on Ensuring American Leadership in Advanced Manufacturing*, Washington, DC: Executive Office of the President, June 2011, page 1. The PCAST report notes that "The United States was the world's leading producer of manufactured goods from 1895 through 2009; some experts estimate that China surpassed the United States as the leading manufacturing country last year." Access at *<http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcastadvanced-manufacturing-june2011.pdf>*.

[3]Manufacturing Extension Partnership, *The Future of the Hollings Manufacturing Extension Partnership*, Gaithersburg, MD: National Institute of Standards and Technology, December 2008, *<http://www.nist.gov/mep/upload/MEP_NextGenStrategy-2.pdf>*.

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Box A
The Hollings Manufacturing Extension Partnership

The Manufacturing Extension Partnership (MEP), administered by NIST within the Department of Commerce, has sought for more than two decades to strengthen American manufacturing.

Mission. MEP's mission is to "act as a strategic advisor to promote business growth and connect manufacturers to public and private resources essential for increased competitiveness and profitability."

Program Scale. In 2012, the NIST Manufacturing Extension Partnership had a budget of $128 million. The total NIST-MEP headquarters staff numbers some 45 people who focus on setting strategy, evaluating the needs and demands of clients, helping facilitate the development of tools, and "gluing together the Centers into a network that can share best practices." NIST funding is matched 1:2 by individual state Centers, using funding primarily from state governments and client fees. The nationwide network includes some 1,300 staff supported by over 2,300 third-party service providers, and the overall budget for the MEP system was about $300 million in 2012.[a]

Decentralized Structure. NIST-MEP works cooperatively with organizations that include non-profits, state government agencies, and universities to complete the MEP mission. In all, some 60 MEP Centers are located across the country, with Centers in every state. They vary widely in structure and operating strategy. Pennsylvania, for example, has seven Centers; many states have only a single MEP Center. California, which accounted for 13 percent of the nation's manufacturing GDP in 2011, has two MEP Centers serving the state. The work of these Centers is further dispersed among some 300 field offices. The Centers rely heavily on local partners to design and deliver services that are tailored to the needs of the manufacturing clients.[b]

Evolving Focus. According to then MEP Director Roger Kilmer, "Part of our evolution was to change from offering a technology push, where we knew about which technologies work in a federal lab, to looking at what manufacturers really needed. It also meant learning to look at the entire manufacturing enterprise—not just the tech piece of it, but everything else: the financing, workforce development, marketing, and sales." From an early focus on off-the-shelf manufacturing technologies, basic technical assistance, and plant layout, MEP evolved towards "lean production" in response to demand from companies. The program continues to adapt with a new emphasis on growth and on innovation, reflecting the need for firms to be more proactive in an increasingly competitive world economy.

[a]Roger Kilmer, "MEP's Place in the Innovation Chain," presentation at the November 14, 2011, National Academies Symposium.
[b]MEP centers are structured in various ways. "Most MEP centers are not-for-profit (501(c)(3) corporations affiliated with state governments or universities." U.S. Government Accountability

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Office, "NIST Manufacturing Extension Partnership Program Cost Share," GAO-11-437R, Washington, DC: U.S. Government Accountability Office, 2011.

THE NATIONAL ACADEMIES STUDY OF MEP

In his opening remarks at the workshop, Philip Shapira, the chair of the National Academies committee that is overseeing the analysis of MEP program, noted that the study would review and assess the performance of MEP program, including the ways in which states use the program, the diversity of the users, and issues of funding and co-funding. From a user's perspective, he added, the study would also gauge how the program is used by manufacturers and how well it relates to their needs.

Dr. Shapira observed that the Academies study is also an opportunity to shed new light on several "deeper" questions. "Our companies are competing with companies around the world," he said. "MEP is one of the major ways in which we are trying to stimulate our small and medium-sized manufacturers to be productive, to export, and to train productive workers. In this era of global competition, we need to ensure that MEP is configured in such a way that it can meet not only these current challenges, but future challenges as well."

THE IMPORTANCE OF A STRONG U.S. MANUFACTURING INDUSTRY

As MEP Director Roger Kilmer noted at the workshop, MEP's new focus on innovation and competitiveness reflects the importance of manufacturing to the nation's economic growth, job creation, exports, and innovation.[4] Dr. Gregory Tassey of NIST and Dr. Sridhar Kota, then of the White House Office of Science and Technology Policy, also underscored the relevance of a robust manufacturing sector for the United States in their workshop remarks.

A Source of High-quality Jobs

In his presentation, Dr. Tassey noted that "manufacturing contributes $1.6 trillion to GDP, and employs 11 million workers," with many of the

[4]A recent assessment by the Department of Commerce makes the point that a vibrant manufacturing sector is important for the health of the U.S. economy. Further, the report sets out why strong measures are needed at both federal and local levels to support its continuing strength. U.S. Department of Commerce, *The Competitiveness and Innovative Capacity of the United States*, Washington, DC, January 2012. The report states that in 2009, manufacturing made up 11.2 percent of gross domestic product (GDP) [Bureau of Economic Analysis, "Survey of Current Business 2006-2009," Washington, DC: U.S. Department of Commerce, January 2011] and that 9.1 percent of total U.S. employment, 4 directly employing almost 12 million workers [<*http://www.bea.gov/scb/pdf/2011/01January/0111_indy_accts_tables.pdf*>].

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manufacturing jobs providing above average pay and benefits.[5] The manufacturing sector also has powerful indirect employment effects on other sectors of the U.S. economy, supporting millions of additional supply chain jobs across the economy.

An Important Source of R&D

Dr. Tassey noted that manufacturing companies in the United States represent 11 percent of GDP but are responsible for 67 percent of R&D performed by business and industry. Reflecting this, the sector employs 57 percent of the nation's industrial scientists and engineers.[6] "If you remove manufacturing, you have decimated the research infrastructure of the private sector," and while some service industries do a moderate amount of R&D internally, that amount "pales in comparison with the amount done by the manufacturing sector."

Largest Contributor to U.S. Exports

As an economic sector, manufacturing is the largest contributor to U.S. exports.[7] In 2010, the United States exported over $1.1 trillion worth of manufactured goods, accounting for 86 percent of all U.S. goods exports and 60 percent of U.S. total exports. However, as Dr. Tassey pointed out, "we have not had a trade surplus in manufacturing in 35 years." Every year of a deficit, he said, detracts from the economy's GDP, and the projections for GDP growth in the future are "not particularly robust."

Linkages to Innovation

A strong manufacturing sector is also of central economic importance because of its strong linkage to innovation. In his presentation, Dr. Kota highlighted the importance of sustaining an "industrial commons," a term he said that describes the complex and enduring partnerships among manufacturers, universities, technical colleges, firms, research institutes, financing entities, and other links in the supply chain. He drew attention to recent reports by the

[5]"Total hourly compensation in the manufacturing sector is, on average, 22 percent higher than that in the services sector. About 91 percent of factory workers have employer-provided benefits, compared to about 71 percent of workers across all private sector firms." See Executive Office of the President, *A Framework for Revitalizing American Manufacturing*, Washington, DC: Executive Office of the President, 2009, <*http://www.whitehouse.gov/sites/default/files/microsites/20091216-manufacturing-framework.pdf*>.

[6]National Science Foundation, National Center for Science and Engineering Statistics, *Research and Development in Industry: 2006-07*, NSF 11-301, Arlington, VA, 2011, Detailed Statistical Tables. Available at <*http://www.nsf.gov/statistics/nsf11301/*>.

[7]In order to stimulate the creation of additional jobs, President Obama's National Export Initiative has set the ambitious goal of doubling U.S. exports by the end of 2014.

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President's Council of Advisors on Science and Technology that emphasize "the critical importance of advanced manufacturing in driving knowledge production and innovation in the United States."[8]

The Importance of Proximity

Dr. Tassey stressed the importance of understanding the strong linkage between innovation and manufacturing; numerous benefits flow out of the co-location of design, research, and production, as well as from other links in the value chain.[9] Dr. Tassey emphasized that the fast-growing high-tech services sector must have close ties to its manufacturing base to fuel innovation. "There are definite co-location synergies between services and the sources of their technology," he said. Those working in a manufacturing supply chain find increasingly important interactions with workers in related activities. "These co-location synergies flow between the tiers of the supply chain and ultimately the hardware and software that are used by the service industries."[10]

Manufacturing Capacity and National Security

In his presentation, Dr. Kota affirmed that a key goal of the Obama Administration's Advanced Manufacturing Partnership is to "jumpstart domestic manufacturing capability essential to our national security." As the military comes to rely more heavily on complex and advanced technology systems, retaining the capacity and knowledge necessary to manufacture these goods in the United States becomes more important. The ability to source critical infrastructure components, from communications equipment to power

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[8]Department of Commerce, *U.S. Competitiveness and Innovation Policy*," Washington, DC: U.S. Department of Commerce, January 2012, page 6-2. See also President's Council of Advisors on Science and Technology, *Report to the President on Ensuring American Leadership in Advanced Manufacturing*, op. cit.

[9]A recent MIT wide research effort reaffirms the importance of proximity to manufacturing and innovation. From extensive interviews with managers at small and medium-sized U.S. manufacturers, the MIT researchers found that these companies "often repurpose existing technologies or techniques and apply them to make new products. And they often bundle products together with services—thus blurring the boundary between the manufacturing and service industries. They conclude that proximity and collaboration matter in this sphere: "A key to innovation for these firms is being located in a diverse industrial ecosystem that offers many complementary resources, such as training and opportunities for collaborative research." Suzanne Berger et al, *A Preview of the Production in the Innovation Economy Report*, Cambridge: MIT Press, 2013.

[10]See the summary of Gregory Tassey's remarks in this volume. In its 2011 manufacturing report, the PCAST states: "Proximity is important in fostering innovation. When different aspects of manufacturing—from R&D to production to customer delivery—are located in the same region, they breed efficiencies in knowledge transfer that allow new technologies to develop and businesses to innovate." President's Council of Advisors on Science and Technology, *Report to the President on Ensuring American Leadership in Advanced Manufacturing*, op. cit., p. 11.

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generation also affects our ability to protect against disruptions in the supply chain.[11]

RECENT DECLINES IN U.S. MANUFACTURING

While manufacturing continues to play a vital role in the U.S. economy and is a major source of employment, the U.S. manufacturing sector has faced significant challenges in recent decades.

A Shrinking Fraction of U.S. GDP

In her workshop remarks, Dr. Ginger Lew, formerly of the White House National Economic Council, reminded the participants of how much ground the U.S. manufacturing sector has lost to foreign competition in recent years. In the 1950s, manufacturing's share of the GDP peaked near 30 percent. Today its share is about 11 percent, a decline that accelerated after 2007. The United States is still the world's largest manufacturer, with a global share of about 22 percent of global output, she said, but "it faces more challenges from around the world." There is a growing awareness in this country that thriving manufacturers are critical to America's economic recovery. "As the President has said, we've got to go back to making things." The United States cannot completely move into a knowledge-based and services-based economy, she said; it also has to produce tangible assets.

Decline in Manufacturing Employment

Mark Rice (President of the Maritime Applied Physics Corporation and member of the MEP Advisory Board) and Dr. Tassey both noted in their workshop presentations that employment in the U.S. manufacturing sector has declined by about 8 million in the past 26 years.[12] In the past decade, employment levels in manufacturing have declined steeply by about one-third. (See Figure 1.)

[11]Department of Commerce, *U.S. Competitiveness and Innovative Capacity*, op. cit., Chapter 6.
[12]This information is based on data prepared by the U.S. Census. Access at <*http://www.ces.census.gov/index.php/bds/sector_line_charts*>. For additional information, see Robert D. Atkinson, *Explaining Anemic U.S. Job Growth: The Role of Faltering U.S. Competitiveness*, Washington, DC: The Information Technology and Innovation Foundation, December 2011.

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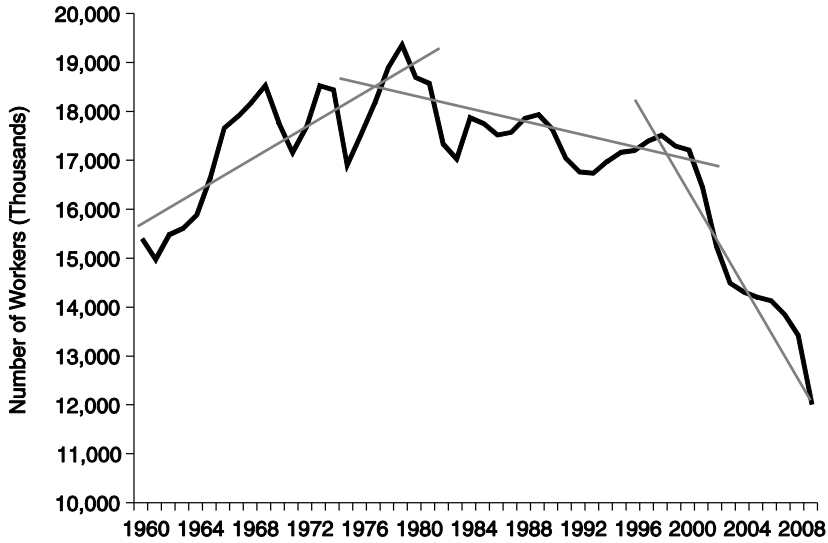

Source: Bureau of Labor Statistics.

FIGURE 1 U.S. manufacturing employment: 1960-2009.
SOURCE: Gregory Tassey, Presentation at November 14, 2011 National Academies Symposium on "Strengthening American Manufacturing: The Role of the Manufacturing Extension Partnership."

They noted that, in part, this decline is the result of greater competition from low-wage countries, leading to the off-shoring of low-skilled jobs to lower-cost locations.[13] Manufacturing employment fell by 16.1 percent from 2003 to 2009, before recovering by 4.6 percent to end 2012.[14]

Growing Trade Deficit

These employment and wage trends also roughly coincide with the increased foreign competition faced by the U.S. manufacturing sector. As Mark Rice and Gregory Tassey noted in their workshop presentations, the United

[13]For example, one study has shown that between one-quarter and more than one-half of the lost manufacturing jobs in the 2000s are the result of import competition from China. See David Autor, David Dorn, and Gordon Hansen, "The China Syndrome: The Local Labor Market Effects of Import Competition," Cambridge, MA: MIT Working Paper, 2011; *<http://www.mit.edu/files/6613>*. Some of this decline is conventionally described as due primarily to increased efficiencies and productivity gains, though the basis for this view has been questioned by Susan Helper and Susan Houseman, among others.
[14]Bureau of Economic Analysis. Access at *<http://data.bls.gov/timeseries/CES3000000001?data_tool=XGtable>*.

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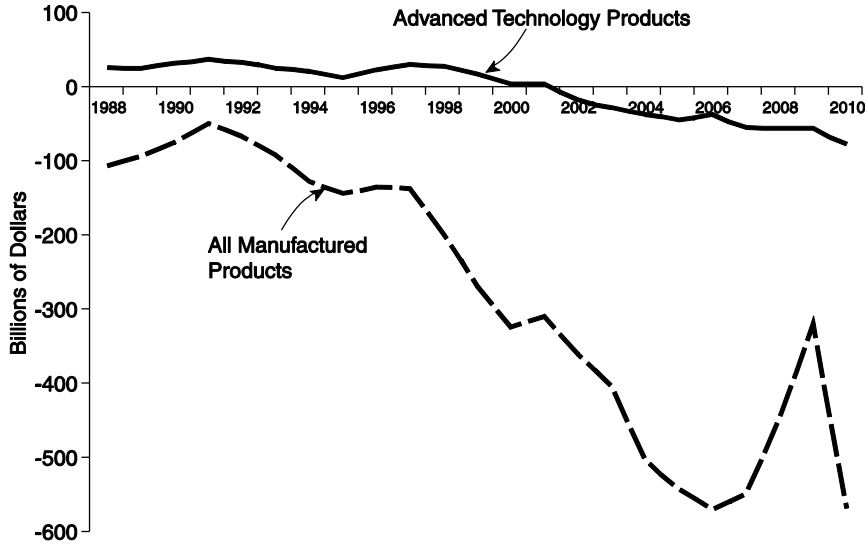
States continues to lose ground in key manufacturing sectors, including those sectors that are likely to drive our economy in the future. Until 2002, the United States ran a trade surplus in "advanced technology products," which includes biotechnology products, computers, semiconductors, and robotics. By 2010, however, the United States ran an $81 billion trade deficit in this important sector.[15] This represents a very significant shift. (See Figure 2.)

The Impact of Off-shoring Manufacturing

Dr. Tassey observed in his workshop presentation that much of the trade deficit in advanced technology is attributable to the phenomenon of progressive off-shoring over the past few decades. First, U.S. manufacturers began by setting up manufacturing facilities abroad, either to be near growing markets, to make use of skilled, low-cost labor, or both. The offshore facility did



Source: Census Bureau, Foreign Trade Division for ATP data;
International Trade Administration for all manufactured products.

FIGURE 2 U.S. trade balances for high-tech vs. all manufactured products, 1988-2010.
SOURCE: Gregory Tassey, Presentation at November 14, 2011 National Academies Symposium on "Strengthening American Manufacturing: The Role of the Manufacturing Extension Partnership."

[15]U.S. Census, Trade in Advanced Technology Products, Washington, DC: U.S. Department of Commerce, 2010, *<http://www.census.gov/foreign-trade/balance/c0007.html>*.

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a small amount of R&D in order to move products into the market. As the host countries provided more of the skilled labor, they began to gain R&D experience and expand their internal R&D infrastructures to capture synergies at the "entry" tier of the high-tech supply chain. For example, Taiwan and Korea became skilled at producing electronic components, while China excelled at assembly. In this way, those countries gradually became competitive in their own sub-markets.[16]

Hollowing Out of U.S. Supply Chains

As economies specialize in a particular tier of the high-tech supply chain, they begin to integrate backward along the supply chain, taking more value-added from the Western economies, including the United States. Dr. Tassey maintains that this "hollowing out" of supply chains has cost the United States in terms of wealth creation, high-value jobs, and technology sales. Although the United States had been the "first mover" in developing many commercial technologies, "poor technology life-cycle management" has led to a gradual loss of market share in products such as oxide ceramics, semiconductor memory devices, semiconductor production equipment, lithium ion batteries, flat-panel displays, robotics, and advanced lighting.

Forward Integration in Asia

Many emerging economies have begun to integrate forward along supply chains. For example, said Dr. Tassey, Taiwan has integrated forward from electronic components into electronic circuits, and Korea has integrated forward from components to electronic products. These economies are beginning to integrate forward into services as well, so that co-location synergies are being lost by the United States and captured by others. An inference of this trend, he said, is that U.S. firms, including small and medium enterprises (SMEs), are not able to take advantage of significant manufacturing opportunities, including R&D, technology transfer, and other essential links of the supply chain.

THE FEDERAL GOVERNMENT'S ROLE IN SUPPORTING MANUFACTURING

SMEs often play a significant role in introducing new technologies; the most successful of these firms find the technical and financial support needed to develop, test, scale up, and transfer a technology-based product to the marketplace. Too often, however, this does not happen—or is not achieved by a U.S. firm—even when the technology itself has clear value because of

[16]See Gregory Tassey, National Institute of Standards and Technology, workshop presentation in this volume. See also Gregory Tassey, *The Technology Imperative*, Edward Elgar, 2009.

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information asymmetries in the market. This classic "market failure," as Phillip Singerman of the National Institute for Standards and Technology pointed out, provides a basis for a role for government support. Dr. Singerman also observed that "the nation has not had a coherent manufacturing policy before," but argued that given the challenges facing the manufacturing community it is time "to develop a more sophisticated and nuanced model of innovation for the policy discussion at the federal level."

Support for Applied Research

In his workshop presentation, Dr. Kota noted that U.S. firms have excelled in being first to acquire knowledge, thanks in large part to the steady production of good ideas though substantial and sustained federal investments in basic research. However, U.S. policy has been less successful in supporting the application of new ideas through engineering and the commercialization of new products in the market, Dr. Kota said. The United States has lost out in many cases to foreign competitors whose governments have devoted more resources and policy support for these two stages of innovation.

Disseminating Knowledge and Building Links

In this regard, Dr. Kota noted that the Manufacturing Extension Partnership could play an important role in advancing the nation's manufacturing competitiveness through disseminating and accelerating the use of modeling and simulation tools by SMEs. He added that MEP could also help SMEs bridge the skills gap by encouraging small manufacturers to engage with community colleges and Original Equipment Manufacturers. By being the first to identify challenges and then find the resources to address these challenges, Dr. Kota said that MEP Centers can "serve as a glue" between the small and medium manufacturers and the resources that are being developed by the Advanced Manufacturing Initiative—a plan to "support innovation in advanced manufacturing through applied research programs for promising new technologies, public-private partnerships around broadly-applicable and precompetitive technologies, the creation and dissemination of design methodologies for manufacturing, and shared technology infrastructure to support advances in existing manufacturing industries."[17]

[17]See the opening letter to President Obama from the PCAST Chair and Co-chairs in the June 2011 PCAST report, President's Council of Advisors on Science and Technology, *Report to the President on Ensuring American Leadership in Advanced Manufacturing*, op. cit.

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Box B
A New Strategy for Manufacturing

In his remarks, Dr. Kota highlighted *A Framework for Revitalizing American Manufacturing,* a report issued by the White House in December 2009 that lays out the Administration's strategy to revitalize U.S. manufacturing. The strategy addresses key issues such as cost drivers, access to capital, training and education, tax policies, and investments in technology. The report notes that "the key to success [in manufacturing] lies in American workers, businesses, and entrepreneurs—but the federal government can play a supportive role in providing a new foundation for American manufacturing."[a]

[a]Executive Office of the President, *A Framework for Revitalizing American Manufacturing*, Washington, DC: Executive Office of the President, 2009, p. 11.

NEW CHALLENGES FOR MEP

To adapt to the competitive challenges of the twenty-first century, MEP Director Roger Kilmer said that his organization would work to encourage innovation by manufacturers. Historically, he said, MEP has focused on promoting lean manufacturing, quality, and cost effectiveness. While those are still key services delivered by MEP Centers, they are considered today to be one important element of a broader portfolio.

The new challenge, he added, is to look at the other side of the business ledger: "How do I grow the company? How do I get new sales with existing products? How do I get into new markets by exporting? Most important, how do I develop new products either by working with new supply chains or technologies built into other things I currently do?" He said that these new concerns have been summarized under five key areas:

- Continuous improvement.
- Technology acceleration.
- Supplier development.
- Sustainability.
- Workforce.

An essential point, he said, is that all of these functions are interrelated and must be developed in an integrated fashion. "When we're working with a company, it is not just about the supply chain piece or the workforce piece. All of those have to be built into a strategy the company can implement."

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Helping Small Manufacturers Adapt

A challenge for manufacturers today, Mr. Kilmer said, is to sort through the many programs available to manufacturers to find what is most useful. Most assistance programs are designed for large manufacturers, who already have the resources to make changes and benefit from them. "A lot of it has to do with how we get to a strategic level with small and medium-sized manufacturers rather than just fixing problems," he said. Addressing the needs of small manufacturers is important because, as MEP's Gary Yakimov pointed out at the workshop, SMEs represent some 99 percent of all manufacturing establishments and employ 10.2 million people, about 70 percent of all manufacturing employment. These smaller firms, he said, account for about 57 percent of the value added by all U.S. manufacturers.

Expanding Supply Chains

In her workshop remarks, Susan Helper of Case Western Reserve University noted that rapid changes in global economies have brought pressures on SMEs to change rapidly. For example, many large manufacturers now depend on SMEs for an increasing range of supply chain activities. For example, about a third of suppliers to the U.S. automobile industry are firms of fewer than 500 employees that are expected to provide products once produced in-house.

In his remarks at the workshop, Joseph Houldin of the Delaware Valley Industrial Resource Center noted that outsourcing does create opportunities for SMEs and reallocation of value within the chain, but it also means that new functions are "pushed down the value chain" to SMEs, including more R&D, logistics work, and just-in-time production. SMEs either may see these requirements as part of a larger opportunity to develop new customers or as a web of challenges too complicated to deal with. MEP, he said, can help a company work its way through such questions.

Addressing Productivity Challenges

SMEs are also under pressure to raise productivity. As Gary Yakimov noted, a substantial and growing productivity gap between large and small firms has been observed, with SMEs lagging larger firms. This productivity gap, as value added per employee, grew from about $12,000 in 1967 to about $80,000 in 2002. Over the long run, this trend is not sustainable. Small manufacturers will face increasing international competition, and to compete they must become more agile, develop better marketing skills, and find profitable niches in lengthening supply chains. These global pressures are a principal driver of MEP's new strategic thrust to help companies innovate, enhance their marketing capabilities, and export.

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Growing SME Innovative Capacity

According to Philip Shapira, smaller firms typically lack market power and are often cautious about adopting innovations. This hesitation is not surprising given "the real risks of business failure and constraints of knowledge, expertise, and finance." "While policy narratives focus on entrepreneurial high-technology firms," he added, "these are only a small minority of all SMEs in the economy. Many small firms operate in traditional or resources-based industries, serving the lower ends of supply chains and subcomponent operations. Many are 'lifestyle' or family-run operations."[18] In this regard, as Mr. Kilmer noted in his workshop presentation, a key objective of MEP is to increase the innovative capacity of a broad range of manufacturers.

Introducing New Tools and Concepts

In her workshop remarks, Dr. Helper drew attention to recent research on what manufacturing firms need to do to become more innovative.[19] She noted that MEP can play a valuable role in instilling "high-road techniques" that harness everyone's knowledge—not just that of top executives—to achieve innovation, quality, and variety.[20] Dr. Helper called this "agile production," by which a firm can design, set up, debug, and produce a variety of products quickly—"just in time." She observed that in the face of knowledge-based global competition, "production can no longer rely on a fixed division of labor because the product mix changes constantly; it must employ people who can do more than one job, because no one knows what the next job is going to demand." As value per employee is added, it is used to pay the workforce, invest in new capital and equipment, and deliver profits to the owners. A key top-line strategy for high-road firms, she said, is to design their own products.

Dr. Helper said that her study findings also reinforced the value of continuous improvement. This calls for distributed knowledge for workers at all levels; the more people on the shop floor who understand the purpose of what they are doing, the better they understand the importance of debugging and other improvements of the manufacturing process. Firms that employ continuous improvement practices, such as quality circles, suggestion systems, and preventive maintenance, must also be able to design a higher percentage of their own products, do more R&D, and improve processes quickly.

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[18]Dr. Shapira's comments reflected research published in P. Shapira, *Product and Service Innovation: Report to the Manufacturing Extension Partnership, National Institute of Standards and Technology,* Atlanta, GA, and Arlington, VA: Georgia Tech Program in Science, Technology, and Innovation Policy, and SRI International, 2006.

[19] See S. Helper, T. Krueger, and H. Wial, *Why Does Manufacturing Matter? Which Manufacturing Matters? A Policy Framework*, Washington, DC: The Brookings Institution, February 2012, *<http://www.brookings.edu/~/media/research/files/papers/2012/2/22 percent20manufacturing percent20helper percent20krueger percent20wial/0222_manufacturing_helper_krueger_wial.pdf>*.

[20]Susan Helper, *Renewing U.S. Manufacturing: Promoting a High-Road Strategy*, Washington, DC: Economic Policy Institute, 2008. Access at *<http://www.sharedprosperity.org/bp212/bp212.pdf>*.

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Training Center Staff

For MEP to promote, bridge, and facilitate connections between innovation, manufacturing, and the sustainable growth of SMEs, its staff need to be trained and equipped appropriately. At a symposium question-and-answer period, Diane Palmintera of Innovation Associates observed that while many Center directors applaud the effort of MEP to move toward innovation and technology, their staffs are not always prepared to coach firms on tech transfer and innovative technologies. MEP's Mr. Kilmer agreed, and said that the NIST-MEP has been working on a training curriculum related to innovation. "Quite honestly," he said, "it's a difficult thing for the centers. Some staff will be able to make those changes, and some won't. We try to equip them with training and professional development, but it is a challenge."

Improving Outreach

As several speakers noted, MEP faces unique challenges in reaching out to a diverse mix of small firms spread out over the country. According to Philip Shapria, small firms exhibit "great heterogeneity in enterprise characteristics, resources, motivations, sectoral and regional attributes and other factors, and concomitant wide variations in orientation toward and capabilities to undertake innovation."[21] Challenges exist at the firm level, industry level, within the context of social infrastructure, and in the innovation environment. There are internal company barriers, with SMEs lacking information, experience, training, resources, strategy, and confidence to adopt new technologies. There are also external barriers in the costs of vendors, customers, consultants, and other business assistance sources that might be useful to SMEs.[22] For these reasons, as James Watson of California Manufacturing Technology Consulting noted in his workshop presentation, simply reaching those SMEs best positioned to take advantage of MEP advice is difficult.[23]

Identifying and Sharing Lessons Learned

Finally, MEP, as a national program, faces the challenge of developing and sharing the best practices across the system. As Mr. Kilmer noted, "MEP's role in this innovation chain is really to advise the manufacturer, helping it to

[21]P. Shapira, "Innovation and small and midsize enterprises: innovation dynamics and policy strategies," in R. Smits, S. Kuhlmann and P. Shapira, eds., *Innovation Policy: Theory and Practice. An International Handbook,* Cheltanham, UK: Edward Elgar, 2009.
[22]A. Caputo, et al, "A methodological framework for innovation transfer to SMEs," *Industrial Management and Data Systems* 102(5):271-283, 2002; P. Shapira, "U.S. manufacturing extension partnership: Technology policy reinvented?" *Research Policy* 8(3):66-72, 2001.
[23]Supporting this conclusion, recent data commissioned by MEP found that the MEP national network only provides in-depth assistance to 9 percent of the available market of companies with 20-499 employees that are willing to seek out and invest in outside support." Stone and Associates, "Re-examining MEP Business Model," October 2010, p. 7.

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assess different opportunities and challenges to make strategic decisions. The Centers also need to be connectors that can help small and medium-sized manufacturers find the other resources and components it needs."

MEP'S EVOLVING ROLE

How is MEP addressing these challenges? Several speakers at the workshop noted that MEP's role has evolved from an emphasis on lean production to a focus on enhancing the innovative capacity of manufacturers. Philip Shapira observed that "originally, these Centers were created to transfer federally sponsored, state-of-the-art technology to firms. Later they started delivering pragmatic assistance, appropriate to state and local conditions, with business services, quality systems, manufacturing systems, information technology, human resources, engineering, and product development—the 'soft' business practices."[24] Today, as MEP's Gary Yakimov noted, the principal goal of the partnership is to increase the competitiveness and productivity of U.S. manufacturing by helping manufacturers in the United States improve production performance and by helping manufacturers grow their business by making the right product for the right customers profitably.

Building Local Innovative Capacity

Echoing these themes, Mr. Kilmer noted in his remarks that while the founding focus of MEP was to promote lean manufacturing, quality, and cost effectiveness, these early activities are now considered not "the end of the journey, but the beginning." NIST-MEP has come to believe that cost efficiency alone is not sufficient, and that companies needed to think about growth strategies as well. MEP's overarching strategy today is to increase the innovation capacity of manufacturers so as to drive profitable sales growth. Part of our evolution," said Mr. Kilmer, "was to change from offering a technology 'push,' where we knew about which technologies work in a federal lab, to looking at what manufacturers really needed in the field. It also meant learning to look at the entire manufacturing enterprise—not just the tech piece of it, but everything else: the financing, workforce development, marketing, and sales."[25]

Supporting Local Resources

MEP's decentralized organization allows each Center, within certain operational and performance parameters, to customize its organizational model, service offerings, and delivery mechanisms based on the needs of its clients and

[24]P. Shapira, J. Roessner, and R. Barke, "New pubic infrastructures for small firm industrial modernization in the USA," *Entrepreneurship and Regional Development* 7:63-84, 1995.
[25]See the summary of Roger Kilmer's presentation in the Proceedings chapter of this volume.

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the institutional capabilities within its service region.[26] While this diversity among MEP Centers is "a little confusing to us at the national level," said Mr. Kilmer, "the key thing is that manufacturers now recognize local entities as the source of their manufacturing assistance." MEP Centers themselves may function as advisors, consultants, and/or matchmakers, helping small manufacturers address their short-term needs in the context of a long-term business strategy.

Dr. Shapira noted that a key challenge for MEP is to reach out and stimulate individual firms to innovate in sustained fashion. "You can't force firms to change, but you can encourage them, point them toward resources, mentor them, and stick with them. Change is not a one-time event." It was important to note, he said, that the strong partnership orientation means that each MEP takes on the regional flavor where it is located. "That adds opportunity and complexity into the mix," he said, "because every state does its partnership a bit differently, and in this review we want to understand how."

Encouraging Cluster Growth

MEP can play an important role in strengthening the innovation clusters that are seen by many as important to the revitalization of U.S. technological leadership.[27] In his conference remarks, Dr. Sridhar Kota observed that other federal agencies can and do help with the development of new technologies through public-private partnerships. But "once you have a technology, the MEPs play an important role in terms of business and technical assistance. The MEPs do even more in adding to the value chain, simulation, prototyping, and thinking about scaling. We already have MEPs, and they can help us." Illustrating this point, Ms. Petra Mitchell of the Catalyst Connection, a Pennsylvania-based MEP Center, described her organization's T-RIC, or Technology Acceleration in Regional Innovation Clusters Initiative. The objective of this program, she said, is to develop a consortium of regional clusters focused on accelerating technology within the small manufacturers in the region.

PERSPECTIVES FROM THE MEP STATE CENTERS

Illustrating the differentiated nature of the partnership, speakers from the MEP Centers in Minnesota, Ohio, California, and Pennsylvania described the importance of manufacturing to their state or region's economy and the role

[27]For a review of current clustering strategies and approaches, see National Research Council, *Clustering for 21st Century Prosperity: Summary of a Symposium*, C. W. Wessner, rapporteur, Washington, DC: The National Academies Press, 2012. See also National Research Council, *Growing Innovation Clusters for American Prosperity: Summary of a Symposium*, C. W. Wessner, rapporteur, Washington, DC: The National Academies Press, 2011.

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their organization plays in growing this sector. They also provided their perspective on the value of the federal MEP program to their local initiatives.

Minnesota

In his remarks, Robert Kill of Enterprise Minnesota emphasized the importance of manufacturing to Minnesota's economy. The state has more than 8,000 manufacturers that collectively create 15 percent of its jobs and 18 percent of its payroll. Employing about thirty professionals, Mr. Kill said that his organization pays special attention to helping small and mid-sized manufacturers succeed by providing business consulting services and by building connections to public and private stakeholders. After losing state funding eight years ago, Enterprise Minnesota endures as a non-profit consulting organization.

Currently, Mr. Kill noted, more than half of Enterprise Minnesota's services are aimed at business growth. In turn, the organization has reduced its emphasis on such activities as lean manufacturing and quality management in favor of "idea engineering," executive leadership, and other growth-enhancing activities. A simple focus on "lean-and-mean," he said, would not bring the rate of growth that was needed for small and mid-sized manufacturers.

Mr. Kill said that his organization values its partnership with MEP. In particular, he cited the significance of the independent follow-up surveys required by MEP, which he said, is a key distinction separating it from other groups who offer consulting to small and medium manufacturers. "We go back to each client annually through independent third-party survey research to confirm each client's individual successes in sales increases, cost reductions, and profitable investments. MEP, our federal partner, requires this data as evidence of our value to each manufacturing client."

Ohio

In her remarks, Beth Colbert of the Ohio Department of Development said that her state ranked fourth in the nation in manufacturing. Ohio has about 20,000 to 25,000 manufacturers, and "what's important here" is that 98 percent of those employ fewer than 500 workers and so meet the criteria for NIST-MEP services. The state has some large manufacturers, she said, but is primarily a "supplier state" that provides inputs to large manufacturers. It ranks first in tier two and tier three companies, and in automotive suppliers. "So when the big guys go down," she said, "we go down hard, too."

Prior to 2008, the MEP system in Ohio operated multiple independent centers. In 2009, as part of a new strategy for economic development, these were merged into a partnership with the Ohio Department of Development, bringing a new statewide perspective. She said that the strategic plan "really sparked Ohio's interest" because of its emphasis on continuous improvement, sustainability, workforce development, and technology advancement. At the

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same time, the Ohio Edison Technology Centers were brought into the partnership. The Edison Centers had been created in 1984 by the Ohio legislature as a $20 million program operated by the Department of Development. Its mission is to fund centers and incubators for innovation and technology advancement by linking universities and industries.

With so many manufacturing suppliers in Ohio, the program divides them into three groups. These include (1) some 75-80 percent of all suppliers, who have little experience and can benefit from many forms of general manufacturing assistance; (2) about 10-15 percent of all suppliers, which require more specialized assistance; and (3) about 5-10 percent of all suppliers, a small group of experienced manufacturers that require "customized growth projects." Ms. Colbert estimated that many firms in the first, largest group would benefit "almost immediately" from the basic programs and services of the MEP, such as cost-improvement training, financial coaching, general business assistance and trade and marketing assistance.

She said the state's MEP program had found it did not have to try to offer every service to everyone, but could work in partnership with free or low-cost services for very small manufacturers. Many of these are found among the 88 state colleges and community colleges in the state as well as local partners and economic development groups that provide business services and have access to financing through local banks.

California

Mr. Watson, who leads California Manufacturing Technology Consulting (CMTC), began his presentation with a sketch of manufacturing in California, where about 44,000 manufacturers employ approximately 1.2 million workers. This number, he said, is down from 1.6 million at the beginning of the 21st century as the state lost companies to other states, including Nevada, Arizona, and especially Texas. Even so, he said, California remains the ninth largest economy in the world, and manufacturing will always be important in the state, which continues to have the largest concentration of manufacturers in the United States.

Mr. Watson described the CMTC's new mission as "creating solutions for manufacturing, growth, and profitability." CMTC provides a "comprehensive suite of services," generated both internally by staff and externally by 50-60 third-party providers throughout the state. "We are essentially a one-stop shop, and when a manufacturer comes to see us, they don't have to look somewhere else. We'll help you run your business strategically from where you are today to where you want to go tomorrow, and you don't need to step outside of CMTC." CMTC does this, he said, through hands-on facilitation and coaching "both on the plant floor and in the board room." CMTC also helps manufacturers partner with universities and junior colleges and colleges, and other business organizations. It also helps small manufacturers benefit from federal programs. In all, he noted, "we have

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probably the largest network of third-party providers that handle manufacturing in the state."

According to CMTC surveys, manufacturers had invested some $130 million in the past year. "That's good for us," he said. "I always like to see that because it means manufacturers are reinvesting in themselves, and the more they do that, the better they can compete and the more likely they are to stay in California." The surveys had also revealed some $359 million in increased sales, which means "they are selling more than they were before. Our hope is that as sales increase, jobs will increase as well." A final point from the survey was "a very high client satisfaction rating with our customers." He said that this result had been recognized by the state, and the CMTC was now the "go-to organization" for anyone with manufacturing issues.

With regard to the role of MEP, Mr. Watson suggested that the partnership assist the various centers to share learning and integrate new initiatives. "This is all about pace and volume," he said. "There are a lot of initiatives, and the challenge is how much and how fast can a Center absorb." He said that by working together as a system and as Centers, all members would have access to the best practices. "The more we can share those best practices, the faster we can bring these initiatives to our customers and really take manufacturing back to where it needs to be for us to retain our leadership in the world."

Pennsylvania

Petra Mitchell of the Catalyst Connection described her organization as a stand-alone, non-profit economic development organization in Pittsburgh and southwestern Pennsylvania. It was founded in 1988 and now has about 25 staff members. The Catalyst Connection receives less than half of its funding from state and federal programs; the rest is generated from fees, foundations, and other private sources. She calculated that $1.4 million in state investment has leveraged $3 million in additional funding.

Ms. Mitchell added that Southwestern Pennsylvania has about 3,500 manufacturers, which employ more than 100,000 people. The area is also home to about 25 universities and colleges, including the University of Pittsburgh and Carnegie Mellon University and 120 corporate or federal R&D centers. The economy is diverse, with a relatively low rate of unemployment. However, she noted that this diversity presents challenges for a small Center like the Catalyst Connection that seeks to offer manufacturing extension services across different types of manufacturing industries and sub-industries.

Ms. Mitchell said that her organization serves manufacturing clients by helping them improve staff skills through professional development as well as by introducing opportunities for networking and collaboration. Catalyst also seeks to develop new business opportunities such as those from natural gas

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extraction from the Marcellus Shale.[28] Catalyst also helps companies improve lean manufacturing and quality standards and provides a variety of business growth services to help companies find new customers, develop new products, and export products. It has helped firms with talent management, which has led to involvement with the Manufacturing Skills Institute, community colleges, and universities. Finally, Catalyst is developing a consortium of regional clusters focused on accelerating technology within the small manufacturers in the region. Current partners in this initiative include the University of Pittsburgh, National Energy Technology Laboratory, Innovation Works (a Ben Franklin Technology Partner), Pennsylvania Nanomaterials Commercialization Center, and AMTV, the Advanced Manufacturing Technology Ventures, LLC.

Ms. Mitchell said that she was "very proud" of the MEP system that she had been part of for 17 years, and was proud of the federal agency collaborations that had given her organization recognition, visibility, and standing in the development community. Going forward, she suggested continued emphasis on impact data and evaluation metrics. She also called for cohesive, system-wide goals that can help MEP achieve common purpose and direction. "We have many states, many Centers, and many stakeholders," she said. At present, the Centers do most of their progress reports as individual Centers. "If we can create one set of goals and a common purpose, we can report on our progress as a system. How are we doing? I think we should celebrate our successes, because there have been many over the years."

ASSESSING ACTIVITIES, OUTCOMES, AND IMPACTS

As MEP makes the shift from "lean production" to emphasize product innovation and commercial development, several speakers observed that new metrics would be required to assess its effectiveness. As Deborah Nightingale of MIT noted at the workshop, "Relevant and accurate measurement is critical during a time of transition to make sure that we are measuring the right kinds of things." There are many different kinds of measurements, including outcome metrics and process metrics, which are quantitative, as well as qualitative metrics. As Dr. Nightingale further noted, "I think it's going to be important as we move forward to really understand how and what we should measure so that assessments are aligned with the new strategy MEP is laying out."

[28]The Marcellus Shale refers to a large formation of marine sedimentary rock that "extends throughout much of the Appalachian Basin. The shale contains largely untapped natural gas reserves, and its proximity to the high-demand markets along the East Coast of the United States makes it an attractive target for energy development." Source: Wikipedia.org.

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Box C
The Role of Partnerships for Manufacturing Around the World

A number of workshop participants made note of partnerships in other countries that seek to accelerate innovation through support for manufacturers.[a] Indeed, a number of other countries have generated their own versions of partnerships intended to accelerate the commercialization of technology. These technology extension services include the Kohsetsushi Center in Japan, the Fraunhofer Institutes and Steinbeis Centers in Germany, the Industrial Research Assistance Program in Canada, the Federación Espanola de Entidades de Innovación in Spain, and the Instituto Nacional de Tecnología Industrial in Argentina. A basic premise of these programs is that SMEs lack the resources of time, expertise, and finance to undertake all aspects of the innovation process, which can lead to suboptimal innovation investments and economic outcomes. Sources of support for these TES Centers range from mostly public funding (Japan) to mostly contract fees (Steinbeis).[b]

In his workshop presentation, Dr. Mark Rice observed that effective public-private partnerships are essential for bringing new ideas to the marketplace. "It needs to be linked to a strategy," he added; "not a Fraunhofer strategy, or a Korean version, but an American strategy. The beauty of the American system is the diversity we bring to these problems. Let's embrace that and figure out how to make it work on the local, state, and federal scales."

[a]See for example, remarks by Sridhar Kota, Gregory Tassey, Susan Helper, Mark Rice, and Robert James on Germany's Fraunhofer institutes and Canada's IRAP program.
[b]Philip Shapira, Jan Youtie, and Luciano Kay, "Building Capabilities for Innovation in SMEs: A Cross-Country Comparison of Technology Extension Policies and Programs," *International Journal of Innovation and Regional Development,* 3-4: 254-272, 2011.

MEP's Assessment Efforts

In his conference presentation, Gary Yakimov noted that that MEP's performance has been reviewed on several occasions, with what he described as generally positive outcomes by the Office of Management and Budget, the National Academy of Public Administration (in 2003), and others. He noted, the assessment process has generally been considered thorough and detailed, and MEP officials have often been invited by other agencies to describe their techniques.

The Role of Surveys

According to Mr. Yakimov, MEP assessments provide a snapshot of its performance. He reported that a recent survey of client impacts for FY 2009

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Box D
MEP Performance Metrics

As described by Mr. Yakimov, MEP has developed a performance metrics system that addresses performance at three levels:

System-level Metrics. This is the broadest level of evaluation, and includes productivity growth of SMEs, global competitiveness of U.S.-based manufacturers, supply chain efficiency, job opportunities for workers, and rates of business survival. It measures center performance in terms of costs, staffing, outputs, outcomes, and surveys. It also measures client impact and performance improvements. Metrics include cost savings, improvements in manufacturing systems, human resources systems, IT, marketing, sales, and company management. Based on Center data, MEP found that Centers contracted with 7,000 to 8,000 companies annually, through approximately 12,000 projects.

Center-level Metrics. Each Center has been reviewed annually, using a weighted scoring system that measures impacted clients, bottom-line client impact ratio, investment leverage ratio, percent of quantified impacts, and clients served per million federal dollars. These data are collected in part through the annual client survey (see below) and in part from data provided directly by each Center to NIST. Based on these metrics, Center performance improved substantially after 2004. A striking characteristic of the program, however, is the wide variation among Centers on almost all metrics. For example, in 2010 total expenditures per project hour in staff and contracted time ranged from $88 per hour in Mississippi to more than $1,000 per hour in eight other states.

Client-level Metrics and Performance Assessment. This level is based largely on an annual survey of MEP clients by Turner Research, a marketing and survey research firm. For FY 2009, about 8,900 MEP participants were queried, and 85.7 percent responded—an "incredible" rate, according to Mr. Yakimov. In response to planned MEP strategic changes, the survey began to change in January 2010. Notable changes include new tools to assess the increased focus on growth through innovation and the increased focus on market penetration.

New CORE Metrics. The new metrics, introduced in 2012, made a number of important changes: they replaced the previous pass/fail approach with a more graduated grading system; they sharply reduced previous dependence on the client survey without eliminating it; they added new qualitative metrics; and they focused attention for the first time on a range of indicators related to the provision of growth-oriented services.

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was highly positive, showing $3.9 billion in new sales, $4.9 billion in retained sales, $1.9 billion in added capital investment, $1.3 billion in cost savings, and 72,075 jobs created/retained.

He added that this survey also asked clients about their three biggest challenges. The top responses were (1) ongoing continuous improvement / cost-reduction strategies, (2) identifying growth opportunities, and (3) product innovation and development. He said that this information could be interpreted in various ways. After all, every business wants to reduce costs—and yet this objective is not sufficient to fuel long-term growth or global leadership.

Putting these survey results in perspective, Mr. Yakimov recalled the famous remark by Henry Ford, who said that if he had relied on his customers for advice on the most promising growth opportunities, they would have asked him to build a faster horse. "I think one of the challenges we have across our system is to create a sense of urgency in small/mid-size manufacturers about the need to grow, innovate, export, and become more sustainable. What's really important about this survey is whether we have products and services to meet this list of needs, and the fact is that we do, and we continue to develop them."

Survey Challenges

Daniel Luria of the Michigan Manufacturing Technology Center, an experienced reviewer and participant in the development of the MEP program, noted that while the current evaluation system is logical, consistent, and works "passably well" in generating "large-seeming sum-of-impacts" that generally help the program and motivate Centers, it does less well when it asks MEP clients to compare their current situation "with an imagined situation without MEP services." This difficulty is compounded by survey queries that require dozens of calculations to answer meaningfully. "For example," said Dr. Luria, "one of the cost reduction questions is: 'After working with a Center, how much lower are your labor, material, overhead, and inventory costs?' Leaving aside the lack of agreement on a definition of overhead, and the problem that inventory costs are a one-time savings on the balance sheet, it is a very difficult question to answer." Similarly, he said, the true role of outliers—i.e., Centers that substantially out- or underperform others—is difficult to understand because the survey looks only at changes with no reference to base levels.

While acknowledging that "ingrained habits" are likely to make it difficult to change the assessment techniques, he nonetheless argued that claims of MEP impact need to be based on changes in value added and productivity. The current evaluation does not address either question very well, he said, and does not tell Centers what they should be doing to increase these outcomes. Failure to do so "invites a reasonable presumption of near-zero net impact."

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Transitioning to a New Evaluation System

Mr. Yakimov said that in the transition to a new reporting and evaluation system, the MEP would continue to hold the individual Centers accountable for three things: financial stability, market penetration, and client/economic impact. "That model will never change, whether it's the current system of evaluation or the new system." The system in place through 2011 evaluates clients on new sales, retained sales, investment, cost savings, and jobs created and retained. The MEP holds the Centers accountable for these results, and evaluates them based on minimally acceptable impact measures (MAIM), annual and panel reviews, the operating plan, and quarterly data reporting.

The reason for the imminent change, he said, was that the MEP needs a "more balanced scorecard." At the beginning of the MEP program, he said, the evaluation focused too much on documenting Center activities and its interactions with manufacturers. About a decade ago, the MEP moved to the client impact survey as the sole mechanism to hold Centers accountable. "I think what we want to do now is reach a balance between those two things. We want to look at the activities in addition to the outcomes and impacts."

IN CLOSING

This workshop summary provides a variety of perspectives on how the Manufacturing Extension Partnership seeks to strengthen the nation's small and medium manufacturers. This overview highlights key issues raised by speakers in the course of a National Academies workshop including, more broadly, the importance of manufacturing for the U.S. economy, the decline of the U.S. manufacturing sector, and the role that government can play in supporting this sector. More specifically, the workshop addressed the role of MEP in strengthening manufacturing in the United States, the evolution of MEP to address new global realities and opportunities, and the need for relevant metrics to shape this evolution. The next chapter provides detailed summaries of the presentations by each of the conference participants. The overall objective of the meeting and this volume are to enhance our understanding of the operations, achievements, and challenges of the MEP and the new strategies it plans to adopt to help small U.S. firms adapt to global competition.

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II

PROCEEDINGS

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Welcome

Charles Wessner
The National Academies

Dr. Wessner welcomed participants to the National Academies. The Academies Board on Science, Technology, and Economic Policy (STEP) has, over the past two decades, addressed the importance of innovation as a driver of economic growth and competitiveness and the challenges of transitioning new ideas to the commercial marketplace. The occasion of this meeting, he said, was to launch STEP's review the role of the Manufacturing Extension Partnership (MEP). MEP was initiated in 1989 by the Department of Commerce's National Institute of Standards and Technology (NIST). He said that the aim of this workshop was to review, clarify, and publicize the value of the MEP for U.S. manufacturing, and to recommend improvements to the program and to its assessment mechanisms.

In its reviews of innovation policies and programs around the world, said Dr. Wessner, the STEP Board had come to understand the importance of collaboration among the public and private sectors in promoting economic development.[1] Seeking to become more competitive and to grow their economies, many other countries are creating effective public-private partnerships involving universities, research centers, private innovation and manufacturing firms; state and federal governments; and foundations.[2] This global push for innovation, he said, is characterized by the recognition that:

- Innovation is a key to growing and maintaining a country's competitive position in the global economy;

[1]National Research Council, *Government-Industry Partnerships for the Development of New Technologies*, C. W. Wessner, ed., Washington, DC: The National Academies Press 2003.
[2]National Research Council, *Rising to the Challenge: U.S. Innovation Policy for the Global Economy*, C. W. Wessner and A. Wm. Wolff, eds., Washington, DC: The National Academies Press, 2012.

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- Collaboration among small and large businesses, universities, and research institutes is essential for innovation;
- Proven innovation programs, such as the Small Business Innovation Research program (SBIR), can play an important role in supporting this collaboration.

Leading countries and regions are responding to the innovation challenge, he said, through similar strategies.[3] First, they are focused on growth and strength through—

- Sustained support for universities.
- Rapidly growing funding for research.
- Support for innovative small businesses.
- A focus on manufacturing.
- Public-private partnerships to hasten the movement of new products and services to market.

In addition, they are investing substantial resources to create, attract, and retain the industries of today and tomorrow.

A COMMITMENT TO INNOVATION AROUND THE GLOBE

The commitment to innovation around the world had shifted, he said, as indicated by R&D expenditures as a share of economic output. He offered an illustration of this measure for selected countries from 1996 to 2007, with steady increases shown for South Korea, Japan, and China, which had doubled its expenditures on basic research between 2004 and 2007; in comparison, the United States and European Union evinced slow or no R&D growth.[4] He also singled out the rapid rise of innovation hotspots like Shanghai and Singapore. The investments of the latter, he said, were "absolutely remarkable," especially the construction of new science parks and a strategy of attracting and supporting top academic achievers through high salaries.[5]

Similarly, he said, the government of Australia had begun a program to strengthen research facilities, mobilize capital for young high-tech firms, use public procurement to stimulate commercialization, reach out more to other institutions, and strengthen the institutional framework that supports

[3]Ibid.
[4]National Science Board, *Science and Engineering Indicators 2010*, Arlington, VA: National Science Foundation, 2010.
[5]In addition to building the major new S&T parks Biopolis and Fusionopolis, Singapore has spent about $5 billion in innovation funding for a population of some 4.5 million.

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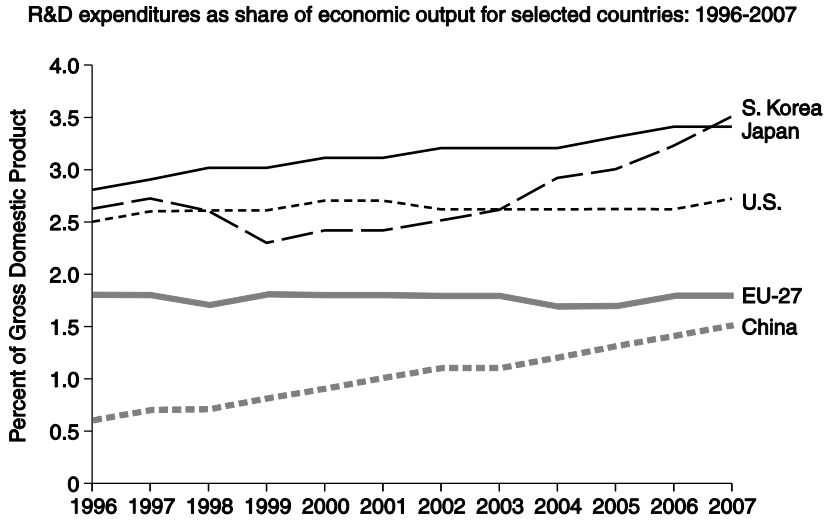

FIGURE 1 Global R&D: Measuring commitment to innovation.
SOURCE: National Science Board, Science and Engineering Indicators, 2010, Arlington, VA: National Science Foundation, 2010.

innovation.[6] The Australians were not yet "completely successful," he said, but they were "focused, investing, and paying attention."

In Germany, he said, the government understood "that if you invest in job training, and if you generate enough productivity, you can offset the high wages paid for manufacturing jobs." Germany's notable achievement, he said, is a trade surplus, "which is very impressive." German manufacturers are even succeeding in exporting manufactured goods to China, Dr. Wessner added, with a 55 percent rise in overall exports to that country in 2011. One reason is that Chinese consumers see German goods as superior in quality to Chinese goods.[7]

THE PLAYING FIELD IS NOT LEVEL

How can the U.S. compete in this environment? Dr. Wessner said that a popular view was that "on a level playing field, the United States can out-

[6]Commonwealth of Australia, *Powering Ideas: An Innovation Agenda for the 21st Century*, 2009.
[7]Washington Post, "Made in Germany, Sold in China," September 17, 2010.

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compete anyone in the world." He said that there are two errors in this view. The first is that the playing field is not level. "The rest of the world is committed to not having a level playing field," he said, "particularly where the U.S. might win." He quoted a foreign official who had once said to him: "Why would we give an American company like Intel a level playing field? They'd beat us every time." The second problem is the presumption that U.S. workers would necessarily out-compete the rest of the world without sufficient investments in their education and skills development.

AN EFFECTIVE INNOVATION POLICY MUST BE HOLISTIC

Another lesson from countries with a with successful innovation strategies, he said, is how holistic they are. They are investing more in research and development (R&D), training a skilled workforce, and investing in their nation's technology infrastructure, including the roads, utilities, and transportation needed for new manufacturing plants. They also focus on clean energy, incentives for entrepreneurship, and pro-manufacturing policies.[8]

Dr. Wessner said that the recent innovation strategy prepared by the Obama administration was one of the most comprehensive and well-though-out policies the country had ever had, featuring the following elements[9]:

- Invest more in R&D.
- Grow and attract a skilled workforce.
- Invest in infrastructure for innovation.
- Invest in clean energy innovation.
- Reform the patent system [now partially accomplished].
- Encourage entrepreneurship.
- Strengthen manufacturing.

He observed that this integrated, coherent approach offers great promise on the condition that it is enacted and funded in the current budgetary environment.

AN ASSESSMENT OF U.S. MANUFACTURING IN THE 21ST CENTURY

The National Academies assessment of Manufacturing Extension Partnership, Dr. Wessner said, provides us an opportunity to review and

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[8]National Research Council, *Rising to the Challenge: U.S. Innovation Policy for the Global Economy*, op. cit.
[9]National Economic Council, *A Strategy for American Innovation: Driving Towards Sustainable Growth and Quality Jobs*, Washington, DC: The White House, 2011.

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document the program's current achievements, challenges, and new opportunities; identify and review similar national programs from abroad in order to draw on foreign practices, funding levels, and accomplishments as a point of reference; and discuss current needs and initiatives in light of the global focus on advanced manufacturing.

He closed by introducing the chair of the MEP study, Philip Shapira, a Professor in the School of Public Policy at Georgia Institute of Technology and Professor of Management, Innovation and Policy at the University of Manchester. Dr. Wessner observed that Professor Shapira's interests "encompass science and technology policy, economic and regional development, innovation management and policy, industrial competitiveness, technology trajectories and assessment, innovation measurement, and policy evaluation."

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The National Academies Evaluation of the Manufacturing Extension Partnership

Philip Shapira
University of Manchester and Georgia Institute of Technology

Dr. Shapira began by recalling that he first came to Washington in 1986 as a congressional fellow in the Office of Technology Assessment. "That was exactly the time when Washington and the country were discussing what was happening in the manufacturing sector," he said. The competition from Japan was so daunting that he and other congressional staff began taking lessons in Japanese—"an interesting sign of the times." That was the period when the Omnibus Foreign Trade and Competitiveness Act of 1988 was being prepared and the major features of the MEP were being developed. Now, in 2011, he added, "it's very interesting for me to have the opportunity to revisit the program."

He said that there are more than 300,000 SMMs in the United States, and "they are a crucial part of our nation's economic foundation." Given their importance, he said, it is imperative to better understand how best to stimulate and support their development. "There are many innovative small manufacturing companies," he said. "There are also many which seem to lag in terms of performance, productivity, innovation capabilities, training, sustainability, and export performance."

SUPPORT FOR MANUFACTURERS MUST BE SUSTAINED

The challenge at the MEP, he said, is to work with all kinds of companies, in all regions of the country, and to link those companies with larger supply chains and value chains. Broadly, the task of the MEP is to stimulate those individual firms in sustained fashion. "You can't force firms to change, but you can encourage them, point them toward resources, mentor them, and

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stick with them. Change is not a one-time event." It was important to note, he said, that the MEP works with the states in partnership, not as a federal program generated from Washington. "That adds opportunity and complexity into the mix," he said, "because every state does its partnership a bit differently, and in this review we want to understand how."

By federal standards, the MEP is a small program, budgeted at about $128 million and matched by roughly similar amounts of state and industry funds. "It's significant, not huge, but it's very strategic and very important." Dr. Shapira said that his committee had been requested to undertake a study of the MEP to understand its functions and strategies. The committee would look not only at past performance, but try to understand how the program could best address future challenges. It would also examine similar programs in other countries, particularly in Europe and Asia. "We think that international standards and insights are crucial to understand and to benchmark the MEP approach." Finally, the committee would look at how the MEP is connected to the broader set of challenges and opportunities as the country seeks to build and retain manufacturing resources.

A PARTICULAR FOCUS ON SMALL AND MEDIUM-SIZED MANUFACTURERS

Dr. Shapira said that the study would not attempt an overview of all aspects of manufacturing, a perspective being addressed by others. The committee's particular charge is the needs of small and mid-sized enterprises (SMEs)—"the regular companies that pay taxes, hire people, and produce things. They are often overlooked, particularly in Washington."

He emphasized that the study would be evidence-based and analytical. "I think our job is not to micro-manage this program, but to review where it's been, where it is now, and where it could go, given our assessment of what's happening in manufacturing in this country and internationally." He described several lines of inquiry: the performance of the MEP program, the ways in which states use it, the diversity of the users, and issues of funding and co-funding. The committee would also investigate how the program is used by manufacturers and how it relates to their needs; how it relates to the general array of assistance opportunities available at federal and state levels; and how it compares with programs of U.S. trading partners.

Dr. Shapira praised the breadth of the panel itself, whose members had gained broad experienced in small and large firms, the policy world, federal and state agencies, and academia. He thanked the members of the committee for volunteering their time to the study and expressed his appreciation for the work of the National Research Council staff.

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THE IMPORTANCE OF THE STUDY

He concluded with some thoughts about the importance of the study. During an era of tight resources, he said, it was important to assure people that the public money going into the program, even though not large, was well leveraged by private resources. It is appropriate to ask how those resources are being invested, what the return is, and how to maximize that return.

The study also had an opportunity to shed new light on the "deeper" questions suggested by Dr. Wessner in his opening remarks, he said. "We are in an era of global competition. Our companies are competing with companies around the world. The MEP is one of the major ways in which we're trying to stimulate our SMEs to be productive, to export, and to train productive workers. In this era of global competition, we need to ensure that the MEP is configured in such a way that it can meet not only these CURRENT challenges, but future challenges."

Dr. Shapira reflected on the formation of the MEP in the 1980s, a program "that we've inherited and which we are now asked to address amid the much broader challenges of the 2010s. I think it's appropriate to ask, how should it be configured as we go forward? Is it the right size? Should it operate differently? How should it be integrated with other programs? I think these are the questions that we need to think about if we're going to be serious about global competition."

Finally, he said, a general concern has spread through the country that the United States is less able to make things than it is to finance and sell them. "We need to ensure that the MEP is contributing to our national objectives," he said, including the reversal of the current economic imbalance. "The MEP is a very concrete activity, and it can be a significant part of national strategy in the years ahead."

Dr. Shapira then introduced Sridhar Kota of the White House Office of Science and Technology Policy (OSTP).

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Revitalizing American Manufacturing

Sridhar Kota
White House Office of Science and Technology Policy

Dr. Kota said he would describe the Obama administration's priorities for advanced manufacturing, beginning with the assertion that "the President 'gets it' in terms of the importance of manufacturing." He noted the topic's high position among White House priorities, and quoted President Obama from the *Report to the President on Ensuring American Leadership in Advanced Manufacturing* that had been released by the White House in 2010: "When new technologies are developed and new industries are formed, I want them made right here in America. That's what we're fighting for." This report was written by PCAST, the President's Council of Advisors on Science and Technology, in response to the President's request.[10]

He referred also to *A Framework for Revitalizing American Manufacturing,* a report issued by the White House in December 2009 that laid out fundamental platforms for a revitalized manufacturing, including cost drivers, access to capital, training and education, tax policies, and investments in technology. In terms of technology investments, he identified in particular several items in the NSF budget to pursue funding for manufacturing technology and the creation of advanced manufacturing centers.

[10]According to the PCAST report, "Advanced manufacturing involves the manufacture of conventional or novel products through processes that depend on the coordination of information, automation, computation, software, sensing, and networking, and/or make use of cutting edge materials and emerging scientific capabilities." Executive Office of the President, *A Framework for Revitalizing American Manufacturing*, Washington, DC: Executive Office of the President, 2009.

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ADVANCED MANUFACTURING AS A PRESIDENTIAL PRIORITY

The PCAST report, Dr. Kota continued, had been shaped by the President's request to explore and identify opportunities and challenges in advanced manufacturing. He said that the report distinguished two common aspects of advanced manufacturing: the use of new abilities to create new industries, and the use of new abilities to strengthen existing industries. He emphasized that while these two aspects are not truly different, but tend to merge in response to innovative ideas, they provide a convenient framework to discuss technologies that are truly new from those that develop incrementally through the application of new techniques.

Many of the most innovative ideas, he said, including radical new technologies, were emerging from universities and federal labs, and leading to technology-based start-ups. For this process of innovation to create new industries, it usually must evolve through the stages of discovery, invention, technology development, scale-up, manufacturing, and finally commercialization.

A serious challenge faced by start-ups as they attempt to prove and scale up their technologies is to raise the financing they need to reach the marketplace. This is the familiar "valley of death," or investment gap, that must be traversed if a promising idea is to become practical and profitable. This journey can be speeded by early adoption by federal agencies or by partnerships with larger firms, but few other resources are available to even the most promising small firms.

The second aspect of advanced manufacturing, technology that sustains business growth that is more incremental in nature, is the more common use of R&D and the process that actually leads to most new products and practical solutions. Dr. Kota cited four "essential elements to grow and sustain existing industries." These include technology innovation, which may include both incremental and radical innovation; business innovation, which may influence adjacent markets and adjacent products; tools and resources, which include a skilled workforce at all levels and tools to improve quality, flexibility, and efficiency; and low structural non-production costs, such as taxes and regulations.

AN EROSION OF THE INDUSTRIAL COMMONS

Dr. Kota returned to the concept of innovation. A recent National Academies report, he said, has suggested that innovators are defined by three achievements: they are the first to acquire new knowledge, the first to apply it through world-class engineering, and the first to introduce it to a commercial or

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other market.[11] Traditionally, U.S. firms had excelled in being first to acquire knowledge, he said, thanks to the steady emergence of good ideas and "the best innovation infrastructure in the world." This excellence was fueled by the substantial ongoing investments by the federal government in basic research.

U.S. policy has been less successful in supporting the application of new ideas through engineering and the commercialization of new products in the market, Dr. Kota said. The United States has lost out in many cases to foreign competitors whose governments have devoted more resources and policy support for these two stages of innovation. For advanced manufacturing, the latter two stages of innovation require complex and enduring partnerships among universities, technical colleges, firms, research institutes, financing entities, and other links in the supply chain, known collectively as the industrial commons. He noted that the U.S. industrial commons is in decline, leading to the recent trade deficits in advanced technology products.

In the realm of manufacturing, the weakening of the industrial commons was reflected in some loss of the knowledge base, skills, and technology to make certain competitive products. He listed many products invented and developed in the United States that are no longer made here;[12] some of them cannot be made here, he said, because U.S. firms no longer have the engineering and application skills needed to scale them up and develop prototypes. Many other products in which U.S. companies were once dominant are today at risk, including LEDs for solid-state lighting, next-generation "electronic paper" displays for portable devices, thin-film solar cells, blade servers and mid-range servers, and carbon composites components for aerospace and wind energy applications.[13]

THE 'MISSING MIDDLE' OF INNOVATION: TECHNOLOGY DEVELOPMENT

If technology development is viewed schematically as a process beginning with scientific knowledge and culminating in output to the market, he said, the kinds of developmental skills needed to develop products for market

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[11]National Academy of Sciences/National Academy of Engineering/Institute of Medicine, *Rising Above the Gathering Storm, Revisited—Rapidly Approaching Category 5,* Washington, DC: The National Academies Press, 2010.

[12]Examples include products in the categories of semiconductors ("fables" chips), lighting (compact fluorescent bulbs), electronic displays (LCDs for monitors, TVs, and handheld devices), energy storage and green energy production (lithium-ion, lithium polymer, and NiMH batteries for cell phones, portable consumer electronics, laptops, and power tools), computing and communications (desktop, notebook, and netbook PCs; low-end servers; hard disk drives; consumer networking gear); and advanced materials (advanced composites used in sporting goods and other consumer gear; advanced ceramics; integrated circuit packaging). Gary Pisano and Willy Shih, *"Restoring American Competitiveness," Harvard Business Review*, July 2009.

[13]Ibid.

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are the "missing middle" of innovation. He showed an illustration indicating the strength of the U.S. federal investment in basic research, led by agencies such as NIH, NSF, and DoE. But this investment weakens in the stage of applied research, where the NSF virtually disappears, and in the development stage, where the DoD, NASA, and DoE are significant investors. By the stage of prototype and systems development, virtually all federal funding goes to the DoD, primarily for weapons testing. One way to view this imbalance, he said, was to tally the total federal investment in S&T—about $100 billion—with the annual trade deficit in advanced technology products—about $80 billion.

Dr. Kota cited the common misconception that the United States is falling behind in advanced manufacturing primarily because it has higher labor costs. While this might be true for many products, he said, from shoes to T-shirts, it is seldom true for high-technology products. He said that this point becomes clear in a comparison between the United States and Germany, which has higher wages than the United States. While German taxes are slightly lower than U.S. taxes, its energy and other infrastructure costs are about the same or higher. While the United States spends six times as much as Germany does in R&D investment, a significant distinction is that Germany spends six times as much as the United States on what is called "industrial production and technology." A result was that in 2008, the United States recorded an $800 billion deficit in manufacturing, while Germany had a $200 billion surplus.[14] "I think if Germany can do that, we should be able to do that, too."

CLOSING THE GAP THROUGH A CLUSTER APPROACH

Dr. Kota showed some global models for technology development, pointing out again the stage of basic discovery, "which is essential for the pipeline" and comes from the universities and federal laboratories. An important model for activities that occur in the "missing middle," he said, is the German Fraunhofer Institutes, which begin with research ideas and develop them through scale-up and prototyping to technological maturity. It uses a cluster approach with pilot production centers to close the gap between research and products. A variation of that model is seen in Taiwan, which does a "fabulous job of taking the best ideas from around the world and maturing them into commercially mature innovations ready for bio-sector investment."

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[14]Sources: (1) Bureau of Economic Analysis; (2) Daniel S. Hamilton and Joseph. P. Quinlan, *Germany and Globalization,* 2008; (3) NSF Science and Engineering Indicators 2010; (4) World Development Indicators database, World Bank, 2005; (5) Organization for Economic Cooperation and Development, Main Science and Technology Indicators, 2008; (6) Bureau of Labor Statistics, 2010; (7) Jeremy A. Leonard, "The Tide Is Turning—An Update on Structural Cost Pressures Facing U.S. Manufacturers"; (8) Manufacturers Alliance/MAPI and the Manufacturing Institute, November 2008.

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He returned to the PCAST report on advanced manufacturing, and one of its basic tenets: The maturing of an idea into a commercial product requires the participation of private industry; therefore, said Dr. Kota, the transition from ideas to products is expedited by public/private partnerships. This tenet, he said, lies behind some of the key PCAST recommendations, which grew out of more than a year of consultation with experts from the public and private sectors.

LAUNCHING AN ADVANCED MANUFACTURING INITIATIVE

Of the three recommendations, he said, one was to recommend that the S&T investment tax credit become permanent—a suggestion that has been made but not implemented for decades—and the other concerned the need to train more people for jobs in an advanced manufacturing workforce. The third recommendation was to launch an Advanced Manufacturing Initiative to support innovation through applied research—the "missing middle." In particular the Advanced Manufacturing Initiative would support:

- Innovation in advanced manufacturing through applied research programs for promising new technologies;
- Public-private partnerships around broadly-applicable and pre-competitive technologies;
- The creation and dissemination of design methodologies for manufacturing;
- Shared technology infrastructure to support advances in existing manufacturing industries.

In response to the report, the president announced an Advanced Manufacturing Initiative in June 2011. It contained a series of "commitments" representing a combination of ongoing and new initiatives to speed technology adoption and commercialization. These commitments, known collectively as the Advanced Manufacturing Partnership, include the following:

- Critical national security industries, including technologies "that will jumpstart domestic manufacturing capability essential to our national security";
- Materials Genome Initiative, which would invest more than $100 million in research, manufacture, and deployment of advanced materials;
- National Robotics Initiative, a multi-agency effort to support research in next-generation robots that will "work closely with human operators—allowing new ability for factory workers, healthcare providers, soldiers, surgeons, and astronauts to carry out key hard-to-do tasks";
- Innovative Manufacturing Initiative of DoE, to enable companies to cut costs of manufacturing while using less energy;

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- DARPA's Open Manufacturing Initiative to reduce a factor of up to five the time required to design, build, and test manufactured goods;
- NIST's Advanced Manufacturing Technology Consortium (AMTECH) to identify public-private partnership to tackle common technological barriers to the development of new products;
- DoD-Online Marketplace, to increase domestic manufacturing capacity in industries critical to national security;
- National Science Foundation's Accelerating Innovation Research program to support the transition of promising ideas into commercial reality, and the Innovation Corps (I-Corps), a public-private partnership to link NSF-funded researchers with technological, entrepreneurial, and business communities.

"Our good news," he said, "is that we have all this together. This is a good start."

Most important is to bring all the other universities and companies under the tent, he said, which was being stimulated by a series of four Advanced Manufacturing Partnership (AMP) workshops at Georgia Tech, MIT, University of California at Berkeley, and the University of Michigan. "This is a call to action to come together and look at the structural challenges," he said, "to see how we can collaborate on technology development and what the skills and educational opportunities we need to tackle."

Dr. Kota reviewed manufacturing competitiveness in terms of the tools and resources needed. In 2009 the government launched an interagency report on modeling and simulation tools to determine what was available, what was being used, and what the barriers to their use by companies were. The study found that modeling and simulation (M&S) tools had the potential to improve all three key manufacturing metrics: cost, quality, and time to market. However, it was found that the majority of SMEs do not use M&S tools because of two key barriers: they are expensive, with an M&S software program alone costing about $40,000, and they require staffing by a masters-level technician. It was difficult for SMEs to see this as a value proposition.

'DEMOCRATIZING' THE USE OF ADVANCED MANUFACTURING TOOLS

In response, OSTP launched a pilot program, working with the Economic Development Administration (EDA) in the Midwest. Known as the National Digital Engineering and Manufacturing Consortium, this public-private partnership was begun with a modest investment of $2 million by the EDA, matched by $2.5 million from P&G, Lockheed, Boeing, GE, and John Deere. The goal was to set up a program to "democratize" the use of M&S tools by SMEs. It began by using a simulation program based on software originally developed by Los Alamos National Labs that had allowed P&G to save over

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$500 million in the last decade in its diaper manufacturing process. The program created a web-based tool using cloud computing and making open-source codes for the SMEs that are easy to use, along with interactive applications and templates developed by a manufacturing company that was launched recently. This new "software-as-service" business model is expected to make it a lot easier for small firms to run model simulations, use the tools, and see the value of M&S. The model uses a standard graphical user interface across applications, requires no software to download or install, allow sharing of live work sessions, and offers easy access to supporting content. "That's just the tip of the iceberg," he said. "Democratizing digital manufacturing is what this initiative is about, and in Ohio and Indiana there are some really great companies that are poised to take advantage of it."

Reviewing the MEP centers, Dr. Kota said that their role was more critical than ever in providing the "glue" between the SMEs and the resources that are being developed by the new manufacturing initiative. MEP centers can be the first to identify challenges and then find the resources to address these challenges, he suggested. He added, in closing, that MEPs can play an expanded role as well, in two ways. First, to advance manufacturing competitiveness, the MEP can help democratize and accelerate the use of modeling and simulation tools by SMEs. Second, to advance manufacturing skills, the MEP can help bridge the skills gap by engaging with community colleges, the Manufacturing Institute, Original Equipment Manufacturers (OEM), and SMEs. In other words, the MEP can have an even more important role in strengthening the innovation clusters that are seen by many as central to the revitalization of U.S. technological leadership.

DISCUSSION

Dennis Chamot, of the National Research Council, said that in the past, the major suppliers of skilled workers were the trade unions. He asked whether they would be able to do so again, despite their diminished role in manufacturing. Dr. Kota said that he was not a labor expert, but acknowledged that "labor surprises" of various kinds were likely. When the National Robotics Initiative was launched, for example, many people thought that the robots would displace workers. That was not the case, he said; the robots turned out to be "co-workers," supplementing the abilities of the human workers. The labor unions recognized this and in fact had written letters of support for the National Robotics Initiative. "Without these robots," he said, "you wouldn't have any of those jobs." The unions came forward to help train workers and help to advance the development of robotics technologies.

Dr. Shapira said he was impressed by the Advanced Manufacturing Partnership, but that with so many federal agencies involved, it was not clear where the SMEs fit into the picture. The MEP, for example, already has an infrastructure that is national in scale, and offers direct assistance to SMEs. He wondered how this ongoing program was related to the DoE's new $120 million

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initiative to expand energy partnerships with companies—an initiative that would be required set up its own new infrastructure. What consideration, he asked, was given to scaling up a selective number of SME resources instead of distributing resources across a variety of federal agencies?

Investments Aimed at the Innovation Gap

Dr. Kota agreed that there was not enough money to spread it widely, and he added that the importance of a program lies not in how much it spends, but in how strategically it allocates its resources. The investments he had mentioned, which were recommended by the PCAST report, were aimed at the "missing middle," the innovation gap. The DoE's objective would be to develop strategies for moving ideas into commercialization. "One of the things DoE will do is set up public/private partnerships to develop the manufacturing technologies and shared infrastructure for nanotechnology and other advanced manufacturing. That's a different focus than the MEP, which enhances the competitiveness of existing companies."

Dr. Wessner said that a perceived advantage of MEP is its distributed nature and engagement with local and regional firms. He asked whether there would also be advantages if MEP were adapted to help manufacturing with "heavy, direct investment" or with incentives to strengthen manufacturing clusters. He noted that one barrier to collaboration among separate agencies is that "everyone wants to act separately so they can control how their funds are spent."

The MEP's Unique Role in Adding Value

Dr. Kota suggested that the MEPs play a unique role, "and they're the only ones that can play that role, and they do it very well." Other agencies have other roles in helping the translation of technology, he said, and were focusing on the clusters and the public- private partnerships that develop the technologies. "Once you have a technology, the MEPs play an important role in terms of business and technical assistance. The MEPS do even more in adding to the value chain, simulation, prototyping, and thinking about scaling. We already have MEPs, and they can help us."

Dr. Wessner asked what level of funding would be needed to fully fund a robust advanced manufacturing sector, and whether the United States should build some version of the Fraunhofer Institutes. Dr. Kota said that PCAST had suggested investing $400 million per year in advanced manufacturing. He also said that the United States could build its own public-private partnerships, deciding which if any elements of the Fraunhofer model might be helpful here.

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Panel I

Introduction to the Manufacturing Extension Partnership: System Development and Strategic Orientation

Moderator:
Ginger Lew
Three Oaks Investments

Dr. Lew, who was Senior Advisor to the White House National Economic Council and to the Administrator of the Small Business Administration until September 2011, is now CEO of Three Oaks Investments, a consulting firm that provides advice to emerging companies. She began by thanking Dr. Wessner and Dr. Kota for providing a framework for some of the administration's initiatives, and said that this panel would attempt to explore a specific policy framework for the MEP. The subsequent speakers would then be invited to fill in gaps of opportunities and challenges. Dr. Kota's remarks, she said, demonstrated that the administration does understand the importance of innovation, and of funding basic research.

THE NEED FOR MORE CLUSTERS AND INTERAGENCY COLLABORATION

"As a civilian," she said, she would make some additional comments. First, she said, the nation continues to miss opportunities, such as the need for more public-private innovation clusters. It also needs more inter-agency collaboration in order to optimize its leveraging of existing agency dollars, initiatives, and programs. She suggested that the MEP study examine whether the program should in fact position itself as a hub for agency coordination. The MEP's own budget is modest compared with the "giants," such as DOD, but it "provides the critical function of translating the pre-commercial research that the government invests in, and taking it to the marketplace."

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Dr. Lew underlined the urgency of the panel's task by reminding participants of how much ground the U.S. manufacturing sector has lost to foreign competition in recent years. In the 1950s, manufacturing's share of the GDP peaked near 30 percent. Today its share is about 11 percent, a decline that accelerated after 2007. The United States is still the world's largest manufacturer, with a global share of about 22 percent of global output, but "it faces more challenges from around the world." There is a growing awareness in this country that thriving manufacturers are critical to America's economic recovery. "As the president has said, we've got to go back to making things." The United States cannot completely move into a knowledge- and services-based economy, she said; it also has to produce tangible assets.

THE 'TREMENDOUS RISKS' THAT FACE NEW TECHNOLOGY FIRMS

A challenge for many American businesses, she said, is to gain access not only to technology, but also to capital. "We keep saying the U.S. government will invest in high-risk technology, but translating that technology into marketable products that consumers will buy requires sustained financial support." She cited the demise of the solar energy company Solyndra as an example of the "tremendous risks" that face new technologies. "We can invest all this capital in the early stages," she said, "but if the private markets are not stepping in to fill the gap from there to the market, we can be throwing billions of dollars down a black hole."

Dr. Lew said she spoke partly from her experience as a venture capitalist in Europe, where governments offered incentives to accelerate the development of promising technologies, including solar, wind, and bio-fuel products. When government subsidies and tax initiatives ended recently, she said, no private investors were willing to step in. The high risk had caused them to pull back, and she predicted that this lack of capital would become a greater problem in the future.

This raises the question," she said, "of what type of assistance the MEP can and should provide to companies." She described her recent visit to China, where she witnessed evidence of "its stunning economic growth," increased GDP, and rising per capita income. She said she saw an "explosion" of universities and "unabashed government investment in R&D." After touring some SMM facilities, she said that "clearly China is on a march to become a global giant in the manufacturing sector. That is a formidable competitor for the U.S. to face." The United States must be equally aggressive, she said, and one contribution of the MEP evaluators could be to suggest ways to maximize the program's benefits and enhance the SME client base.

Dr. Lew then introduced the next speaker, Roger Kilmer, director of the MEP, who had requested the Academies' study. She expressed the committee's thanks to Mr. Kilmer for "his visionary leadership" at MEP since 1993, and

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applauded his commitment to make the MEP more "strategic and relevant in this shifting environment."

THE MEP IN THE INNOVATION CHAIN

Roger Kilmer
Manufacturing Extension Partnership
National Institutes of Standards and Technology

Dr. Kilmer thanked Dr. Lew for her service, and said that he looked forward to the Academies' study as a complement to the feedback already gathered by the MEP from its manufacturing centers across the country. It was also important to have the same kind of conversation from a policy perspective that the Academies could provide, and to educate the public on the mission and accomplishments of the MEP.

The MEP was created in 1988 specifically to make useful technologies more easily available SMMs.[15] He noted a gap between the needs of these SMMs and the perceptions of those who invent or develop technology. For example, the kinds of technologies he had worked with at the National Institute of Standards and Technology (NIST), such as advanced manufacturing robotics, were not needed by small manufacturers—and this continues to be largely true today. "I think there's a lack of understanding of what the SMMs need, what expertise they have, and what constraints they have. Many technologies are aimed at a different set of folks than those the MEP deals with."

With that perspective, Dr. Kilmer said, the MEP created a system of centers around the country on a partnership model. By legislation, MEP centers can provide only a third the value of the services they provide, with the balance coming from industry and state partners in their region. The MEP must also work with larger manufactures, and once a project is identified, it charges a fee for its service.

The MEP Depends on Partnerships

The MEP is a relatively small program, Dr. Kilmer added, so that partnerships are necessary. The total headquarters staff numbers about 45 people who focus on setting strategy, evaluating the needs and demands of clients, helping facilitate the development of tools, and "gluing together the centers into a network that can share best practices." More broadly, the MEP has about 1,300

[15]NIST defines a small or medium-sized manufacturer as one with fewer than 500 employees.

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staff distributed among its 60 nationwide centers. This staff relies heavily on local partners to deliver services tailored to the needs of manufacturers. [16]

"Part of our evolution," he said, "was to change from offering a technology push, where we knew about which technologies work in a federal lab, to looking at what manufacturers really needed. It also meant learning to look at the entire manufacturing enterprise—not just the tech piece of it, but everything else: the financing, workforce development, marketing, and sales."

Helping Both with Short-term Needs and Long-term Strategy

During this evolution, Dr. Kilmer said, the MEP began to rely more on local resources. While this is "a little confusing to us from a national level," the key thing is that manufacturers recognize local entities as the source of manufacturing assistance. The MEP centers themselves may function as an advisor, consultant, and/or matchmaker, helping small manufacturers address their short-term needs in the context of a long-term business strategy. The center helps companies set priorities and make the incremental changes that a small manufacturer can afford in terms of both cost and time. To date, the centers have worked with some 30,000 SMMs on more than 9,000 projects.

He said he was proud of the degree to which the MEP understood its manufacturing clients and the features of the manufacturing world. In the first decade after MEP was founded, its task was to create the centers and begin operations. Then in 2000 it shifted into connecting and integrating individual centers into networks. The first decade of this century saw a revolution in productivity for the SMMs, but MEP leaders believed that productivity alone would not be sufficient; companies needed to think about strategy as well. Accordingly, the MEP began to advocate a focus on future priorities.

Moving from a One-on-one Approach to the Community Context

Today, Dr. Kilmer said, the program is moving from its traditional one-on-one approach to more collaborative activities, such as encouraging hubs, clusters, and community partnerships. The E3 Initiative specifically looks at the community context, including all the elements that affect a small business.[17] These changes were stimulated by feedback from clients and reported to the

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[16]MEP centers are structured in various ways. "Most MEP centers are not-for-profit corporations (501(c)(3)) affiliated with state governments, or affiliated with universities." U.S. Government Accountability Office, *NIST Manufacturing Extension Partnership Program Cost Share*, GAO-11-437R, Washington, DC: U.S. Government Accountability Office, 2011.

[17]E3 provides the framework for government agencies to establish and collaborate on an Economy, Energy, and Environment Initiative. E3 projects are public-private partnerships that are driven by communities to assist manufacturers in becoming more sustainable, competitive and energy efficient.

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headquarters by the centers. The E-3 program also takes into account the changes in manufacturing itself, including globalization, and its dual aspects of competitive challenges and export opportunities. Other changes included the greater attention to supply chains, technology innovation, and new ideas coming from outside manufacturing.

Innovation is a principal driver of manufacturing change and a key to profitability, he said, and MEP responds by helping small manufacturers to develop product/process and business model innovations. While technology itself directly improves manufacturing processes, it must be incorporated into products in ways that differentiate them from competitors' products. Another key, he said, is sustainability—ways in which a company can benefit by using sustainable practices, including those that benefit the larger community and society.

The MEP Strategy

The overarching strategy of the MEP, Dr. Kilmer said, is to increase the capacity of manufacturers to be innovative so as to drive profitable sales growth. For more than a decade, the MEP has focused on promoting lean manufacturing, quality and cost effectiveness. While those are still key services delivered by the MEP centers, they are today considered not the end of the journey, but the beginning. The new challenge is to look at the other side of the business ledger, he said: "How do I grow the company? How do I get new sales with existing products? How do I get into new markets by exporting? Most important, how do I develop new products either by working with new supply chains or technologies built into other things I currently do?"

He said that these new concerns have been summarized under five key areas:

- Continuous improvement.
- Technology acceleration.
- Supply chain.
- Sustainability.
- Workforce.

An essential point, he said, is that all of these functions are interrelated and must be developed in an integrated fashion. "When we're working with a company, it is not just about the supply chain piece or the workforce piece. All of those have to be built into a strategy the company can implement."

A challenge for manufacturers today, Dr. Kilmer said, is to sort through the many programs available to manufacturers to find what is most useful. Most assistance programs are designed for large manufacturers, who already have the resources to make changes and benefit from them. "A lot of it has to do with how we get to a strategic level with SMMs rather than just fixing problems," he

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said. For a manufacturer, there are many steps to transferring a good idea into a saleable product or process. One step is to put the new technology to use not only in one market, but in multiple places. Another is to apply the incremental advances in technology in different circumstances and places. Finally, the MEP, as a national program, faces the challenge of sharing the lessons learned and best practices across the system to improve economies of scale and leverage its efforts. "The MEP's role in this innovation chain is really to advise the manufacturer, helping it to assess different opportunities and challenges to make strategic decisions. It is also needs to be connectors that can help SMMs find the other resources and components it needs."

Connecting Firms with Resources to Develop and Sell Their Product

Given the diversity of the MEP's centers across the county, Dr. Kilmer asked, "how do I develop a system that can help all of them as they help manufacturers?" The centers need to help firms create new ideas, discover market opportunities, and find the right tools to drive the ideas into development and production. "That's been our focus," he said. "How do I help companies very quickly and very cheaply? We're usually talking about small manufacturers that don't even have an R&D budget, but they need to determine whether or not this is something that, one, will work, and, two, has a market. If the firm reaches that point and the answer is yes, how can I connect them with resources to do the development and commercialization, get it into production, and move out into the market?"

Some cutting-edge elements for success, he said, are access to modeling and simulation tools; a CEO of the company who leads and drives the process; continuous innovation to keep a pipeline flowing with ideas; and consistent incremental improvement, especially for the smaller firms. "Our centers can't just hit the switch once and leave. You have to help them through this whole process as they continue to innovate and make changes."

Services Developed by MEP

Dr. Kilmer listed some examples of the services and tools developed by MEP. For technology acceleration—to actually get technology into the hands of small manufacturers—there were many links, including places where an organization may perform basic research, applied research, technology transfer into a product or service, and then manufacturing. While this process is often called a chain, he said, the image is not strictly accurate; there are many branching components situated in many organizations. For MEP, he said, the challenge has been how to partner, translate, and communicate with all the organizations and elements on those branches. These partnerships are often based on what technology is doing to manufacturing, or on how the manufacturers can adjust to the technology.

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One tool the MEP helped develop is the National Innovation Marketplace, an online resource of technology solutions identified in universities, federal labs, or institutes. It allows centers (and anyone else) to find and use technologies that can help them improve their products or processes. It can also be used by those in the market for a technology or a manufacturing capability. For example, the E3 tool mentioned earlier can help develop sustainability, a community-based approach involving utilities, local communities, manufacturers, and economic development groups.

"We really are the connector between the manufacturer and the technology source," Dr. Kilmer concluded. However, the manufacturer needs to handle not only the technology, but also product development, commercialization, IT management, financing, and scale-up. "MEP is the partner that tries to help develop those tools and innovative approaches that keep that process alive and moving."

REPOSITIONING THE MEP SYSTEM TO MEET THE GLOBAL MANUFACTURING CHALLENGE

Mark Rice
Maritime Applied Physics Corporation
and MEP Advisory Board

Mr. Rice began by describing the MEP advisory board, of which he is the chair. In 2007, the America Competes Act changed its makeup from primarily academic members to mostly manufacturing members. Today, the 10-member board has seven CEOs of manufacturing companies and three members from academia.

Mr. Rice said that he had been a board member for four years, and that it had taken him that long to understand the MEP system. "It's a large, complex system," he said, "that does some wonderful things that are truly hard to appreciate until you get into the depths of what each center does."

The Link Between Manufacturing and Innovation

As a product of the 1960s and 1970s, "the Apollo generation," Mr. Rice said that he had grown up with a strong understanding of the link between science and innovation. "But what that generation did not gain was a strong understanding of the link between manufacturing and innovation. It's when I travel to Germany or South Korea that I am impressed with the engineers there and their understanding of that link." He did not find that understanding in American universities, he said. One reason he had decided to join the MEP board was his conviction that the program could help build this understanding through better communication with the nation's engineers and engineering students.

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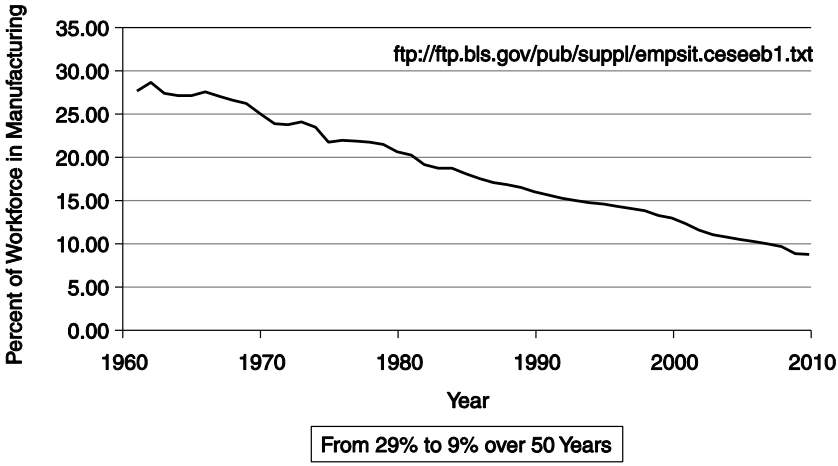

FIGURE 2 Decline of manufacturing jobs as a percentage of total U.S. workforce.
SOURCE: Bureau of Labor Statistics.

He began with a brief sketch of the context of manufacturing employment in the U.S. In the last 26 years, he said, U.S. manufacturing had lost eight million jobs.[18] The manufacturing workers, with the percentage of the workforce in manufacturing population as a percentage of the total U.S. workforce had declined from 30 percent to about nine percent over the same period. Most of the loss came from companies with more than 500 employees. While about 99 percent of all manufacturing firms today have fewer than 500 employees, only 40 percent of manufacturing employees work for those small firms.

The balance of trade of goods and services has also deteriorated, with the balance shifting away from trade in goods and toward trade in services.[19] This trade deficit has been associated with a loss of about $7 trillion dollars from 1992 to 2010. For manufacturing as a percentage of GDP, the U.S. portion of GDP from manufacturing has dropped from about 18 percent to about 13 percent. In the same period, the manufacturing portion of GDP has risen.

Other Countries Outspend the United States by Wide Margins

Similarly, an analysis of exports by company type and employment size shows that 82 percent of all manufactured exports came from companies that

[18] *<http://www.ces.census.gov/index.php/bds/sector_line_charts>*.
[19] *<http://www.bea.gov/international/index.htm#trade>*.

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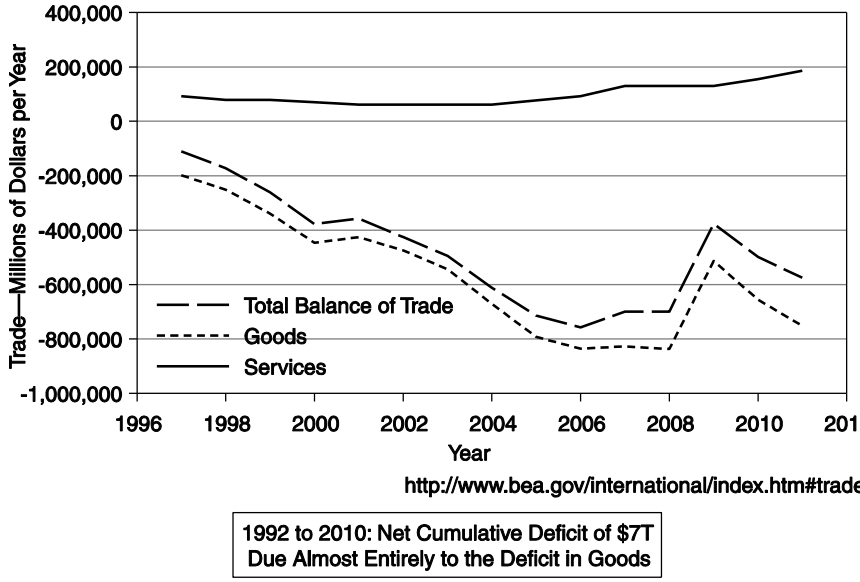

FIGURE 3 U.S. trade balance in goods.
SOURCE: Bureau of Labor Statistics.

had more than 500 employees. He noted that recent reports by the Information Technology & Innovation Foundation (ITIF) further characterized the crisis by showing that Japan, Germany, and Canada all outspend the United States on manufacturing programs by wide margins, although program differences make direct comparisons difficult.[20]

Mr. Rice offered a historical example of how the MEP may have the ability to strengthen manufacturing in the United States. He said that his company had attempted to open an export operation in South Korea, but "made a lot of mistakes" and had to halt the effort. Much chastened, he returned home and decided to meet with his local MEP center, the local export assistance center, and the Small Business Association. Out of that meeting came not only financial assistance, but also further discussions with the MEP center, which realized that many small firms trying to begin exporting would have similar problems. The MEP center, collaborating with SBA and the export assistance

[20]According to the ITIF, "...Germany's and Japan's experience belies the received wisdom that manufacturing as a share of GDP is falling in most advanced economies over time….Clearly, Germany and Japan's SME manufacturing support programs have played an important role in sustaining the strength and vitality of their nations' manufacturing sectors over the past forty years." *<http://www.itif.org/>*.

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center in Baltimore, developed a course for potential exporters. "They saw a need," he said, "they jumped in, and they paid for the course curriculum development. Our company took the course, piloted it, and introduced it through the MEP centers."

The Public-private Partnership Model as the Future of MEP

By now, Mr. Rice said, about 400 CEOs have taken the course, written their own business plans—with federal help—and are engaging in trade missions and exporting around the world. This is the kind of project, he said, that the MEP system is good at—bringing several federal agencies together to meet a need. "This is very tough to do from Washington," he said. "It's easier to do from the field through an inter-agency solution that is delivered through a public/private partnership that has skin in the game. So the public/private partnership model represents the future and the strength of the MEP system." Its strength, he added, was in its grass-roots nature, and its ability to "pull" the technology and the need out of the manufacturer, address it with state and federal help, and then distribute it through 60 centers.

He said that his "enthusiasm for public-private partnerships had grown immensely" through his exposure to the MEP system. The different perspectives of companies, state government, and federal government "inherently separate these functions," so that a strong force is needed to "drive them back together." That force, he added, needs to be based locally, not in Washington; "it can't be a federal program that's pushed down from the top. It has to be something that's out listening to the clients, the state, the cluster, the manufacturing sector. We're an extremely varied country, and this thing is not the same across the country." He also said it was important that "no entity has full control." Bringing all participants together is an "immense job," he said, and the MEP performs it well.

Mr. Rice said that the MEP's oversight role brings it into effective contact with both small and large companies. He recalled his own participation in a partnership that included Amtek, a large automotive supplier, as well as other large and small companies. "That marriage of small and large value chain thinking in the formulation of a program, and its delivery through a network of centers, is really the magic of this program." He said it resembled the Fraunhofer program of Germany as adapted to U.S. customs, and encouraged the attendees to "think about what public/private partnerships can be, not just what they are."

The Manufacturers Need to Have 'Skin in the Game'

The disputes that arise within the centers, he added, "are part of the landscape," and inherent to the public-private partnership process. He encouraged the audience not to focus on them, because "these are tough things to manage and disputes are part of the system. The beauty of the MEP centers is

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the manufacturers having skin in the game. The needs of the clients and the pressure from the federal government meet in the middle, and that middle ground is where the magic and the chemistry takes place."

Mr. Rice also praised the feedback mechanisms for the MEP. The use of the national advisory board by Mr. Kilmer's office, he said, was paralleled at the local centers, each of which has a local advisory board. He said that for national issues, he had "felt completely comfortable" telling Mr. Kilmer when he thought a policy was wrong, and vice-versa.

A strong feature of the program, he said, was the diversity of the centers, and the way the program accommodates that diversity. "In a sense," he said, "this mirrors the way this country works. It isn't a really top-down system, it's one that embraces all parts of this 'living organism' and tends to evolve as a result."

Mr. Rice turned to "some repositioning recommendations." He began with funding, which he said should be about four times as large as it is at present. This would allow expanding the interagency links, which at present don't always work smoothly, and continue to increase the competency of the center staffs, including addition of more scientists and engineers. It would also allow rotation of the federal, state, and local staffs between positions, strengthening linkages by bringing in new perspectives. Another recommendation was for the program to continue the state match at current levels. This is difficult to do at a time of tight state budgets, "but state involvement in this is absolutely critical to the success of this program. The state brings a perspective that neither the federal government nor the local company can bring."

Technology Transfer is 'Where We're Falling Down'

The program needs to improve its ability to facilitate technology transfer, he said, which is "where we're falling down." One model of effective technology transfer is the German version, but suggested that the Korean programs "may turn out to be closer to our business model than the German one." What the Koreans have done is to link manufacturing to innovation, using science to support rather than drive the process. This approach can benefit from additional partnering of industry with federal labs, he said, adding that this model can overcome a major weakness in the U.S. system. "We do a great job of innovating, we do a great job at science, but we don't do a good job at technology transfer."

Mr. Rice urged more attention on consortia as bridges between federal labs and industry, but these consortia need to embrace the full range of the manufacturing sector, not just a few large firms. "Some of the novel thinking about the evolution of contracting is right where public/private partnerships operate. We don't have the legal structures in place to regulate these partnerships as part of a procurement chain, but we ought to think about it. Because that's where we're getting beaten." A centralized economy doesn't

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have that problem, he said, and is able to "just blow through it." One U.S. advantage, he said, is that the MEP centers provide a brokerage function and can interface between agencies and governments, both large and small.

"I'm a big advocate for what the MEP is," Mr. Rice said in closing, "but I'm a bigger advocate for what it could be. I sense that it is the essential missing piece for the evolution of this tech transfer process through public-private partnerships. It needs to be linked to a strategy—not a Fraunhofer strategy, or a Korean version per se, but an American strategy. The beauty of the American system is the diversity we bring to these problems. Let's embrace that and figure out how to make it work on a local, state, and federal scale."

DISCUSSION

Diane Palmintera of Innovation Associates said that when she talks to MEP directors around the country, they say that while they applaud the effort of MEP to move toward innovation and technology, their staffs are not always prepared to coach firms on tech transfer and innovative technologies. Mr. Kilmer agreed, and said that the MEP has been working on a training curriculum related to innovation. "Quite honestly," he said, "it's a difficult thing for the centers. Some staff will be able to make those changes and some won't. We try to equip them, with training and professional development, but it is a challenge."

Dr. Wessner followed up on that question, asking how much authority the federal MEP office had to revise programs or strategies in the centers, and whether any centers had been discontinued over the years. Mr. Kilmer said his first approach was to show centers how a new or revised program would benefit the manufacturing clients; this might be accompanied by a performance evaluation. There have been a few cases where the national office has had to close down centers, but it plans to reopen them. "It is very much is a process of leading, dragging, and in some cases, stronger action," he said.

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Panel II

A Differentiated Program: New Center Initiatives

Moderator:
Edward Breiner
Schramm, Inc.

Mr. Breiner introduced his perspective on the MEP in terms of personal experience. In 2000, he had left his position with a large manufacturer, Ingersoll-Rand, a Fortune 200 company, to a small, family-owned business, Schramm, Inc., a manufacturer of drilling rigs in Chester County, Pennsylvania.[21] From then until 2004 he was charged with managing the transition of that business, including a leveraged buyout. He was coming from an environment accustomed to bringing in consultative resources to look at operations with fresh eyes, he said, but when he arrived at Schramm, he found a very different environment, in which outsiders were regarded as anathema. Fortunately, he said, he was introduced to people from the Delaware Valley Industrial Resource Center (DVIRC), the local MEP center, who understood his predicament.

Action was urgent, he said, because his new company had little profit and very low growth in sales. He needed help, and quickly found that the DVIRC consultants were able to help him set up several valuable initiatives, starting with some lean manufacturing principles and ultimately the hiring of a "lean expert."

Mr. Breiner then, under their guidance, proceeded to strategic planning, bringing in a consultant on a quarterly basis to facilitate the process. "This allowed me to be a participant, rather than trying to herd the cats," he said. Then about two years ago he was visited by an MEP marketing advisor from Proctor & Gamble who "taught us some 'marketing physics' in very powerful,

[21]Schramm, Inc., is notable for having developed the drilling rig responsible for helping rescue the 33 miners trapped for 69 days in the Copiapó copper mine in Chile in 2010.

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clean language." He learned how to demonstrate "why a customer should want your product and how to convince the marketplace that your product is differentiated from others." Most recently, the DVIRC helped Schramm do a professional customer survey.

"I hadn't done a customer survey of that quality since my days at Ingersoll-Rand," he said, "when we paid a group a very large sum of money. So, for MEP, I like the price and I like the service, and it's very important to me personally and to our company. I might add that 50 to 70 percent of our product is shipped overseas."

With that Mr. Breiner introduced the panel and welcomed the first speaker.

A DIFFERENTIATED PROGRAM: CMTC CENTER INITIATIVES

James Watson
California Manufacturing Technology Consulting

Mr. Watson, who leads California Manufacturing Technology Consulting (CMTC), began with a sketch of manufacturing in California, where there are 44,000 manufacturers. These firms employ about 1.2 million workers. This number, he said, is down from 1.6 million at the beginning of the decade as the state lost companies to other states, including Nevada, Arizona, and especially Texas. Even so, California remains the ninth largest economy in the world and manufacturing will always be important in the state, which continues to have the largest concentration of manufacturers in the United States.

He showed a map of the state that provided an approximate location of the state's major industries. The southern part of the state is where the aerospace and defense industries are located; in the center is the food processing industry; in the north is the high technology industries; and in the desert is a growing renewable energy industry. The key part of the illustration, he added, were the palm trees in the sunshine. "For most of our manufacturers, the quality of life is the main reason they're here. Without those palm trees, I'm not sure we'd have 44,000 manufacturers in the state today."

While there has been "very little job creation" in recent years, Mr. Watson said that the CMTC had made contributions to retaining jobs over the last couple of years, and for every job saved, about 2.5 non-manufacturing jobs were supported. "We think that in the years upcoming we're going to see a little bit more job growth," he predicted. "We're already beginning to see some companies begin to hire, although it's not yet on a broad base."

According to CMTC surveys for calendar year 2010, manufacturers had invested some $130 million in the last year. "That's good for us," he said. "I always like to see that because it means manufacturers are reinvesting in themselves, and the more they do that, the better they can compete and the more likely they are to stay in California." The surveys had also revealed some $359

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million in increased sales, which means "they are selling more than they were before. Our hope is that as sales increase, jobs will increase as well."

Client Satisfaction

A final point from the survey was "a very high client satisfaction rating with our customers." He said that this result had been recognized by the state, and that CMTC is being positioned as the "go-to organization" for anyone with manufacturing issues. In California, the state receives notification when a company is deciding to leave, and "we participate on red teams that to go out and try to keep those companies here."

In applying strategic priorities, Mr. Watson said, "the most important thing at our center is creating our own culture of innovation." This was a difficult challenge for both the center and its customers. The CMTC has launched an internal program called Innovation Station to which all employees can contribute ideas. Those ideas are tracked, and the contributors are recognized when their ideas lead to improvements. He said he is hoping to take some of the best practices from the Innovation Station and disseminate them more widely, both internally and externally.

Another goal is to expand the number of new customers. In calendar year 2010, more than 687 customers were surveyed, but "our penetration needs to improve." The company is now focusing on new sales approaches, with an emphasis on partnering to reach more clients. "We can only reach so many customers alone," he said.

Increasing Market Share for California's Small Manufacturers

One sector drawing concern is food processing, a backbone of the state's economy and the dominant activity for the middle of the state. "The food processing business for us was considered essentially bullet-proof," Mr. Watson said. "I was amazed the other day when I went into the market and found a lot of fresh produce that did not come from California, and it was not seasonal. There were tomatoes from China. So we're going to really focus on food processing, because it appears to be the next area that's going to have a serious problem."

CMTC has been active in sales and marketing, but a primary focus is export. He said that he had worked in manufacturing, and like the previous speaker, had made his own mistake when he first tried to export manufactured products. He said that of small manufacturers, 80 percent of them do not export at all; of the 20 percent that do, most export to only Mexico and Canada. So his company will emphasize export even more vigorously because of the "big, big changes coming to manufacturing in California." Many business models are beginning to change in terms of product mix, how products are manufactured, and where products are sold. This effort will include the emerging importance of "re-shoring," or bringing jobs back to California. "A member of our board of directors recently brought jobs back to California," he said, "because he did the

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arithmetic on total cost of ownership, and found it was much more efficient for him to have products produced in California than in China or South America."

Mr. Watson said that an advantage for his company is its nonprofit status. It does charge for its services but its primary mission is not to maximize profit but to take care of its customers. "When a customer first meets us," he said, "the first questions we hear are, 'How long are you going to be around?' and 'What are you going to charge?' We've been able to forge relationships with many of our customers that are beyond money. Our mission is all about making manufacturers more competitive, creating trust and building jobs."

CMTC's Mission

He described the CMTC's revised mission, which is "to create solutions for manufacturing, growth, and profitability." There is no point in growing, he said, without profit. We try to show customers how growth goes to the bottom line of the organization, which improves competitiveness and creates jobs. He drew a line between what customers focused on and what CMTC stakeholders focused on. Customers think about competitiveness, he said; they are not interested in adding jobs. Stakeholders, however, are interested in adding jobs. "And if we create a competitive environment and a firm sells more, they will hire more. Then we can take care of not only our customers, but federal and state stakeholders as well."

Mr. Watson said that CMTC tries to reach these multiple objectives by using a "comprehensive suite of services," delivered both internally by staff and externally by 50 to 60 third-party providers throughout the service area. "We are essentially a one-stop shop, and when we work with a manufacturer, they don't have to look anywhere else. We'll help manufacturers strategically from where they are today to where they want to go tomorrow, and they don't need to step outside of CMTC."

The CMTC distinguishes itself in many ways, said Mr. Watson. It emphasizes hands-on consulting. "We don't do reports. We don't leave them with a bunch of stuff to read. We work with them through facilitation and coaching with hands-on assistance on the plant floor or in the board room to help them take whatever action they need to take. And we'll stay to make sure they sustain it as well." Additionally, CMTC understands and promotes the value of the public/private partnership. "We use that because we probably have a relationship with most of the major community colleges in southern California. Most of the other business organizations, including SBA, are partners. We have probably the largest network of third-party providers that handle manufacturing in the state."

Another differentiator is that it focuses only on manufacturing. A number of other organizations advise small businesses, but "there's a difference between small business and manufacturing." Other organizations, he said, focus on every kind of business, from banks to fast-food companies. Because CMTC

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is well known for its focus SMMs, it has been able to attract and construct a partner network to help with outreach and access to manufacturing.

Tailoring Outreach to Small Manufacturers

"This is a very difficult market to reach," Mr. Watson said. SMMs can be late adopters, and as a result the amount of time it takes to find them and to convince them that they need to make a change means that we need a lot of partners to help us." The company's average field technician has 25 years of experience in manufacturing, as do many third-party associates.

Several years ago, CMTC was becoming concerned that improvements the companies were making did not last. "There's a lot of evidence that if you don't have the culture in the right place, the minute the pressure is relieved it begins to revert to its previous state." We began to train our consultants on change management. In promoting change, we concentrated on senior management, because we realized that unless the leadership understood the challenge and built a communication plan, there was little hope of success. "If they fail, they're going to wonder about our services; it will affect our client satisfaction rating, it will affect how we're evaluated, and most of all, the company won't sustain their improvements."

Mr. Watson spoke proudly about an export initiative that arose when the Port of Los Angeles came to them with a problem. The port is among the largest in the United States, and its problem was that despite a great deal of training and many workshops, they were unable to follow up and help small manufacturers improve their export capabilities. CMTC created the Export Exchange, a group of organizations in Southern California that can be deployed when needed to help a manufacturer. Previously, there had been export assistance for California firms, especially in Los Angeles, but it had focused on technical issues and tools, rather than strategic planning. "Without a plan," he said, "all the techniques and tools are meaningless. The format of the seminars was in some cases running people off by telling them how difficult it was to export. The Export Exchange is not about how difficult it is, but how you have to develop a plan to export. We organized the workshop in a way that showed you how to succeed."

A Focus on Sustainability

The CMTC tried a "layoff aversion" approach, beginning with a dozen Workforce Investment Boards (WIBs) of the Department of Labor. When CMTC found that manufacturing was not a top priority for some of the WIBs, it began a campaign advocating manufacturing. "We went to almost every WIB in our area and talked to them about the importance of manufacturing, and showed the number of manufacturers in their area and the number of jobs. We turned some of them around. Instead of going out and hiring more people to go out on the street as outreach, they moved money into a layoff aversion program, which

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is basically saving jobs. We're back in our second round with some of them, and they're putting more money into layoff aversion instead of spending it on displaced workers. We did 126 projects. We saved or retained more than 2200 jobs, and we estimate that 400 of those were new jobs."

CMTC was also leading two sustainability initiatives, he said, including E3, which was described earlier by Mr. Kilmer. The first E3 project was scheduled to begin the following month, and the second is a state-mandated program of the public utilities commission called Continuous Energy Improvement (CEI). The objective of the CEI is to sustain energy improvements. We began looking at the food processing industry because they are high users of gas and electricity.

Mr. Watson concluded with more general comments about the MEP. He considered the MEP a system, and CMTC is one part of a statewide system that also includes a second MEP Center in the northern part of the state called Manex. "But we are not a Southern California program," he said. "We work together to represent the state of California, and we represent a national system." He suggested that the system continue its collaboration with federal agencies, which are valuable to CMTC in being able to reach out to other organizations, secure funding, and help businesses.

'Invigorating Manufacturing in California'

He also suggested a continued focus on innovation. He said that the Lt Governor's state manufacturing improvement plan was called Invigorating Manufacturing in California, and a key guiding tenet was innovation. "The little bit of innovation we've done in our state has really, really helped the manufacturers," he said. A second focus, he said, should be continued investment in new tools and capabilities, beginning with the supply chain. "Our manufacturers have to get things to market as quickly as possible, whether they're existing products or new products." A third objective he recommended was workforce development. "There is a retiring workforce. We need to develop the skill sets and skill ladders within the manufacturers themselves to bring in new people and train existing people to take over those jobs."

Next, Mr. Watson emphasized green and sustainable manufacturing. A common misperception was that green and sustainable manufacturing was done only by high-cost manufacturers. "That is not the case," he said. "Our job is to talk about how producing green products, using green manufacturing techniques, is going to save you money, make you more competitive, and bring better products to market that people will want. Consumers will not pay a great deal more money for green products, but statistics say they will opt for green produced products if they don't have to pay a premium."

Finally, Mr. Watson suggested that the MEP assist centers to integrate new initiatives. "This is all about pace and volume," he said. "There are a lot of initiatives, and the challenge is how much and how fast can a center absorb new initiatives." He said that by working together as a system and as centers, all

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members will have access to the best practices. "The more we can share those best practices, the faster we can bring these initiatives to our customers and really take manufacturing back to where it needs to be for us to retain our leadership in the world."

THE CATALYST CONNECTION AND THE TECHNOLOGY-REGIONAL INNOVATION CLUSTER

Petra Mitchell
The Catalyst Connection

Ms. Mitchell, the president and CEO of the Catalyst Connection, began with a "high-level overview" of her organization, a stand-alone, non-profit economic development organization in Pittsburgh and southwestern Pennsylvania. It was founded in 1988, and now has about 25 staff members. "I worry every day about keeping our staff happy and engaged. When they are happy and engaged, they'll go the extra mile for the clients, and that will result in increased economic impact in our community." Pennsylvania is unique, she said, in having seven MEPs that work together as an industrial resource network.

Southwestern Pennsylvania has about 3,500 manufacturers, which employ more than 100,000 people. The area is also home to about 25 universities and colleges, including the University of Pittsburgh and Carnegie Mellon University and 120 corporate or federal R&D centers. The economy is diversified, with lower than average unemployment. This diversity, however, presents challenges for a small center like the Catalyst Connection that is trying to offer services to the entire manufacturing sector.

Manufacturing is the Number One Sector in Pennsylvania

The most important industry sectors, by 2008 gross state product, are manufacturing, real estate/rental leasing, and health care/social assistance. Manufacturing is the number one sector not only in her region, but in Pennsylvania as a whole. "Again," Ms. Mitchell said, "that's something we have to continue to remind various stakeholders and opinion leaders."

For her center, some 2010 economic impacts were $199 million in sales, $24 million in savings, $28 million in investment, and 1,071 jobs created or retained; those jobs contributed approximately $1.7 million in personal income taxes. She showed a picture of a small manufacturer in her region that was recently named an Ernst and Young Entrepreneur of the Year finalist. "We're very proud of him. His company is located in a very rural area in Somerset County. We like to say is he's employing 40 people locally and selling his products nationally and internationally. So small manufacturers can compete—even those from rural Pennsylvania."

The Catalyst Connection is a public/private partnership, and receives less than half of its funding from state and federal programs; the rest is

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generated from fees, foundations, and other private sources. She calculated that $1.4 million in state investment has leveraged $3 million in additional funding. "The story in Pennsylvania," she said, "is that our state funding has decreased by more than 60 percent since 2007. The good news is that we're still here. I believe personally that we hit a low point in that funding and it will be increasing soon."

A Three-pronged Strategy—And Metrics to Evaluate the Results

Ms. Mitchell said that her organization has a three-pronged strategy and metrics to evaluate the results. The first prong is to serve manufacturing clients by adapting operations to meet their needs. This requires investment in staff skills and professional development. The firm now has plans to launch a collaboration site where clients can meet with each other, with Catalyst, and with Catalyst's partners.

Second, the firm is actively engaging in supply chain and new business opportunities. These include exporting, technology commercialization, and opportunities from gas extraction from Marcellus shale. "We want to position ourselves as a key intermediary between small manufacturers and the Marcellus shale economic opportunities."

The third strategic element is the partnerships. "We've talked a lot about that," she said, "but in Pennsylvania we're living it." Catalyst has been asked to partner with all of the state's economic development organizations to secure its state funding, and was in fact developing a partnership "as we speak." The partners allow the firm to pursue new funding opportunities, like those that had been mentioned earlier by others.

Catalyst also helped companies work on lean manufacturing, quality standards, and a variety of business growth services to help companies find new customers, develop new products, and export products. It helped firms with talent management, which has led to involvement with the Manufacturing Skills Institute, community colleges, and universities. An emphasis among the services it offers is technology commercialization, which is currently funded by MEP through a competitive award.

Regional Innovation Clusters

Ms. Mitchell then turned to the firm's T-RIC Initiative, or technology acceleration in Regional Innovation Clusters, run by both Ms. Mitchell and Connie Palucka. The objective is to develop a consortium of regional clusters focused on accelerating technology within the small manufacturers in the region. "Our focus is to really help somebody solve something," she said. "In this particular program, that might be to develop an innovative new product based on a unique technology or unique IP that is developed within the company itself, with a university, or with a national laboratory." Current T-RIC partners include the University of Pittsburgh, National Energy Technology Laboratory,

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Innovation Works (a Ben Franklin Technology Partner), Pennsylvania Nanomaterials Commercialization Center, and AMTV, the Advanced Manufacturing Technology Ventures, LLC. AMTV is a for-profit partner that directs a program called First Link, which helps the DoD commercialize innovative first-responder technology.

Now in its second year, the T-RIC consortium has initiated nine pilot projects and is supporting four university-based technologies judged to be patentable and well suited to a small manufacturer. T-RIC is helping to market those technologies, and had just completed a video describing one of them (a sensor system to detect bridge scour) and posted it on the University of Pittsburgh website.

In September 2010, Catalyst hosted the first annual Energy, Technology, and Manufacturing Conference. It attracted more than 120 attendees, and it was the first opportunity for many of the small manufacturers from the region to meet with leading researchers and professors from universities and national labs.

Finally, T-RIC helps develop tools and methods needed by small firms, including adaptation of the Innovation Engineering methods launched by MEP. "So we will be training ourselves in those materials," she said, "and adding them to our portfolio to help our clients."

Making Use of the Gate Decision Method

Early in the creation of T-RIC, Ms. Mitchell said, Catalyst designed a four-step product innovation process based on work begun at the center with Dr. Robert Cooper of McMaster University in 1999. The firm has become familiar with the gate decision method of product development, which is well aligned with the MEP system of engineering. The four stages of stage gate decision making are opportunity identification, business case development, development testing and planning, and production and commercialization. "We feel that it's had great synergy with MEP and we are in full alignment with their system for innovation."

To illustrate this process, she mentioned a case study of technology acceleration for Cannon Boiler Works, a firm located just outside Pittsburgh. The area had once been a strong manufacturing center dominated by steel mills, but had lost its leadership as a manufacturer. Recently, however, new companies like Cannon had begun to move in and gain a toehold. For Cannon, a major break came when it was approached by the Gas Technology Institute to commercialize an advanced transport membrane condenser system to increase boiler efficiency, and the Catalyst staff, in partnership with the University of Pittsburgh and Ben Franklin, had worked with them through the process. Connie Palucka had been the company's project manager and helped to develop both marketing and commercialization plans. The company is now receiving orders, she said, "and that was our goal. We need them to sell products for us to be successful."

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Creating a Common Purpose and Set of Goals

A key element of success for every manufacturer visited by Catalyst, she said, is an innovative product idea. "The key is to help them move that idea forward—to bring the right technologies, product management skills, and financing." T-RIC funding had helped to provide momentum.

Ms. Mitchell closed with some thoughts on the MEP system. She said she was "very proud" of the system she had been part of for 17 years, and was proud of the federal agency collaborations that had given her organization recognition, visibility, and standing in the development community. Going forward, she suggested continued emphasis on impact data and evaluation metrics. She also called for cohesive, system-wide goals that can help achieve common purpose and direction. "We have many states, many centers, and many stakeholders," she said. At present, the centers do most of their progress reports as individual centers. "If we can create one set of goals and a common purpose, we can report on our progress as a system. How are we doing? I think we should celebrate our successes, because there have been many over the years. I'm very proud of the work we do and I'd like to be able to celebrate it."

ENTERPRISE MINNESOTA'S STRATEGIC GROWTH PLAN

Robert H. Kill
Enterprise Minnesota

Mr. Kill, like other speakers, emphasized the importance of manufacturing to Minnesota, which has more than 8,000 manufacturers that collectively create 15 percent of its jobs and 18 percent of its payroll. "I think that's something that too often gets lost when you talk about manufacturing," he said. "There's too much discussion of low skills and low pay," while the "jobs that we're creating today are high-paying, better jobs than any other competitive industry. I think it's time to step back and let people know that."

He said that his organization pays special attention to the small and mid-sized manufacturers (SMMs). "Employment at large manufactures," he said, "define it how you like, is going down. It is the small and mid-sized firms which are the job creators. Our mantra for the last four years has been helping small and mid-sized manufacturing enterprises grow profitably."

Eight years ago Enterprise Minnesota endured a pivotal event when it lost its state funding. "I hate to say it publicly," he said, "but it was the best thing that ever happened to us, because today we operate as a non-profit consulting organization. Helping manufactures grow profitably is the focus, and you can't do that unless you're growing profitably yourself."

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The Six Core Values

The vision of Enterprise Minnesota is to be the voice of the state's manufacturing industry. To do this, it supports an active "visibility campaign," which he said was probably larger than any equivalent center. The message his organization tried to communicate, he said, was built around six core values:

- Be passionate about helping manufacturers grow their businesses.
- Be enterprising in our thinking, actions, and results.
- Demonstrate extraordinary professional integrity.
- Exude optimism.
- Treat all people with genuine respect.
- Focus on organizational over personal perspectives.

Mr. Kill said the first was most important and included the stake holders, board members, employees, and every client or contact. Many consulting organizations use independent contractors, he said, whereas his firm uses only its own employees. "I think sometimes in consulting organizations you get wrapped up in your own goals over the organizational goals," he said. "We have integrated these six core competencies right into our review process. For example, you might meet the numbers really well, but if you're not following your core values, you probably won't do very well in your review."

The firm has three key goals for the period 2012-2015, he said. The first is to be cash-flow positive, with 10 percent average compound annual growth, which he took "from my old days of running a business." Last year the firm grew by 12 percent from the year before; during the depths of the recession it was flat for one year; and for the first four months of 2011 it was up 21 percent over the 12 percent. "Talking about how bad the economy is not allowed if you're focused on helping manufacturers grow profitably."

Qualitative Measures of a Firm's Leadership

The second goal was to "set the standard within the MEP system for achieving significant client business results." This included leading the Green-Lean initiative within the state and "dramatically" increasing the number of manufacturing clients served. Every two years does a review to update its goals, "and every two years people tell me this is too aggressive, so we just make it a little more aggressive." The review uses both quantitative and qualitative measures. He said the quantitative measures were one of the most powerful selling points within the MEP system, but that the qualitative measures gave a better picture of the firm's leadership and influence in its desire to be the voice of manufacturing for the state.

The third goal is to "solidify our influence and recognition as the 'de facto' manufacturing resource." This was done through the firm's consulting,

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connections to public and private stakeholders, and visibility initiatives that contribute to the success of the industry.

The Value of Being Part of the MEP System

Mr. Kill said that the firm keeps people focused on results by emphasizing profitable revenue growth and a balanced product mix. "It's fun to talk about growth initiatives," he said, "but if you haven't invested in them, they're just great ideas." Measuring the impact in the way of the MEP system, he said, is one of the important distinctions separating it from other groups who offer consulting to SMMs. "You've got to grow clients and create true stakeholder value," he said. This is reflected in the MEP rankings, which he called a very straightforward tool. "We are a part of the system, and we just look at our product mix. So many of those products came out of the fact that we are part of the MEP system."

He showed a consulting services roadmap the "looked busy," because it included a mix of indicators for both business growth and operational excellence. Business growth activities included "idea engineering," executive leadership, marketing, and product management. Operational excellence included a "Green-Lean" enterprise, quality management systems, human capital improvement, and supply chain solutions.

In the category of business growth, he said, the firm's approaches to product management and idea engineering came out of the MEP system. The firm developed the marketing and much of the executive leadership approaches on its own. "But the bottom line is," he said, "that after four years, we could never have fulfilled the business services without being a part of the MEP system."

A Shift Toward Business Growth Services

When the organization was established four years ago, Mr. Kill said, only about 5 percent of its services were aimed at business growth, the rest at operational excellence. Today, he said, more than half of its services were aimed at business growth. The firm was reducing its emphasis on such activities as lean manufacturing and quality management in favor of "idea engineering," executive leadership, and other growth-enhancing activities. A simple focus on "lean-and-mean," he said, would not bring the rate of growth that was needed for SMMs, and growth needed to be the primary objective.

A year and a half ago, the organization was successful in winning a three-year MEP grant called Pathways to Business Growth. The objective of the project, he said, was "very simple": to learn how to integrate the MEP services into "a true growth journey" for SMMs. The grant has allowed his firm to begin working with 30 companies to investigate the MEP process in depth: do the consultants really talk to the CEOs? What kinds of companies are best able to set out on a growth journey?

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Dealing Directly with the CEO

More broadly, he was most interested in what his firm had learned over the past four years in comparing operational excellence and business growth. The lessons, he said, were simple. At the operational level, about 80 percent of what the firm did was service delivery, and 20 percent was consultative. At the business growth level, however, this was reversed. The consultant could only be effective by having the confidence and competence to deal directly with the CEO, who was the expert best situated to effect change. So that more than 80 percent of the firm's business growth activities were consultative, and a small fraction were related to service delivery.

Mr. Kill used the analogy of bringing in an expert when tiling a bathroom. "I have the fingers to do the job myself. But if I bring in a professional, he'll have done the job right, the first time, without cutting off a thumb. That's the key to having a craftsman versus just the tools. It's a dramatic shift in the culture."

He reviewed the shift toward consulting on business growth. Four years ago, he said, the proportion of the firm's effort devoted to business growth-related activities was "a little sliver;" by last year it had approached 50 percent, and in 2011 it passed 50 percent - "even though it's a 20 percent bigger pie. It's also a much more profitable pie, for the clients and for us."

Support from Grants

Mr. Kill reviewed the firm's activities in terms of the kinds of grants it was able to raise. It does not receive direct operational funding from the state. As a stand-alone, fee-based 501(c)(3) corporation, it receives grants in two areas. Development grants are for new services, staff training, finding new clients, and engaging new partners that will be able to help finance the work. The second area, access grants, are used to accelerate growth initiatives, develop consultative activities, build the role of "trusted advisor," and optimize partnerships with state, regional, and industry stakeholders. One such grant, the Growth Acceleration Program, was awarded six years ago and has been used by elected officials and CEOs who praise the program in helping them build the right strategy to invest in their companies.

Finally, he said, the firm supports a continuous stream of monthly business events where CEOs speak about their experiences. During an upcoming presentation, he said, four CEOs were scheduled to speak: a fourth-generation CEO, a second-generation CEO, one that bought a company out of bankruptcy, and one that had just recently bought a company from a private equity firm.

Mr. Kill said that his firm publishes the magazine *Enterprise Minnesota* six times a year, and each issue celebrates the success of six to eight manufacturing companies. The magazine has nearly 45,000 readers, most of them in Minnesota and across the MEP system.

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'The System Does Work'

The "crown jewel" of the firm, Mr. Kill said, is the annual state of manufacturing survey. The current issue featured 15 focus groups and some 400 executives participating in public opinion strategies. In 2012, the firm has seven stakeholders, representing seven of the eight high-priority industries. The eighth is health care, but "it's taken us awhile to get there because manufacturers are surveyed to death." Even so, he said, their survey has received considerable attention and authority because of the trends it describes. The survey helps the firm reach clients that it could not reach on its own. The number of focus groups had increased from seven when they began four years ago to 20 this year. "We had to shut it off at 20, because so many organizations, including state colleges and universities, wanted to be part of it."

"After four years of more or less being on probation," he said, "our impact on the bottom line, our investment leverage, and our impact on clients are all up substantially." The jobs retained and created in the last four quarters were about 1800, up from 1300 in the previous four quarters, which was up from about 700 in the previous three quarters.

"So," Mr. Kill concluded, "the system does work." He said it had many powerful advantages, with "the number one thing being that focus at the CEO level, focus on true business growth, allows us to grow profitably and to become a respected voice. To say we want to be the voice of manufacturing in this state is very hollow unless our clients support us, and they do."

OHIO MANUFACTURING EXTENSION PARTNERSHIP

Beth Colbert
Ohio Department of Development

The Ohio Manufacturing Extension Partnership is a statewide MEP that is managed "from the top level," said Ms. Colbert, which brings the benefit of a two to one match by the state, a portion that has increased over the last couple of years.

She said that Ohio ranked fourth in the nation in manufacturing, although it is virtually tied with neighboring Pennsylvania. Ohio has about 20,000 to 25,000 manufacturers, and "what's important here" is that 98 percent of those employ fewer than 500 workers and so meet the criteria for NIST/MEP services. The state has some large manufacturers, she said, but is primarily a supplier state. It ranks first in tier two and tier three companies, and in automotive suppliers. "So when the big guys go down," she said, "we go down hard, too."

Prior to 2008, the MEP system in Ohio operated multiple independent centers. In 2009, as part of a new strategy for economic development, these were merged into a partnership with the Ohio Department of Development, bringing a new statewide perspective. "We were doing well as MEP centers, but the state

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itself had some discontinuous services. We're very rural in half of our state and very industrial along the I-71 corridor, so the I-71 corridor was getting most of the attention." She said that the strategic plan "really sparked Ohio's interest" because of its emphasis on continuous improvement, sustainability, workforce development, and technology advancement.

At the same time, the Ohio Edison Technology Centers were brought into the partnership. The Edison Centers had been created in 1984 by the Ohio legislature as a $20 million program operated by the Department of Development. Its mission is to fund centers and incubators for innovation and technology advancement by linking universities and industries. With the strategic plan, the Centers were asked to align with "Key Vertical Industries," as outlined by a Battelle study in 2008. These industries included:

- Advanced and alternative energy and environmental technology.
- Advanced materials.
- Aerospace and aviation.
- Agriculture and food processing.
- Biomedical research.
- Instruments, controls, and electronics.
- Motor vehicle and parts manufacturing.

Each of the Edison Centers was charged with outlining its own goals and objectives related to:

- Advancing technology and deployment: linking technology and research from universities, private labs, and Ohio Third Frontier Investments to production and sales;
- Cluster development, networking, and education: Building supply chains, workforce, and networking opportunities in vertical industries;
- Manufacturing assistance: Deploying advanced manufacturing technologies, reducing costs, and enhancing new products and processes.

The operation of the Ohio Edison/MEP centers continues to evolve," she said, but we're getting there." With so many manufacturing suppliers in Ohio, the program divides them into three groups. These include (1) some 75 to 80 percent of all suppliers, who have little experience and can benefit from many forms general manufacturing assistance; (2) about 10 to 15 percent of all suppliers, which require more specialized assistance; and (3) about 5 to 10 percent of all suppliers, a small group of experienced SMMs that require "customized growth projects."

Ms. Colbert estimates that many firms in the first, largest group would benefit "almost immediately" from the basic programs and services of the MEP, such as cost improvement training, financial coaching, general business assistance and trade and marketing assistance. She said the MEP had found it

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did not have to try to offer every service to everyone, but could work in partnership with free or low-cost services for very small manufacturers. Many of these are found among the 88 state colleges and community colleges in the state as well as local partners and economic development groups that provide business services and have access to financing through local banks.

"These partners are a key part of our system," she said. "They allow the Edison Technology Centers to focus on strengthening their technology expertise, making connections to universities, linking to large OEMs to build supply chains, and work on workforce development curricula with colleges. We estimate that we can work with 75 to 80 percent of our SMMs at the community or regional level by having partners and being an honest broker to those partners. Everyone has their own business model, so we really have to broker at that level to get companies ready for some real opportunity."

The second, more experienced group of SMMs would benefit from some technical assistance, she said, and this can be provided by the MEP in partnership with Edison Centers and universities.

At the top of the system are another 5 to 10 percent of SMMs that are ready for accelerated growth. "Any time a manufacturer reaches this stage, either by growing up through our system or coming in through our incubators at the very top level, they are ready for a partnership with other economic development programs at the state level." For them, the MEP provides customized growth projects that are created and executed by the Edison Centers. The Edison Centers will play an important role, including not only solving technical problems, but infusing new advanced technology into these companies. Subject matter tools may include assisted product design and development, and industry specific issues. Many of the manufacturers are suppliers to the auto industry, so that MAGNET is able to help expose firms to new technologies in welding and automotive research.

"As we prepare and vet these companies for growth, we're also going to help them financially, and this is where our Ohio Third Frontier program can play a big part."

Other business partners include MAGNET and TechSolve (both Ohio MEP Centers), the Small Business Development Centers, and JobsOhio, a public/private partnership ready to help companies with capital investment, supply chain opportunities, export, new markets, and new products.

The MEP is continuously changing, she said, and it is strengthened by its partnerships with different federal agencies, such as the Small Business Administration. But she emphasized the value of having partners from Washington come to the state and see the challenges first-hand. "We love what you're doing," she concluded, "in helping us implement the MEP at the local level. But we still need some help here, and the more we can sit around the same table here in Ohio with our partners and collaborators, whether it's DoE, MEP headquarters, SBA, or other agencies, the more progress we can make."

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DISCUSSION

Mr. Breiner asked Mr. Kill of Minnesota what had been the effect of the state removing its funding from the state MEP. Mr. Hill said he had not been with MEP then, but that MEP had benefited from a plan for quickly finding other sources of financial support. The state had given the organization a grant $3 million at termination, and since then the EP had raised more than $2.5 million in grants develop 50/50 cost sharing agreements with companies under 100 employees. "So it's actually been a more successful program," he said, "than if we were getting direct funding."

Dr. Proenza made several comments about the presentations, saying that the four MEP centers had been very diverse, and represented a broad geographical region. He suggested that the diversity is a reflection of the context within which each of the centers operates. "It's very clear that one size does not fit all MEPs, and that the nature of the manufacturing base of each state and region drives the kind of MEP program they need." At the same time, he said, there was a great deal of similarity, and this seemed to be driven by the strategic approach that is "illustrative of how MEP is evolving, how each state deploys resources, and the context in which they operate."

He said he had also heard a great deal of pride from each of our discussants in their efforts—both in supporting the growth of the manufacturing sector, the acquisition of partners that allowed MEP to reach a far greater number of companies that it could reach alone, and what even the most rural regions are able to accomplish.

He ended by suggesting that "some clarity will probably be needed in terms of some of the metrics." Many of the metrics focused on jobs, almost exclusively on those saved or retained within the companies. Other metrics would be valuable if they could measure "some very direct consequences in other companies that may result from the activity you do with one company." He closed by asking Ms. Colbert how she was able to keep track of all of the reporting requirements in a state as big as Ohio. Ms. Colbert replied that her MEP does struggle with the reporting system, but "I wouldn't trade it for the world." Like her colleagues, she said, the third-party survey and the metrics it gathered "are really the catalyst for maintaining and growing our program. Our partners had experience in reporting and help us a great deal."

Dr. Singerman observed that the MEP programs in California seemed to be relatively small, engaging about 700 firms out of a universe of some 30,000. Mr. Watson agreed that he would like to, over time, double the penetration from about a 2 percent engagement rate to about 4 percent. He said that the California Manufacturing Technology Consulting MEP would be doing this in two ways. "First, expanding our partnerships is helping us get out and do more. Instead of one-on-ones, we're doing a lot more collaborative activities with manufacturers. And second, by improving the value to the state, so the state will assist with funding." He said that this required proving the value of the MEP to the state, "which we're doing right now. With their contribution, it will

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allow us to do additional outreach, which will take us closer to the 4 percent level."

Dr. Wessner asked the MEP representatives what they needed going forward, and whether there has been any outreach to foundations. Ms. Mitchell of the Catalyst Connection said that she is definitely collaborating with foundations. She had just received half a million dollars from the R.K. Mellon Foundation to expand the T-RIC program, with a focus on technologies related to the Marcellus Shale activity. "So that's our starting point, and we hope to build on that."

Bob Hershey, an engineer, asked to what extent the MEPs were able to do collaborative work with several companies at once on a project they're all interested in. Mr. Watson said they had just such a partnership that same day with seven companies wanting to export. "They're going through one day a month for the next three months to develop their export plan. The other way that we can increase your penetration is by putting manufacturers in the same room who are interested in the same things and then generate impact from that. As we expand our number of customers, the idea of 'group delivery' is at the top of our list." Ms. Mitchell said that in addition to exporting technologies, her group does open-enrollment training for many companies. The most popular are those that discuss lean certification and leadership certification. " And we're getting ready to launch an online tool which will facilitate cooperation between companies and providers, and between the companies themselves."

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Panel III

Small and Medium-Sized Enterprises and High-Value Manufacturing

Moderator:
Jamieson Brown
Subcommittee on Science and Innovation
House Committee on Science, Space, and Technology

Mr. Brown noted that members of Congress were especially interested in learning how programs like MEP can maximize their effectiveness in the current budget environment. The meeting so far, he said, had proven valuable in describing how the MEP program can leverage both expertise and funding across agencies. The MEP does an excellent job, he said, of disseminating new technologies and processes to SMMs.

Support for small firms and manufacturers create jobs and new products. Their greater flexibility and greater tolerances for risk allow them to innovate successfully. But, he said, many people think that innovation and efficiency displaces jobs. In fact, studies have shown that over time, innovation creates *more* jobs that are more productive and higher-paying. "I think that message is often lost," he said, "and I think it's imperative for supporters of advanced manufacturing innovation to get that message out."

The fact that innovation creates higher-paying and more productive jobs, he said, has important implications for federal funding policy. A related point, made by an earlier speaker, is that innovation suffers when manufacturing moves offshore and removes the "side result of continuous learning." He introduced the next speaker, Dr. Gregory Tassey, as an economist one who has studied these issues and would summarize some of the benefits of keeping manufacturing jobs in the United States.

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THE MANUFACTURING IMPERATIVE

Gregory Tassey
Economic Analysis Office
National Institute of Standards and Technology

Dr. Tassey began his presentation by observing that while most people agree that manufacturing is essential to the U.S. economy, no such agreement exists in explaining why this may be true. He said also that many economists saw no special importance in what products are manufactured; he repeated the quip that it does not matter whether we're manufacturing potato chips or semiconductor chips, "as long as we're manufacturing something." Still other economists, he said, argue against producing a product in the United States if the relative prices of the world economy favor production offshore. To dispute such arguments, and the inference that the United States would do equally well as a service-based economy, he said he would propose four major rationales in favor of a strong onshore manufacturing base. [22]

Rationales for Strong Onshore Manufacturing

The first was diversification, which was seldom discussed in the debates over manufacturing. The United States is a large economy, and "putting too many eggs in one basket is a risky strategy. Manufacturing contributes $1.6 trillion to GDP, and employs 11 million workers. If you're going to replace all of them with service jobs," Dr. Tassey said, "you have to make some very convincing arguments that services can drive this economy at the rates that we want." He said that many economists believe that services are not tradable, which is an argument that pertains to a time when a typical service was very labor intensive and needed to be produced on site. In other words, one would not send the laundry to China every Monday morning to benefit from lower wages. In fact, he said, many services are now tradable, such as customer assistance, engineering, and accounting, and some 30 countries have an explicit agenda to encourage service exports. "So if we became a service economy, we would end up having to compete just as vigorously as we are forced to do in manufacturing," he said.

A second argument in favor of on-shore manufacturing is that it accounts for 67 percent of business and industry R&D, which represents a contribution of 11 percent of GDP. It also supports a 57 percent share of the nation's industrial scientists and engineers. "If you remove manufacturing, you

[22]For a more detailed presentation of Dr. Tassey's discussion, see Gregory Tassey, "Rationales and Mechanisms for Revitalizing U.S. R&D Manufacturing Strategies," *Journal of Technology Transfer* 35: 283-333, 2010.

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have decimated the research infrastructure of the private sector," he said. This could be rebuilt over time, he said, and some services do a moderate amount of R&D internally, but that amount "pales in comparison with the amount done by the manufacturing sector."

In addition, Dr. Tassey said, the fast-growing high-tech services sector must have close ties to its manufacturing base to fuel innovation. "There are definite co-location synergies between services and the sources of their technology," he said. Those working in a manufacturing supply chain find increasingly important interactions with workers in related activities. "These co-location synergies," he said, "flow between the tiers of the supply chain and ultimately the hardware and software that are used by the service industries."

Finally, he said, the majority of the nation's trade is in manufactured goods, but "we have not had a trade surplus in manufacturing in 35 years." Every year of a deficit, he said, detracts from the economy's GDP, and the projections for GDP growth in the future are "not particularly robust."

The Impact of R&D on the Economy

Dr. Tassey returned to the impact of R&D on the economy, beginning with innovation. The innovation process begins with science, he said; the science is used to develop technology, and the technology is developed into something useful to a commercial market. "What happens after that is the key to determining economic benefits," he said, "for manufacturing or any other sector of the economy." That is, the product or process must be proven and scaled up to the point of reliability that meets the demands of manufacturing and the tastes of the market. "It's only as a market expands and we in the domestic manufacturing industry capture a lion's share of the benefits that we deliver the value-added needed by the economy."

The nation has not well understood the relationship between R&D and innovation before, he said, but lately the NSF has begun to collect broad-based innovation data; the first of these data were released in the fall 2010. "So I took that data and created an index, plotted against R&D intensity,[23] and there is definitely a positive correlation."[24]

In addition, Dr. Tassey said, the distinction between software and hardware as products is beginning to blur, partly because software is embedded—and produced—as part of so many physical products. "So in my opinion, we're really not talking about hardware and software, we're talking about manufacturing."

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[23]In economics, R&D intensity may refer to a firm's spending on R&D in relation to sales. In this context, Dr. Tassey is referring to R&D spending in relation to GDP.

[24]Gregory Tassey, "Beyond the Business Cycle: The Need for a Technology-Based Growth Strategy," forthcoming.

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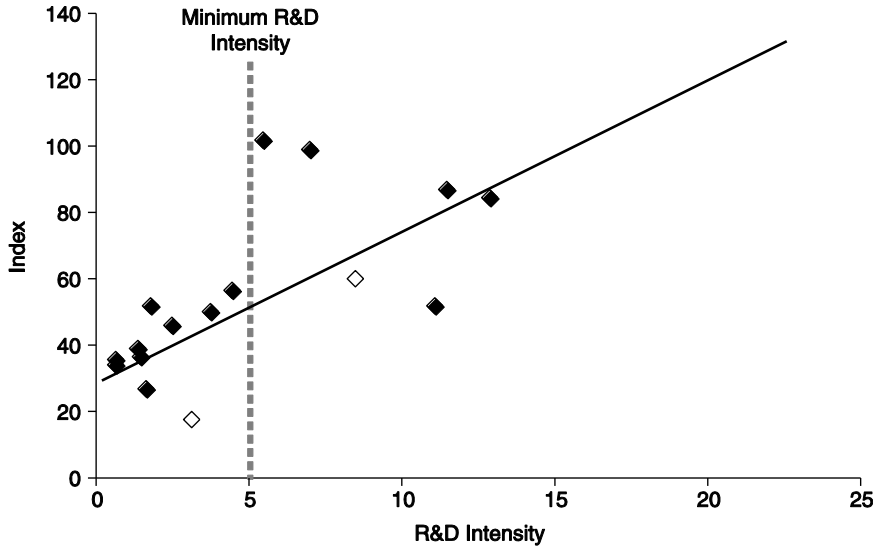

Source: Gregory Tassey, "Beyond the Business Cycle: The Need for a Technology-Based Growth Strategy," forthcoming. Index = sum of percent of companies in an industry reporting product innovations and percent reporting process innovations. R&D intensity data from *Science and Engineering Indicators 2010*, Appendix Table 4-14 (industry and other non-federal funds for R&D); innovation data from Mark Boroush, "NSF Releases New Statistics on Business Innovation," NSF InfoBrief, October 2010.

FIGURE 4 Rate of innovation vs. R&D intensity.
SOURCE: Gregory Tassey, Presentation at November 14, 2011, National Academies Symposium on "Strengthening American Manufacturing: The Role of the Manufacturing Extension Partnership."

R&D-intensive Industries

Innovation is just the first stage of commercialization, he said; economists are interested in all of its stages and the total economic impact that generates jobs, salaries, profits, and other benefits. To frame this larger picture he compared the degree of R&D intensity in manufacturing industries with real economic output for the period 1999-2007. He divided industries into two categories: R&D-intensive industries, including pharmaceuticals, semiconductors, and communications equipment, and non-R&D-intensive, including basic chemicals, machinery, and electrical equipment. He found an R&D intensity in the first group averaging 9.5, and an R&D intensity averaging only 2.5 in the second groups. He then looked at the percent change in real output between 2000 and 2007 and found a group average of 25.4 percent in the R&D-intensive industries, and a group average of just 2.9 percent in the non-

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R&D intensive industries, which was attributed almost entirely to the change in output for basic chemicals.

Given the importance of R&D intensity to the economy, one might argue in favor of situating high-intensity industries in the United States, rather than offshore. In fact, the United States is in danger of losing—or has already lost—the domestic leadership it once had in high-value manufacturing sectors. Part of the cause of this loss, said Dr. Tassey, is attributable to off-shoring.

How Off-shoring Leads to Stronger Competition from Abroad

Off-shoring is a complicated process, Dr. Tassey said, which had little importance until about two decades ago, when U.S. companies were globally dominant. Then companies began to target foreign markets and to send their manufacturing abroad to be close to those markets. At first they supported just a small amount of R&D to move those products into the market. At first, this did not represent a huge loss of value added. However, as the host countries provided more of the skilled labor, they began to gain R&D experience and expanded their internal R&D infrastructures to capture synergies at the "entry" tier of the high-tech supply chain. For example, Taiwan and Korea became skilled at producing electronic components, while China excelled at assembly. In this way, those countries gradually became competitive in their own sub-markets.

The process usually begins as the country specializes in a particular tier of the high-tech supply chain. As they become successful, they begin to integrate backward along those supply chains, taking more value added from the Western economies, including the United States. This "hollowing out" of supply chains has cost the United States in value added and jobs. According to this "poor technology life-cycle management," he said, the United States had been the "first mover" in many commercial technologies, but gradually lost virtually all market share in many of these technologies, including:

- Oxide ceramics.
- Semiconductor memory devices.
- Semiconductor production equipment, such as steppers.
- Lithium ion batteries.
- Flat-panel displays.
- Robotics.
- Solar cells.
- Advanced lighting.

At the same time, the new host economies began to integrate forward along the supply chains. One study found that 30 economies have explicit high-tech service export strategies. For example, Taiwan is integrating forward from electronic components into electronic circuits, and Korea is integrating forward

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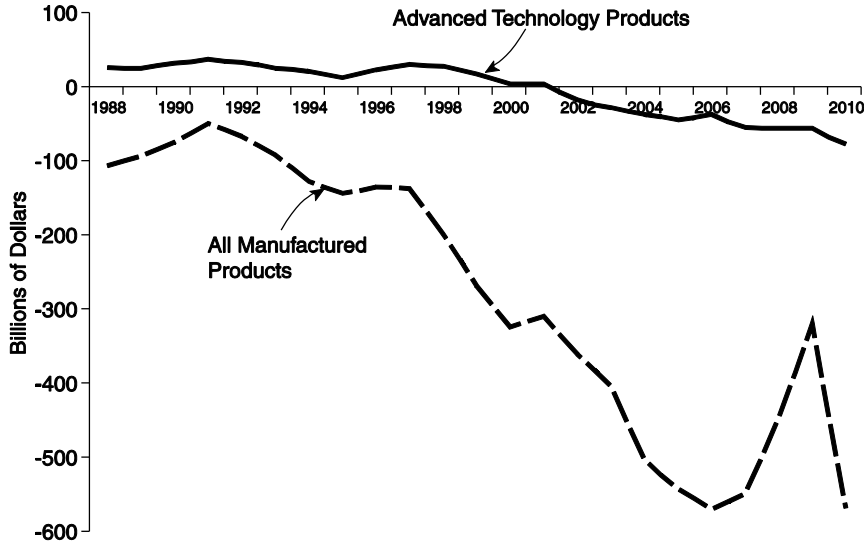
from component to electronic products. Such economies are beginning to integrate forward into services as well, so that co-location synergies are being lost by the United States and captured by others. Some observers downplay the seriousness of this hollowing out of U.S. supply chains, citing the success of the Apple model, for example, and some design-only semi-conductor firms. "I don't consider that a viable long-term strategy," said Dr. Tassey. "There's nothing to stop the Asians from integrating forward into design, and they are doing it." He cited the Android-based phone made by Samsung as a "classic example."

The Downturn of the High-tech Trade Balance

Historically, Dr. Tassey continued, the United States has been a world leader at innovating products for the major technology-based markets, but in subsequent market expansions it has let this leadership slip away. Within the U.S. trade balance, the figures of most interest for economic development have been those labeled by the Census Bureau as high-technology products, which amount to some 500 product codes out of 22,000 manufactured products. This



Source: Census Bureau, Foreign Trade Division for ATP data;
International Trade Administration for all manufactured products.

FIGURE 5 U.S. trade balances for high-tech vs. all manufactured products, 1988-2010.
SOURCE: Gregory Tassey, Presentation at November 14, 2011, National Academies Symposium on "Strengthening American Manufacturing: The Role of the Manufacturing Extension Partnership."

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high-tech trade balance was positive when the government first began tracking it in 1988, but by 2002 it had turned down. It has continued downward since then, and is now about negative $80 billion a year, with no sign of a reversal.

The effect of this decline shows up clearly in U.S. manufacturing employment. When the United States was dominant during the first few of decades after World War 2, U.S. manufacturing and manufacturing employment both expanded rapidly, until about 1980. For the next two decades employment lost momentum and turned downward, influenced by the economic success of Japan and then of Germany. In the last decade, the rapid growth of newly competitive economies have pushed the employment curve more sharply downward. Some people have blamed some or much of this job shrinkage on automation, he said, but automation had become a significant part of manufacturing long before the downturn began, with no noticeable effect on employment.

Dr. Tassey said he had recently participated in a seminar in Germany where he learned several interesting things. First, Germany has a trade surplus in manufacturing, in spite of having a 9 percent lower R&D intensity, a 39 percent

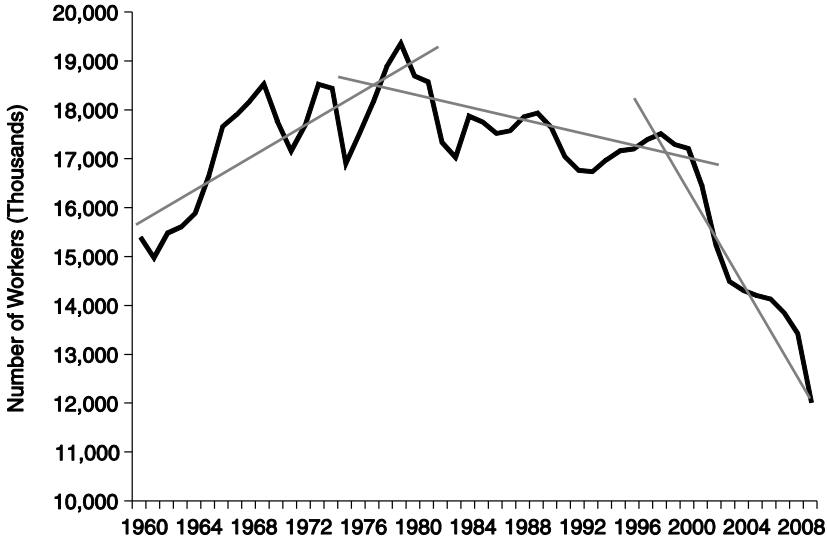

FIGURE 6 U.S. manufacturing employment: 1960-2009.
SOURCE: Gregory Tassey, Presentation at November 14, 2011, National Academies Symposium on "Strengthening American Manufacturing: The Role of the Manufacturing Extension Partnership."

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higher level of hourly manufacturing labor compensation, and a 12 percent higher corporate tax rate than the United States. Even so, he said, German manufacturing firms still perform far better than U.S. firms.[25] "And in my opinion, the reason is they take a comprehensive, whole technology life-cycle approach to their government support of the domestic manufacturing industry. They have an extremely good educational system. I'm not just talking about college; I'm talking about high school, vocational training, and apprenticeship programs."

Germany has also optimized its industry structure, for both large firms and SMEs, by subsidizing the transfer of skilled labor in SMEs through the Fraunhofer Institutes. "They optimized their industry structure," he said. "They have the highest percentage of their manufacturing value added coming from R&D-intensive industries. And this means that their competitive advantage is very likely to be more stable over the next decade or so. It doesn't mean their strategy is perfect; I can find some holes in it. But right now they're out-performing us."

Trends Needing Policy Attention

Dr. Tassey then asked what policy attention those trends might inspire in the United States. First, he said, was R&D intensity, which has remained flat at 3.7 percent since the mid-1980s. This pales in comparison to truly R&D-intensive industries, whose intensities range from 5 to 22 percent. It also defies the expectation that low-R&D-intensive industries would be off-shored first, causing the overall intensity figure would rise. The need for an effective policy response to this situation, he said, is great. About $1.3 trillion are being spent globally on R&D now, he said, which is "a huge amount," and represents even greater leverage; for every dollar of R&D and every technology produced, additional money is spent on capital formation, marketing, and other functions, raising economic growth generally. In particular, the high-tech industries account for just 7 percent of GDP, and yet that 7 percent is leveraging the other 93 percent of industries, which depend primarily on the 7 percent of high-tech industries. "So it's incredibly important to focus on that and make it robust," he said.

A final trend that needs policy attention, he said, is the trend of off-shoring R&D itself. U.S. manufacturing firms are off-shoring their R&D at three

[25]While the U.S. has one of the highest nominal corporate tax rates in the world, effective tax rates are often much lower. In this regard, a recent GAO report notes that using allowed deductions and legal loopholes, large corporations enjoyed a 12.6 percent tax rate far below the 35 percent tax that is the statutory rate imposed by the federal government on corporate profits. See U.S. Government Accountability Office, *Corporate Income Tax: Effective Tax Rates Can Differ Significantly from the Statutory Rate*, GAO-13-520, Washington, DC: U.S. Government Accountability Office, May 30, 2013.

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times the rate of growth of domestic R&D spending. This is not a trend that can be fixed by federal intervention, he said, because government funding of manufacturing R&D increases the sector's R&D performance intensity from 3.7 percent only to 4.1 percent.

Another important topic, he said, was the farther-on private investment that provides the necessary capital equipment, hardware, and software that leads to productive uses. This fixed private investment rose by 167.7 percent during the 1990s, due primarily to the growth in IT innovations, but during the following decade the increase dropped to 14.6 percent. "That is definitely a serious problem," he said.

Another view of R&D intensity, Dr. Tassey continued, is its funding as a percentage of GDP. This ratio has been more or less flat since 1953. In the 1960s, there was almost no technology-based competition, whereas 50 years later the world has exploded in R&D spending to some $1.3 trillion a year, most of it in manufacturing. And yet the R&D intensity levels as a share of GDP have remained essentially the same. Industry has done its part, he said, increasing its spending steadily over that period until the last decade, when it leveled out—probably because of the off-shoring trend. "But the real villain here," he said, "is the federal government, which has reduced its R&D funding relative to GDP for 50 years." Globally, the United States ranks 8th in national R&D intensity. "That's not terrible," he said, "but it's a trend you have to pay attention to. We were once the most R&D intensive, and now we're slipping."

How, he asked rhetorically, is the United States responding to this slippage? "Well," he answered, "we're not." Between 1995 and 2008, the United States increased national R&D intensity by 10.4 percent, less than its major economic competitors. Much larger increases were recorded by China (170 percent), Singapore (135 percent), Finland (65 percent), Taiwan (61 percent), South Korea (42 percent), Japan (26 percent), and Germany (20.5 percent). He showed another chart comparing the manufacturing value added from R&D intensive industries. The United States ranked near the middle, exceeded by Japan, Korea, and Germany, which had the largest percentage.

Revisiting the 'Black Box' Model of Innovation

The response to the underinvestment in R&D intensity, Dr. Tassey said, is commonly described in terms of technology-element growth models. The model that has been embraced by most economists and used to drive policy in this arena for decades, he said, might be called the "black box" model. It rests on a base of federal investment in science, which is considered a pure public good. This element of the model is not disputed, as the government's responsibility for supporting basic science is generally acknowledged. However, he said, conservative economists tend not to recognize the economic importance

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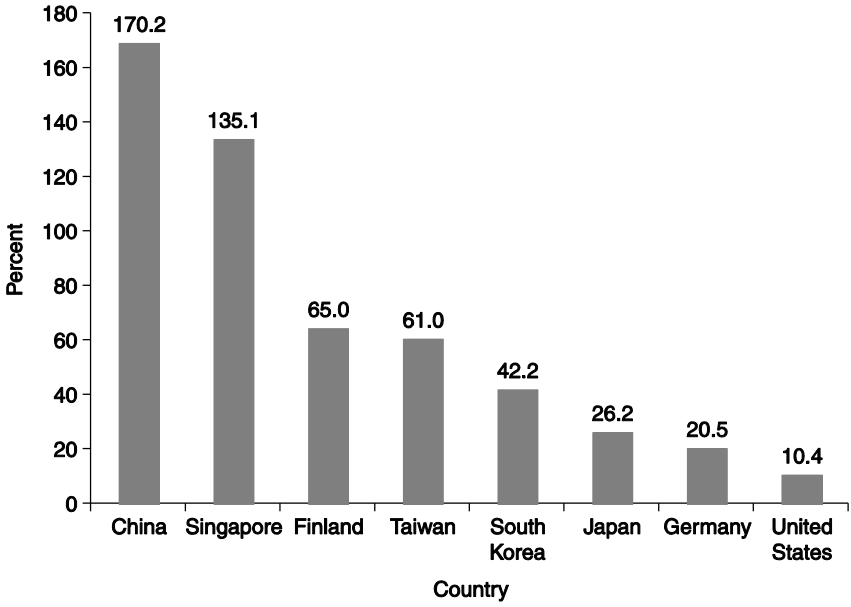

Source: Gregory Tassey, "Beyond the Business Cycle: The Need for a Technology-Based Growth Strategy," forthcoming. Data from OECD, *Main Science and Technology Indicators*, 2010/1.

FIGURE 7 Changes in national R&D intensity, 1995-2008.
SOURCE: Gregory Tassey, Presentation at November 14, 2011, National Academies Symposium on "Strengthening American Manufacturing: The Role of the Manufacturing Extension Partnership."

of this investment. Instead, they limit the source of economic growth to the "black box" of proprietary technology—such as patents—that become the raw material whereby companies, venture capitalists, entrepreneurs, and other actors commercialize a technology and add value to it. Because the proprietary technology in the black box belongs to the private sector, and the value added represents the payments to labor and the payments to corporations as profit, the model affords few leverage points for public policy.

In place of this black box model Dr. Tassey proposed a model that "breaks the black box apart" into three elements, each of which responds to different needs and investment incentives. One is the same proprietary technology that dominated the original black box model. A second element is generic technologies, often known as platform technologies. These are

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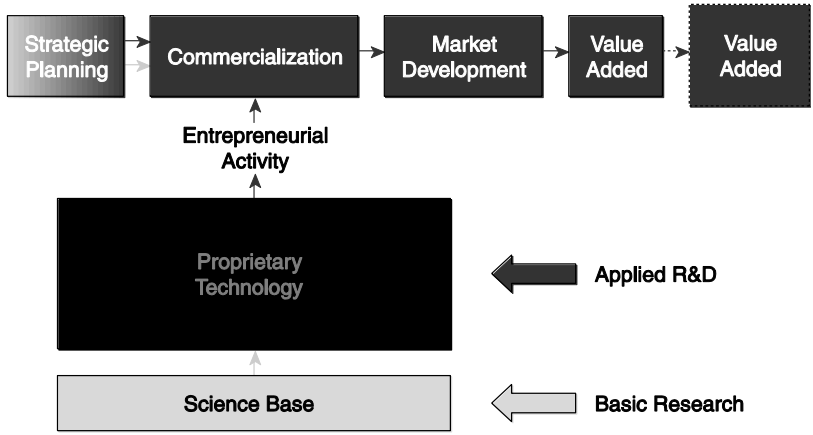

Source: Gregory Tassey, *The Technology Imperative*, 2007; and, "The Disaggregated Technology Production Function: A New Model of Corporate and University Research," *Research Policy*, 2005.

FIGURE 8 'Black Box' model of a technology-based industry.
SOURCE: Gregory Tassey, Presentation at November 14, 2011, National Academies Symposium on "Strengthening American Manufacturing: The Role of the Manufacturing Extension Partnership."

significant but not proprietary kinds of R&D that are usually co-funded and co-developed by public and private interests and hence considered to be quasi-public goods. The third element, called infra-technologies, includes tools that are essential in making the innovation process efficient. They include such complex elements as test methods, databases, modeling, and standards, many of which are critical for small companies but beyond their technological or financial reach.

As an example, he showed how this technology-element model would be applied in biotechnology. He showed lists of activities in each of five categories, only the first and last of which—science base and commercial products—were present in the original black box model. The three middle categories—infra-technologies, generic product technologies, and generic process technologies—were not present. "Yet in reality," he said, "they do exist, and a simple list of these categories demonstrates how important it is for policy to recognize them and this complexity." He also characterized this model in terms of public-technology goods, mixed technology goods, and private technology goods.

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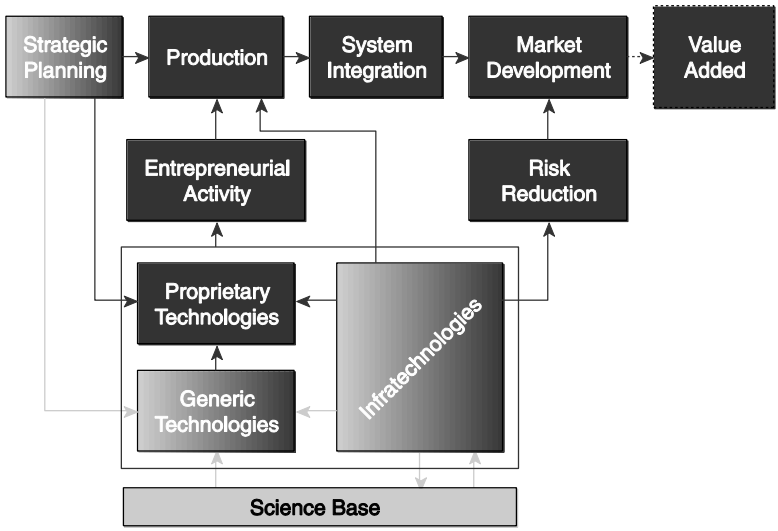

Source: Gregory Tassey, *The Technology Imperative*, 2007; and, "The Disaggregated Technology Production Function: A New Model of Corporate and University Research," *Research Policy*, 2005.

FIGURE 9 Economic model of a technology-based industry.
SOURCE: Gregory Tassey, Presentation at November 14, 2011, National Academies Symposium on "Strengthening American Manufacturing: The Role of the Manufacturing Extension Partnership."

Underinvestment in Longer-term Technologies

The last indicator of underinvestment, Dr. Tassey said, was a shift in the composition of R&D toward shorter-term activities. The real growth has been in industry's net investment in next-generation technologies that provide the short-term products for the domestic supply chain. This shift has been accompanied by a fall in R&D investments in technologies that might be expected to bring longer-term returns.

In planning policy, he said, it is essential to keep in mind that most federal R&D funding is directed toward agency mission objectives, including defense, space, health care, energy, and environment. National defense and health together account for 81 percent of the federal R&D budget, while only about 2 percent of the budget supports projects whose primary focus is economic growth. "While economic activity is stimulated by this skewed funding strategy," he said, "the federal portfolio is not close to being optimized for economic growth." An example is the category of federally funded "generic" or proof-of-concept technology research. Of the total amount, some $3.1 billion

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goes to defense, $400 million to energy (ARPA-e), and only $60 million to "general economic growth" in programs that translate technologies into actual, marketable products.

In summary, he said, three important targets for manufacturing R&D policy are (1) amount of R&D, (2) composition of R&D, and (3) efficiency of R&D. The third target was increasingly important in the face of global competition. "You can't take all day to move through a technology life cycle or you'll find out that someone else in another country has beaten you to the market and seized the first-mover advantage."

In closing, Dr. Tassey said that technology clusters are important "because they greatly improve the efficiency of R&D." Clusters are most effective, he said, when they are part of a policy that is planned and sustained over the long term. "We spent a lot of years figuring out how to do this," he said. "In the case of technology investment, it's only through the long term that your strategy can really work. You have to come up with metrics in the short and medium terms to show decision makers that you're making progress of benefit to participants. But only over the longer term will you get beyond benefits to participants to benefits for the national economy as a whole."

THE DVIRC PERSPECTIVE ON THE SUPPLY CHAIN

Joseph J. Houldin
Delaware Valley Industrial Resource Center

Joseph Houldin began by clarifying that he represented the Delaware Valley Industrial Resource Center (DVIRC), the MEP of the Philadelphia area, and had never worked for an OEM or an SME. Nonetheless, he said, his goal was to discuss the relationship between OEMs and SMEs in terms of supply chains. The DVIRC had only recently become actively involved in supply chains, beginning with a partnership with the Catalyst Connection, a "sister MEP" described earlier by Petra Mitchell.

He had worked with the MEP since 1988, and said that like his colleagues, he loved the job. "I feel we're doing something very important for the country," he said. In light of the presentation by Dr. Tassey, he said, it was clear that the job on the ground could be done more effectively under a clearer and more comprehensive set of federal policies. "So here is a request from one of the troops in the field," he said. "To the degree we can get a little more structure and direction from the federal level, it would be greatly appreciated." He did say his organization received good support from the federal MEP, "which is greatly appreciated."

Toward Collaboration Between Levels of the Supply Chain

Mr. Houldin said that he had been watching and reading about supply chains for 20 years, beginning earlier in his career when he was involved in site

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location issues for economic development. Much of the discussion about industrial structure was then academic in nature, he said, but economic development people listened in to learn about the competitive advantages of certain locations. Also, other MEP organizations had looked at the supply chain as a channel through which to bring services to SMEs. They tried to do this, in theory, by encouraging larger companies to reach farther down their supply chain requirements to coordinate for certain business practices; the MEP would help support that when possible.

But there was little collaboration between levels, he said. "What we saw 15 or 20 years ago was that if the OEM was at the top of the chain and the SME was at the bottom, they were separated by many tiers." Not only were there tiers, he said, but tentacles off the tiers, which acted as barriers to improved performance and economic growth. Today there are fewer tiers, and the SME is better able to add value to the chain through better business practices.

From the perspective of the private sector, Mr. Houldin said, the functions of the supply chain used to be limited to purchasing, cost reduction, and productivity improvement. In recent years, these functions are increasingly seen in terms of partnerships between smaller and larger companies in the form of supply chain networks and supply chain managers. This change, which is coming slowly but surely, he said, includes much more discussion of not only price, but the effect on price of logistics. "Hopefully that holds promise for the dynamic changes between larger and smaller companies."

Pushing New Functions Down to SMEs

In addition to the challenges of price and cost reductions, other trends within which the supply chain lives, Mr. Houldin said, include how best to outsource "non-core" functions once housed within the company itself. Such actions, of course, require decisions about which functions should be considered non-core. Outsourcing does create opportunities for SMEs and reallocation of value within the chain. But it also means that many new functions are pushed down the value chain to the SMEs, including more R&D, logistics work, and just-in-time production. The SMEs may see these requirements either as part of a larger opportunity to develop new customers or as a web of challenges too complicated to deal with. The MEP, he said, can help a company work its way through such questions.

When an SME has a large customer whose priorities are not set only by price, it can receive many benefits. These include not only certifications, but also significant productivity improvements which are then owned by the SME. These improvements represent not just an exchange of dollars, but a value added to that company. Among them may be new software or IT systems, on-time delivery methods, lead-time reductions, improved design or engineering, and value added elements that are shifted down the chain or distributed through the

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network. These improvements can allow the SME to create new capabilities and develop new OEM customers.

Both the nature of companies and the challenges for MEP are influenced by geography, he said. The business environment in southeastern Pennsylvania differs from that of the Midwest, for example, where OEMs tend to be large companies. In the Philadelphia/ South Jersey area, few large supply chains are driven by a single company, and fewer are driven by a single industry. About 15 years ago, a third of the firms there were small OEMs, and 2/3 were considered job shops. A job shop typically handles relatively small orders for SMEs, and may move to a new customer as each job is concluded, but they are technically considered to be a manufacturer by selling a manufacturing service.

A Trend Toward Job Shop-OEM 'Hybrids'

The number of job shop customers in the region had recently dropped, Mr. Houldin said, as many of them had moved up to become hybrid job shop-OEM organizations. The DVIRC found through surveys that these small manufacturers usually moved up in terms not of product but of service, which is generally related to engineering. As a hybrid, he said, they are now selling problem solving abilities to larger companies; they are also selling delivery time, and charging a premium for speed. Today, he said, only about one-third of manufacturers are job shops, and one-third have moved up to become hybrids. Another third are $20 million companies that have their own proprietary product and take it to the market, domestically and globally. It is uncertain whether they can be considered an OEM, although they do sell to the end market. "There are public million-dollar companies that are doing that too," he said, "so I think there's something going on that makes the old industrial structure discussion more complicated than it was before."

The good news, he said, is that many American small companies are reinventing themselves and learning how to respond to a changed marketplace where they are pushed and pulled by customers of many kinds. "We need to help change the thinking in SMEs to value providers, value receivers, and value creators."

Linking SMEs with More Customers

Recently, the DVIRC has been included in a regional grant program to expand its work from talking with the SMEs to talking with their customers. The specific purpose of the program is to work with the building industry to determine how best to retrofit existing buildings with new technologies. The program, which began 11 months ago, is funded by the Small Business Administration, the Economic Development Agency, DoE, and MEP, and will be led by Penn State University, other universities, and large companies. Because the DVIRC works with many partners, he said, it is learning a great

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deal, "which is a terrific thing for us and is going to help our clients." Another positive feature of the program, he said, is that the thrust of the program is not to develop new systems or technologies, but to connect existing systems and technologies with manufacturers so as to bring them to market quickly. "I think that has helped move MEP into the discussion in a more aggressive way," he said. As a result, the DVIRC is meeting with United Technologies Corp., IBM, Applied Materials, and other large firms about using technologies they already have or partnering with SMEs to help develop these or other technologies.

Mr. Houldin concluded with the suggestion that OEMs commit to "re-shoring" 10 percent of their offshore work for domestic markets whenever the business case permits. A major advantage, he said, would be to renew the connections between manufacturing and innovation capabilities, as described by Mr. Tassey earlier. He encouraged the federal government to support this suggestion with its own "Buy America" initiatives, especially those involving purchasing power and contracts for more domestic manufacturers.

BUILDING A COMPETITIVE MANUFACTURING SECTOR: HOW MEP COULD HELP

Susan Helper
Case Western Reserve University

Dr. Helper said she would present some of her own data about manufacturing, which illustrated the large number of different manufacturers that need to be served differently by MEP. "I think in general we need to talk about a different model," she said, which can be illustrated by two futures she called "low road and high road." These would illustrate why it is difficult for small manufacturers to succeed, she said, and what the MEP and others can do to help.

She reiterated the importance of supply chains. Because of outsourcing, many large manufacturers now depend on SMEs. For example, about a third of U.S. automobile supply employment is in firms of less than 500 employees. This accounts for about a million of the 12 million total U.S. manufacturing jobs. Another million or so people are employed in supply chains in agricultural equipment, aerospace, and other industries.

Dr. Helper's study, the Case Western Auto Supply Chain Study, lists two primary sources of information. One was interviews with 30 firms during the summer and fall of 2010. These include first- and second-tier suppliers employing 50 to 50,000 workers. Its customers included the Detroit 3, Honda, Nissan, Toyota, and BMW. The second source was a just-completed confidential survey, funded by the Department of Labor, of auto suppliers in the United States. These included all tiers of the supply chain, as well as foreign-owned firms. The survey received 1400 responses, representing about 25 percent of total firms, and 30 percent of firms with fewer than 500 employees. These smaller firms account for about a third of employment in the auto supply chain.

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"I wanted to focus not on the huge companies, like Timken or Magna," she said, "but on the smaller suppliers of the larger companies."

Taking the High Road: Productivity and Continuous Improvement

Of the two possible "futures" for each company in her study, she began with the "high-road" future. This "win-win-win" future was one of well-paid workers making cost-effective and sustainable products for consumers and generating profits for owners. This future embodied "sort of a theory about the nature of knowledge" in which high-road techniques harness everyone's knowledge—not just top executives'—to achieve innovation, quality, and variety. This might be called "agile production," she said, by which firms design, set up, debug, and produce a variety of products quickly—just in time. It no longer relies on a fixed division of labor because the product mix changes constantly; it employs people who can do more than one job, because no one knows what the next job is going to demand. She mentioned a manufacturer in Ohio that used agile manufacturing techniques that could produce and deliver a wind turbine within 24 hours for most of the United States.

The low-road strategy, by contrast, was one in which each company in the supply chain tries to profit by squeezing those who are below. This, she said, is cost-shifting—trying to have somebody else bear the costs—rather than maximize the value of the chain. "We heard this constantly in our interviews," Dr. Helper said. "We also heard, 'Our hands are tied,' 'We'd like to help but we can't afford to pay anybody,' and so on."

With respect to these two strategies, she said, her data showed wide variability within industries. She said that according to data gathered by her colleague Daniel Luria, these different strategies, even within narrowly-defined industries, had different implications for innovation and the nation's standard of living. Within the narrow industry of automotive stampers, she calculated the value added per employee. After subtracting purchase inputs, this is money that is used to pay the workforce, invest in new capital, and deliver profits to the owners. The lowest-performing 20 percent of firms in her survey in terms of value added indicated that this remaining money per worker is about $30,000. "You can't pay minimum wage with that," she said, "let alone re-invest." On the high end, by contrast, firms were generating about $120,000 of value added per worker. This was used to invest in worker training, new product design, and state-of-the-art equipment. One such company paid for college for any employee, and even paid for advanced degrees for people on the shop floor who wanted to move up into management. "This indicates a viable business," she said. Similarly, her data showed that hourly wages reflected the same breakdown. The lower-end firms were paying about $9 an hour, the higher-end firms $17. "That's a difference between a living wage and really a poverty wage."

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Evidence that High-road Firms Succeed

Dr. Helper then examined how well the high-end companies succeeded. A key top-line strategy for them was to design their own products; the high-end group was designing about 70 percent of them, while the lower-end group designed nothing, doing only contract production. This pattern was common to many industries, she said.

She examined the innovation benefits derived from shop-floor skills ("lean" behaviors) and divided them into two aspects. The first was resource reduction, especially waste reduction and inventory reduction, both of which free up capacity. The second aspect was continuous improvement, or "kaizen," often defined in terms of quality circles. "How to debug your products is really important to this innovation strategy that we're all talking about," she said.

Dr. Helper illustrated this point with data from the Michigan Manufacturing Technology Center. It showed that from 2007 to 2010, companies with consistent quality (quality + stability) generated higher productivity as measured by the percentage of products that were "good first time," versus products that had to be discarded or debugged. In the stamping sector, for example, the lowest-productivity group of companies had a "good first time" rate of 97 percent, while the highest-productivity group had a rate of 99.97 percent. This seemingly small difference was reflected by a large difference in productivity. The value added per full-time equivalent in the first group was $55,000, while the value added in the second group was $125,000. Likewise, employee turnover was 32 percent in the first group and 0 percent in the second. She showed the same pattern in other sectors, including molding, machined parts, dies/molds/prototypes, machine tools, and electricals/electronics.

This second aspect of lean, the continuous improvement, appeared to accomplish at least two objectives. First, it provided distributed knowledge to speed de-bugging. And second, firms with quality circles, suggestion systems, and preventive maintenance were able to design a higher percentage of their products, do more R&D, and improve processes faster. Firms where employees attended quality circle meetings, for example, grew 6.4 percent in sales between 2007 and 2010, while firms where employees did not attend quality circle meetings lost 26.9 percent in sales. Firms that performed preventive maintenance grew 17.1 percent in sales over the same period, while firms that did not perform preventive maintenance lost 10.4 percent in sales.

"How do firms achieve such high productivity and high wages?" asked Dr. Helper. One point, she said, is that direct labor accounts for only 5 to 15 percent of firms' outlays. And higher-wage workers have many ways they can reduce costs and increase revenue. The more people on the shop floor understand the purpose what they are doing, the better they understand the importance of debugging, for example. They also know how expensive a mistake can be, when shutting down an assembly line can cost $10,000 per minute. Despite these clear advantages, however, most firms reported that do not

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adopt high-road policies. For example, fewer than 50 percent have quality circles or consistent preventive maintenance. Clearly, substantial barriers exist.

Barriers to the High Road: Complementarities and Externalities

One barrier to the adoption of the high road, she said, is a lack of awareness of the importance of complementarities. That is, one investment in productivity is unlikely to pay off without other, complementary investments. The ability to have an agile production system requires near-simultaneous investments in equipment, marketing, IT, and human resources. For example, the installation of advanced equipment is unlikely to pay off without the information technology that links it with all users. She offered the case of the shop foreman who is in charge of the latest IT equipment but continues to carry the schedule for the shop floor in his shirt pocket. Similarly, a company that makes the same product every day can get by with only fixed automation; today, however, when a company needs the ability to design, schedule, and produce many different products quickly, it probably needs a computerized numerical control system, and it has to train people to use it. "This is really hard for a small firm to pull off," she said.

Another barrier to the high road is lack of awareness of externalities, such as education.[26] In the old U.S. model of skill development, large companies invested in their own training and apprenticeship programs. Today the re-structuring of U.S. manufacturing has weakened this custom. Large companies rely for skills instead on SMEs and shared supply chains. With each supplier selling to several automakers, automakers are tempted to "free-ride" on their rivals' investments in training for suppliers. "If I'm GM," Dr. Helper said, "I'm reluctant to help my supplier get better because Ford's going to benefit." A result is that large companies seek the best suppliers they can find anywhere, including abroad. "It's much easier, particularly if you are constrained for cash, to just complain about who is going to invest in training, and then nobody invests."

Training Systems for SMEs Abroad

Abroad, she said, the situation is different, where governments have invested in their suppliers and in training at all levels. "It's not that shared supply chains here are bad," she said, "it's that they need to be governed differently than the way we've governed them in the past." She cited Germany's Fraunhofer Institutes as an example of a training system where even small firms

[26]An externality is" a cost or benefit, not transmitted through prices, incurred by a party who did not agree to the action causing the cost or the benefit." Source: Wikipedia.org. For example, a firm may pay for a training program at a community college in hopes that graduates will come to work at the firm. This external expense may benefit another firm if a graduate chooses to work there instead.

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can learn from people with deep knowledge and learn to make long-term strategies.

The MEP, said Dr. Helper, responds to these problems in several ways. One is to help firms understand complementarities by providing a comprehensive diagnosis of supply chain or other issues. Unlike many federal programs that offer only training, the MEP helps with solutions to problems it diagnoses. In particular, it directly provides lean training; she urged more emphasis on continuous improvement coaching as well. The MEP also brokers some solutions. It offers links to information about what works, such as help in translating new technology or a new management practice to make it useable by SMEs. It may also provide information sharing within clusters and help with funding.

She made a few suggestions for improvement at MEP. One was a reminder that the MEP cannot be all things to all clients. "MEP will have to solve these problems not by itself, but as part of the whole system," she said. She cautioned that the decentralization of manufacturing makes more kinds of demands on the MEP, but urged the program to remember the priority of upgrading their clients' skills and resources. She also commented that the MEP could make better use of data—not just the data that it collects about the success of particular projects, but about which practices actually work.

Finally, Dr. Helper also urged the MEP to deepen its relationships with universities. An obvious benefit can be to gain current knowledge about new technologies. Universities can also train field agents to translate the technologies to clients once they understand them. In addition, academic partners can help grapple with management issues, such as risk analysis and total cost of ownership. As labor costs go up, companies of all sizes face many costs of different kinds that are difficult to measure. Finally, she said, universities can lead discussions with MEP about leadership development within firms—the skills required of management to not only make positive changes, but sustain them.

THE MAGNET STORY: FROM LEAN MANUFACTURING TO PARTNERSHIPS FOR INNOVATION

James Griffith
MAGNET
and Timken Company

Mr. Griffith, who is the CEO of the Timken Company, a century-old global manufacturing firm, said that the company had undergone a "radical transformation" over the past decade. At the turn of the century, it was an automotive supplier of bearings and other specialty steel products struggling to adapt to hard economic times. Today, Timken is a far more diverse and

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profitable firm that derives less than 20 percent of its revenues from autos. During that decade it has doubled in size with the same number of employees.

The renewed success of Timken, said Mr. Griffith, difficult though it was, convinced him and other leaders that more could be done to revive the rust belt economy of northeast Ohio in which he lived. About five years ago a group of Cleveland foundations raised $30 million to invest in economic development for the region. Building on one of the nation's first MEP organizations, the Cleveland Advanced Manufacturing Program (CAMP), they recognized that technology should be an emphasis and launched a number of initiatives. Nortech was created to bring more technology-based firms to the area. Jumpstart was designed to promote entrepreneurism. BioEnterprise took advantage of the leadership of the Cleveland Clinic to foster the growth of new biomedical firms. And all were partners with the Ohio Third Frontier, which has made high-tech investments in the state totaling at least $1 billion.

The existing manufacturers, Mr. Griffith went on, responded to this activity by wanting to clarify their own role in economic development. In response, Mr. Griffith and others led a review of the most promising opportunities. They discovered that companies that had survived and thrived as global leaders, such as Timken, Eaton, and Parker Hannifin, were now tied to global supply chains, not those of northeast Ohio. And at the SME level, they found two different kinds of companies—older suppliers struggling to determine which markets to pursue, and new, emergent bio-enterprise companies building on 21st-century technologies.

The Need for a Manufacturing Advocacy and Growth Network

The group decided to change and expand the mission of CAMP, and in 2007 renamed it MAGNET, the Manufacturing Advocacy and Growth Network. It remains an MEP, with the fundamental goal of helping manufacturers "to become more competitive and to grow." Mr. Griffith was named Chairman, guiding the development of an organization of a staff of about 36 full-time employees and $10 million in funding from a combination of federal, state, and industry sources. It is also one of 13 Ohio Edison Technology Incubators, and a leader of the northeast Ohio economic development system. About $2 million were added to its budget from foundations, government grants (many of them cooperative with the other technology organizations), and corporations. The corporations wanted not so much to build their own supply chains as to strengthen the entire regional economy that included their headquarter cities and home terrain. The $2 million, in particular, was spent on advocating for manufacturing. This, he said, began with convincing government leaders and "hard-headed CEOs" that there was already an advanced manufacturing presence in northeast Ohio, and that an organization like MEP could increase the value and power of that presence.

Second, the funding went to strengthen the educational community, including community colleges, technical high schools, four-year colleges, and

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private institutions. During the corporations' study, Mr. Griffiths and his colleagues had examined the curricula of the 17 universities in the region and could not find the word manufacturing in any of them—"even though we were the largest piece of the economy." The group set out to change that by encouraging educational institutions to build curricula that serve manufacturers, raise the level of workforce expertise, and promote career opportunities in manufacturing.

Moving from Lean-only to Innovation and Export Strategies

Finally, MAGNET sought to bring leading management skills together to promote not only lean practices—the early focus of MEP—but also innovation and export strategies. It has lead responsibility for serving the automotive sector. Recent steps include adding a new green enterprise development training capability through Purdue University and a new product development management service to help smaller manufacturers. Its Edison Incubator has 22 tenants, and is working to link them more closely with product engineering capabilities.

Mr. Griffith described the impact of MAGNET for FY2011: 57 events attended by 1,601 people from 791 companies; the sale of 99 fee-for-service projects; services to 551 manufacturing companies; and an economic impact including $296 million in increase/retained sales, $17 million in cost savings, $50 million in investments, and 1,382 jobs created/retained. "Five years down the path," he said, "this thing is beginning to work."

A Different Look from the 'Normal' MEP

The effort has focused on bringing a different approach than "the normal MEP," with a different look. "And we're now recognizing that many of these companies don't even know what they need in the way of innovation," said Mr. Griffith. As a result, the group was designing a new program called PRISM, the Partnership for Regional Innovation Services to Manufacturers. This is to be a "boot camp" of marketing and innovation for small companies. The first four companies are now going through a "beta test phase," with an objective of 50 clients. It is also negotiating with two large educational institutions about how to build a new economic model for the region. This would position MAGNET as a "neural network" that connects the universities to the SMMs. The goals would be to help SMMs understand what resources are available and build within the universities the specific engineering, innovation, local, and global marketing skills needed by the manufacturers.

Scaling the MEP to the size required to drive the growth of SMEs, Mr. Griffith concluded, would take an estimated $20 million annually. "This gives some perspective on how one region is now looking at MEP," he said, "within the larger portfolio of what is needed to transform a regional economy."

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DISCUSSION

Robin Gaster asked Dr. Helper whether the auto stamping companies she studied were hiring more workers as a result of their high-road practices. She said that this was probably happening over time, but that the main positive outcome was that they were more likely to stay in business. She added that two kinds of companies were most likely to survive the recent recession. One kind was the "really, really good companies." However, she said that some companies proudly told her they survived because they had no fixed costs: they owned their building and their land, and they laid off their workers to await better times. Among companies that failed, on the other hand, some were well managed but caught by circumstances, such as the purchase of expensive equipment just before the recession.

Advantages of Kaizen

She added that she did have evidence about the link between kaizen—continuous improvement—and innovation. It is only a correlation, she said, but it does suggest that companies with quality circles and preventive maintenance are more likely to do R&D, to design a greater percentage of their products, and to generate a greater percentage of innovative products. "So there's a statistical link, as well as the case studies."

Dr. Wessner asked Mr. Griffith what he needed to make MAGNET work better "Do you have scale issues? Are you getting enough funding?" He suggested that some organizations are obsessed with "that great new company with the latest super-high-tech that will take forever to get to market, rather than supporting companies that just employ people and produce and export." Mr. Griffith said that the board at MAGNET struggles with finding a sustainable funding model. Another struggle, he said, was that the current MAGNET metrics "are built around propagating lean." He noted that several speakers had discussed jobs retained, but few had described jobs created. "Investments in innovation take time," he said. "My view is that it will take a long time to rebuild the economy in northeast Ohio. We spent 50 years building an infrastructure that is bureaucratic and is now in the way of the new technology companies. We have a strategy that works if we can figure out how to put the pieces together, sustain the funding, and accurately measure the progress."

Searching for a Sustainable Model

Dr. Wessner asked if there was enough foundation support for MAGNET. Mr. Griffiths said that "foundation support, unfortunately, is very much like government support. You get it on an annual basis. That's not really a sustainable model." He said the organization had just hired a person to help design such a model, and to advise on which pieces should come from government, which from foundations, and which from MAGNET itself in its

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fee-for-service work. He said that Minnesota's work in funding surveys and other work through sponsorships is an interesting model.

Dr. Wessner noted the similarities between what northeast Ohio is going through and what the U.S. semiconductor manufacturers went through in the 1980s. The semiconductor firms attracted $100 million from DARPA, which they matched in creating the consortium SEMATECH. They also received trade adjustments to stop dumping, along with signals from the government that they wouldn't be allowed to go out of business. Those CEOs that designed SEMATECH eventually adjusted their model to go ahead without the government funding.

Mr. Griffith mentioned also the model of the steel industry, which he represented. It went through a "massive restructuring" in the late 1990s without outside help. Because it made hard decisions, exited markets where it couldn't compete, and closed noncompetitive facilities, the steel industry in the United States is operating profitably today. "So there are lots of different ways to work your way through this. But the future of the northeast Ohio economy will be a grow-your-own kind of economy. There are some success stories of companies that have figured it out with the help of the MEP, the foundations, and some good entrepreneurial business people. It will be interesting in 20 years to come back and see what makes up this economy."

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Panel IV

Measuring Success: Assessment and the Demands of the New Strategy

Moderator:
Deborah Nightingale
Massachusetts Institute of Technology

Dr. Nightingale said that a critical aspect of the MEP was how it measures its success. We need to know more, she said, both about how this has been measured in the past, and how it could better be measured in the future "to understand where we are and how to move forward."

Relevant and accurate measurement is critical during a time of transition, she said, "to make sure that we are measuring the right kinds of things." There are many different kinds of measurements, including outcome metrics and process metrics, which are quantitative, as well as qualitative metrics. "I think it's going to be important as we move forward to really understand how and what we should measure so that assessments are aligned with the new strategy MEP is laying out." She said that the speakers would discuss the current state of assessment, proposals for some future measures, and some of the challenges of measurement, "which are true for any organization I've ever worked with."

THE MEP ASSESSMENT MECHANISMS

Gary Yakimov
Manufacturing Extension Partnership
National Institute of Standards and Technology

Mr. Yakimov opened his talk by saying he was not an economist by training, but a policy person whose focus is on helping develop a system of measures "that can quickly and easily inform policy decisions." When reviewing

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performance and evaluation, he said, the focus is on three distinct levels of data and measurement. One is what happens at the level of the client with respect to impacts and performance improvements. The second is at the level of the MEP center. That is, what does the individual center do as an investor: Are they doing the kinds of things MEP wants them to do, and do they have positive impacts on their clients? Third, at a system level, is the MEP making people aware of its value, and does discussion about its activities inform policy?

This is not the first time the MEP program has been reviewed, Mr. Yakimov noted. The evaluation system and performance measures had been reviewed positively several years earlier by the Office of Management and Budget and by the National Academy of Public Administration (in 2003). OMB indicated that the program was well-managed, with regular reviews to assess performance, while NAPA found that the metrics used to evaluate programmatic performance and outcomes are "extensive," and highlighted an SRI report which noted that "the significance of these efforts is not in the methods used or the results generated, but in the integration of evaluation into a longer-term, strategic framework." In addition, he said, "we are constantly invited to talk to other federal agencies about our approach to data, which I think is a good signal."

A Culture of Accountability

He said that one of the reasons why MEP is praised for its evaluations is that it "has a culture of measurement and accountability." At the beginning of each year, each center files an operating plan, and the MEP uses many tools to "hold the center accountable to us and to our investment." They report quarterly on their clients, and the MEP then surveys those clients. It also uses peer reviews; every other year a center is reviewed by a panel of peers which then analyzes their strategy and makes recommendations. The MEP also does an annual review in parallel, including a caucus of all staff that reviews best practices; this helps provide early warning signals about the centers. It does a longitudinal evaluation every few years, and research policy and analysis.

In managing the reporting and survey process, Mr. Yakimov said, the MEP receives detailed reports from the centers on their work with the clients, including the industry, hours worked, kinds of intervention, and contact information. Six months later a third-party survey firm asks a series of follow-up questions to determine how the MEP assistance affected sales, jobs, and other outcomes.

An 'Incredible' Survey Response Rate

The response rate to a quarterly survey in 2010 had a response rate of about 85 percent, he said, "which for a survey I think is incredible." One of the reasons, Mr. Yakimov said, was that the sales staff is encouraged to tell clients at the outset that they would be surveyed at the end about how much each firm is

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investing in itself, jobs, cost savings, and other results. "We find the centers that do that more proactively and throughout the process have a higher response rate to their surveys."

The MEP also asks centers to report each quarter on any success. That success stories can be entered in a template on the MEP website, where they are grouped with others by geography or industry. Each story, guided by the questionnaire, has the same three elements: what was the problem, what was the intervention, and what was the impact, in narrative form. "We've had a lot of good feedback from our stakeholders around those success stories," he said.

The survey will soon change, Mr. Yakimov said, as the MEP moves its system toward new metrics. In January 2010, the survey was scheduled to begin to ask two kinds of questions. One kind would ask whether the work of the MEP center helped the firm enter a new market, find a new customer, or develop a new product or service. A second kind would ask whether the firm actually invested in a new product or process. A larger upcoming survey would align with MEP's next-generation strategy, which includes E3 (the government's Economy, Energy, and Environment Initiative), as well as export plans.

A Snapshot of MEP Performance

Mr. Yakimov presented a snapshot of MEP's performance, including a series of client impacts resulting from MEP services for FY 2009: new sales ($3.9 billion), retained sales ($4.9 billion), capital investment ($1.9 billion), cost savings ($1.3 billion), and jobs created/retained (72,075). The survey asked clients for their three biggest challenges. The top responses were (1) ongoing continuous improvement / cost reduction strategies, (2) identifying growth opportunities, and (3) product innovation and development. He said that this information could be interpreted in various ways. After all, every business wants to reduce costs—and yet this objective is not sufficient to fuel long-term growth or global leadership. Nor can number 2 be taken at face value. He noted the famous remark by Henry Ford, who said that if he had relied on his customers for advice on the most promising growth opportunities, they would have asked him to build a faster horse. "I think one of the challenges we have across our system is to create a sense of urgency in small/mid-size manufacturers about the need to grow, innovate, export and become more sustainable. What's really important about this survey is whether we have products and services to meet this list of needs, and the fact is that we do, and we continue to develop them."

Transition to a New Reporting and Evaluation System

Mr. Yakimov said that in the transition to a new reporting and evaluation system, the MEP would continue to hold centers accountable for three things: financial stability, market penetration, and client/economic impact. "That model will never change, whether it's the current system of evaluation or the new system." The current system evaluates clients on new sales, retained

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sales, investment, cost savings, and jobs created and retained. The MEP holds the centers accountable for these results, and evaluates them on the basis of minimally acceptable impact measures (MAIM), annual and panel reviews, the operating plan, and quarterly data reporting.

The reason for the imminent change, he said, was that the MEP needs a "more balanced scorecard." At the beginning of the MEP program, he said, the evaluation focused too much on activities and what the centers were doing to work with manufacturers. About a decade ago, the MEP moved to the client impact survey as the sole mechanism to hold centers accountable. "I think what we want to do now is reach a balance between those two things. We want to look at the activities in addition to the outcomes and impacts."

Mr. Yakimov noted that because it is inherently difficult to quantify the impacts of social programs, this shift in balance recommended an emphasis on the "preponderance of evidence" in describing impacts with clients or individuals. "We want to be able to say, 'There is a preponderance of evidence that the centers are doing the kind of good work that we want to see.' We do focus on the client impact survey because it is entirely quantitative. But we want to build on that with qualitative analysis—to not only look at the centers' performance, but to look at it through the eyes of an investor. Are they doing the kinds of things we want them to do?"

This shift in balance is scheduled to feature the following:

- Increased focus on growth through innovation.
- Increased focus on market penetration.
- Minimal performance is not sufficient for understanding and informing performance and investment; there should be threshold levels to distinguish levels of performance and investment.
- Maintain the historical focus on market penetration, client impacts, and financial viability.
- Invest intelligently in centers that are strategic and high-performing.

The first two bullets were new and critical, he said, urging clients to focus on growth and innovation, and on serving more clients. He said that the current system was a "very binary evaluation system. You either met our minimal standards or you don't. We need a way to think about what is a high-performing center. We need to move beyond minimally acceptable impact metrics that allow us to distinguish our really strong performers." He added that there would always be centers that struggle to meet minimal performance, and the MEP would work with them.

A New Scorecard

Mr. Yakimov showed an illustration of the "current scorecard without the detail," a "center on a page" with four quadrants. In the upper right quadrant

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were "the main indicators"—what clients think about the center. This showed an increased focus on growth, investments in innovation, and a new measure of the number of clients served. There was a continued focus on cost savings, but reduced from the previous system; a four-quarter rolling average of metrics, and a new entry for contextual views on the percentage of positive responses over time. "Right now a center can score 100 on the scorecard every quarter, but actually be declining in the number of clients they serve, the number of hours they're working, or the impacts they're having. And we don't really focus on the historical performance of the centers, which we're going to increase. This quadrant will be 80 percent of a center's grade in the future."

In the upper left quadrant was what he called the "preponderance of evidence indicators," which was mostly qualitative. To avoid multiple naming conventions, he said, the qualitative metrics would be organized in the same categories as the panel reviews: Does a center understand and help lead its market, do they have a sustainable business model, what are their strategic partnerships, are they financially sound, and are they aligned with MEP strategies.

Mr. Yakimov praised the Manufacturers Resource Center of Pennsylvania, directed by Jack Pfunder, for its work in a Technology Scouting project with MEP. This is an effort to help firms find technologies that can "move them to the next level." The work was highly effective, he said, in building a business model, but it required patience, because the impact on the

Center Diagnostics: **"What NIST MEP is saying…."**	**Impact Metrics:** **"What your clients are saying…."**
• Categories Aligned with Panel Review (Market Understanding, Business Model, Strategic Partnerships, Financial Viability and Investments, Strategic Alignment with NIST MEP) • Largely Qualitative • Threshold Levels • Percent of Centers Grade	• Increased focus on growth, investments in innovation, clients served, and reduced focus on cost savings • 4 Quarter Rolling Average • Contextual views on Percent Yes, Change over Time, and Median • Percent of Centers Grade
Opportunities and Challenges: **"Insights and Anecdotes…"**	**Review Recommendations:** **"What your peers are saying…"**
• System and Center Operations insights on areas of concern and/or promising practices • Changes in structure, leadership, staffing, finances, etc.	• Panel Review in Brief • Center Review in Brief

FIGURE 10 MEP SCORECARD: "Center on a page"
SOURCE: Gary Yakimov, Presentation at November 14, 2011, National Academies Symposium on "Strengthening American Manufacturing: The Role of the Manufacturing Extension Partnership."

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client is not as quick as it can be in other projects. "Something we may not see in the upper right quadrant," he said, "will be rewarded in the upper left," where the "preponderance of evidence" measures appear. These measures indicate whether a center is doing the kinds of work and using the new tools and products suggested by the MEP.

The bottom right quadrant, he said, reported "what your peers are saying about you." This included the panel reviews and the center reviews. Finally, the bottom left quadrant showed "insights and anecdotes" that inform the scorecard as a whole. This quadrant might report a change in the center's director or key staff, the loss or gain of a funding source, and other areas of concern or promise.

He showed the timeline for the transition to the new evaluation system, which was to be released to the centers with detailed metrics in late January 2012. The two systems would run in parallel for about a year until the new one becomes official.

In conclusion, Mr. Yakimov summarized the MEP's work in research and analysis, including the use of MEP data, policy papers, case studies, and data tools. He highlighted two points. "We want to do a much better job of telling our own story, using our own data. I actually think that we could be informing manufacturing strategy better than anyone else if we can figure out a way to better mine our own data and produce custom reports on a regular basis."

EVALUATING MEP EVALUATION

Daniel Luria
Michigan Manufacturing Technology Center

Dr. Luria, vice president for research at the Michigan Manufacturing Technology Center, an MEP, opened with the thought that "if we keep doing what we've always been doing, we're probably going to get the same kinds of results." He said that he was an economist whose major field of graduate study, done at the University of Michigan's Institute for Social Research, was economic surveys. He had been working for an MEP center since it became one in 1991, and professed a long-standing interest in how to make the MEP more effective. This question, he said, that had been asked regularly since 1993, when members of the first five or six centers began gathering every quarter to discuss the topic."

A Need for Improved Measurements

He reiterated that clients are surveyed for MEP about six to 12 months after the end of delivery of MEP services, asking for impacts results. These surveys, he said, generally reported very large numbers for new and retained sales, new and retained jobs, and cost savings/ cost avoidance; for example, the totals have been about $1.9 billion in cost savings and $50+ billion a year in

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additional/ retained sales. But, he said, "it's still the case that the medians on nearly every metric are at or near zero." He said he would explain why that is a sign of an evaluation that isn't making its measurements very well, but also why it is "not as bad as you might think."

Dr. Luria said that three rigorous client control studies had been done for MEP: one for the 1987-1992 period, by Jarmin & Jensen, which found no sales effect and a 5 percent gain in productivity (value added per employee); another, for the 1992-1997 period, focusing on the seven MEP centers in Pennsylvania, by Eric Oldsman of Nexus Associates, which found the same results; and a third for 1997-2002 by an SRI/Georgia Tech, which found neither a sales nor a productivity effect. "I think that's another way of saying that the medians are zero or close to zero," he said.

He said that while he very much approved of the additions being made to the survey, an important feature of the ongoing survey was the stable, consistent instrumentation and questions it had used for more than 10 years. "The centers are used to it," he said, "and it clearly influences their behavior. For example, part of the pay for our delivery staff at the Michigan center depends on the response rates of clients, whether those clients are able to quantify results, and other familiar behaviors."

'A Very Difficult Question to Answer'

However, Dr. Luria said, an inevitable problem with this kind of survey is the difficulty of expecting clients to compare their current situation as an MEP client with an imagined situation without MEP services. This difficulty is compounded by queries that require dozens of calculations to answer meaningfully. "For example, one of the cost reduction questions is: 'Compared to had you not worked with a Center, how much lower are your labor, material, overhead, and inventory costs?' Leaving aside the lack of agreement on a definition of overhead, and the problem that inventory costs are a one-time savings on the balance sheet, it is a very difficult question to answer." Finally, he said, client control studies can be done only every five years as part of the census of manufacturers. This does not give feedback to MEP that is rapid enough to evaluate the functioning of centers.

Another complexity is the large "sum of impact" results. "We know those are driven by outliers," he said, "because again, the medians are so close to zero." However, he emphasized that a zero median finding does not prove that MEP "doesn't work." For example, in clinical trials, a medicine with 40 percent effectiveness versus a placebo with 15 percent effectiveness is deemed to have clinical value.

'Complex, Counter-factual Questions'

The zero median findings, Dr. Luria said, were not "damning." Instead, he said, they were "part of why I believe that the medians are not zero, but that

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measurement problems are making them seem like they're zero." For example, he said, one question asks, 'Would you recommend your MEP center to provide services to other companies?' The companies that don't report any impact themselves are just as likely to answer yes, they would recommend it. "So that tells me that the more honest you're being as a company, the harder it is to answer these complex, counter-factual questions."[27]

The true role of outliers is hard to assess, he continued, because the survey looks only at changes with no reference to base levels. Thus, a $1 million client reporting a $2 million impact is accepted, while a $100 million client reporting a $25 million impact has to be investigated. What is missing, he said, is a systematic guide for companies about how to think about the impact; for example, embedding instructions and worksheets in the survey. This lack opens the door to centers coaching clients on how to respond, he said, and almost certainly leads many clients not to quantify impacts. As an experiment, Dr. Luria built a simple spreadsheet for clients. It suggested that in regard to the change in sales, for example, "there are four or five questions you can ask yourself. We found that this gave companies a way to think about the question and quantify it. If we can do that, it's going to tend to get the medians up."

Dr. Luria noted, however, that ingrained habits would make it difficult to change techniques. There have been attempts to change the survey "in directions that I like," but those attempts have been resisted by center directors "because they're used to what they've got, and they know that if they serve enough companies, they'll get enough outliers to make them look good. So I think that's a cultural problem." He agreed with Dr. Yakimov that MEP needs a culture of innovation, but for this to occur, he said, "how we measure ourselves maybe has to change as well."

He returned to the planned survey changes, praising the emphasis on evaluating growth and innovation projects. From an evaluation standpoint, he saw little new about such projects, and approved of the changes being proposed for the survey. He agreed that the new sales that are credited to MEP activities are a valid metric.

The Two Elephants in the Room

"But there are two elephants in the room," Dr. Luria cautioned. The first is that "it is highly unlikely that MEP or the centers can get most clients to ascribe new sales to MEP services." It is easy to see the source of a change that eliminates bottlenecks in the production system if the MEP brings in industrial

[27]He offered the following example of this survey problem: An MEP center helped a client achieve compliance to the ISO 9000 standard required by customers accounting for 80 percent of its sales. Client A credits services with retaining 80 percent of its sales. Client B reasons that it would have achieved compliance somehow without MEP, and reports no impact. *Client A generates an outlier; client B depresses the median.*

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engineers who correct the system and calculate the times. But it is more difficult for econometricians to explain variances in sales. "I think what it's really about is that when companies grow, their managers feel like they're geniuses, and when companies don't grow, the managers feel that their customers are bad people. There's not a lot of room for them to say, I am growing somewhat, and a significant part of that is because I learned something from my interaction with MEP."

More serious, he said, is that all sales impacts must be presumed to be zero-sum or very nearly so for U.S. manufacturing. Centers often conclude that they had a large impact on sales or cost savings or exports, he said, but we really have no way of knowing if that work is really new sales, or whether it is being won from other companies, even within the same state. "So the displacement effect has to be measured if we're going to do the evaluation right." He added that this presumption does not apply to productivity growth, where one firm's increase does not imply other firms' decrease.

The key to evaluating the MEP, Dr. Luria said, is to agree on what we want to know. One business model problem is that the stakeholders who are investing in the program are defining it as an economic development or jobs program. This is not the case. "So helping companies become more efficient, and then thinking they ought to be adding employment strikes me as somewhat bizarre. It's a problem with having a major stakeholder that wants to measure the wrong thing."

A Better Metric: Change in Net Value Added

A better metric, Dr. Luria said—mentioned already by Dr. Tassey—is the change in net value added. "The first question is, do MEP services make U.S. manufacturing larger than it otherwise would be? We don't want to measure that just as employment, because that would be measuring inefficiency. What we're really interested in is the change in value added per FTE." To measure this, he said, the survey needs data from both before and after MEP services: sales before, sales after; purchase inputs before, purchase inputs after. To solve the objection that new sales come at someone else's expense, the result can be adjusted by the import-to-domestic-production ratio for the clients' six-digit NAICS code. [28]

New Questions about Productivity

A good evaluation also wants to know about productivity, he said, and the survey needs to be improved in at least two ways for this purpose. He

[28]The North American Industry Classification System, developed under the Office of Management and Budget in 1997, is used to classify U.S. businesses for various purposes.

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offered his first suggestion in the form of a question: "I'm an SME, and my productivity increased 10 percent last year with the same labor input, but my sales did not go up. What am I missing?" The problem, he said, is that the survey does not ask companies whether or not they had to reduce their prices to become more productive. "So there is a huge unmeasured customer surplus impact," he said. "There needs to be a question like the following: 'Thinking about products you made two years ago that you still make now, how much more expensive or cheaper are those products?'"

A second question MEP needs to ask, he said, is whether a client's productivity is rising faster than non-client productivity, other things being equal. The most recent survey does not answer that question in the affirmative, he said, but certain changes could make clearer what is happening. "But until we understand whether or not the reports of no productivity growth and no cost savings by clients are meaningful or are problems of measurement, we're not going to know the answer to that second question. And we're not even asking the first question. We want to know whether the MEP is helping make manufacturing bigger than it otherwise would be, and whether their clients are advancing compared to non-clients."

In summary, Dr. Luria offered the following conclusions:

- The current evaluation system has been logical and consistent. It works "passably well" in generating "large-seeming sum-of-impacts" that generally help the problem and motivates centers.
- However, claims of MEP impact need to be based on changes in value added and productivity. Failure to do so "invites a reasonable presumption of near-zero net impact." The current evaluation does not address either question very well, he said, and does not tell centers what they should be doing to increase these outcomes. For example, he said, his center had reviewed which kinds of MEP interventions produced the largest reported increases in new sales. The results were that quality-based projects produced the largest increases, "lean" projects the next largest, and growth projects the least. "Now I don't believe those results at some level," he said. "But the problem is that our data don't tell us what to do if we are striving for a certain impact." He said that his center had designed a survey no longer than the current survey that would answer these two questions.

DISCUSSANT

Robin Gaster
The National Academies

Dr. Gaster said that "what MEP has done with data is very impressive." He said that in his experience with SBIR and other agency programs, none of the agencies collected data with "anything like the amount or the detail that

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MEP is using, so MEP deserves a lot of credit for that." He also said the program deserved credit for its willingness to re-examine older data to see what needs to change. "That also is not something that's characteristic of all federal agencies," he said.

He said that a lot of what the MEP evaluation does is important, and that its three-tiered approach captured much of what is needed. He commended the new concept of the "balanced scorecard" as "clearly correct."

Dr. Gaster also said that the discussion about the centers pointed to several key variables: inputs, outputs, capacity building, and process, "which is difficult to capture but very important." Also desirable, he said, would be a metric on how stable the centers are. He agreed with Dr. Luria that the zero-sum problem of domestic and foreign sales was "really a deep problem, because you are in a state economy to start with and then in the U.S. economy, and you do have to find the value added, not just the extent to which you manage to cannibalize" from other firms.

A Need for Consistency in How Questions are Answered

Dr. Gaster said that Dr. Luria's comment about the need for consistency in how questions are answered is important, as shown by his own experience in designing a large questionnaire for SBIR companies. "When you look at these things under a microscope," he said, "they dissolve. You look more and more closely at exactly how companies answer questions, and consistency melts away. It's very important to give them clear guidance."

On the issue of moving toward more emphasis on innovation, he said he had some reservation. Innovation can be something that happens either quickly or slowly, and "you have to be prepared to capture both if that's your target. I think the survey has to be able to capture outcomes that don't happen in six months." Second, he encouraged more investigation of the use of data. He mentioned in particular Dr. Luria's comment about how data for different kinds of interventions was being matched with different outcomes.

How to Reach Companies Ready to Advance

In guidance for the centers, Dr. Gaster said that detailed differentiation of the interventions is important, as is differentiation of populations: For example, a company may want to adopt a green manufacturing strategy, but no one at the meeting had talked about what percentage of companies could realistically be expected to adopt a green strategy. Similarly, while there is data on the number of SMEs now exporting, the MEP would benefit by knowing how many more are interested and capable, even with help; this would be a much smaller number. A strategy designed to have every SME exporting in the near future is not realistic. "It would be a tremendous success to reach a significant portion of the companies that were ready," he said. "But you need to know who

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they are, and for this we need to capture or develop some metrics for reaching them."

Better metrics are also needed to bring the most appropriate strategy to each firm, he said. "Just cutting costs is great, and productivity is good. But are we taking a low road or a high road for this firm? I think it's powerful to consider how to develop metrics that differentiate."

Dr. Gaster concluded with a suggestion about the low barrier to entry into the program. For the SBIR program, he said, the success rate for the first round of funding is about 15 percent, and the success rate for the second round is 45 percent of that. So 7 percent of the applicants, not counting those who didn't know about the opportunity, are deemed worthy of support. "It's interesting to examine this program where basically you say, come on in, we'll work with you ready or not. It may be worth developing a way to gauge the readiness of a company that comes in the door for help. This would also give you some kind of baseline for what they were like when they went out the door."

DISCUSSION

Dr. Shapira asked Dr. Yakimov whether the MEP should do evaluations that are "more encompassing but less frequent"—why the centers went to the firms each quarter to pose the same questions as the previous quarter. He also prompted Dr. Luria to comment on his experiments with redesigning the MEP center in Michigan.

Testing a New Questionnaire

Dr. Luria said he had created a spreadsheet in which the current questions and the recommended questions are embedded. It had been tested with four or five companies, all of which were able to answer them all. With only five tests to date, he could not yet talk about the frequency of outliers, but the medians were all strongly positive, unlike those of the current survey, where they were typically zero.

Dr. Yakimov said that the centers currently report clients to the MEP at the end of the client interaction, and the client is surveyed six months after that. They can ask to be surveyed after a year instead, and they can be surveyed up to three times. "But we don't consistently go back to the centers to ask the same clients the same questions." The MEP is embarking on a longitudinal evaluation now, and designing ways to incorporate that into it or a future longitudinal evaluation.

He addressed Dr. Gaster's suggestion that the MEP do a "pre-assessment" to determine whether a firm that is cutting costs is on the low or high road. We said that most of the centers have assessment tools they use when they first interact with a client that lets them understand what the client's challenges are. This is not ordinarily used as a baseline, "because centers typically hold that information pretty close," but "it's something to think about

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in the long term." Also, some of the new questions are meant to determine whether the firms have an innovation and growth strategy. "We want to concentrate much more on those that are willing to invest in themselves and grow. Also, we want to know if they just use the good ideas that are already on the market, or are they creating those new ideas." Finally, another item is the quality of the CEO, "which is another strong indicator."

The Long-term Value of MEP Services

Diane Palmintera said she was concerned about capturing the long-term value of MEP services. She mentioned the example of Georgia Tech, where the MEP program gives a small amount of money to the entrepreneurial venture lab to help with business development. "The impacts on startups you're not going to see for many years, and it's quite diluted. How can you capture the value of that? Dr. Yakimov said the issue of mature vs. startup firms is something the MEP struggles with, as is the possibility that the MEP survey sometimes drives behavior. "I would say it's definitely a place where we would love to hear the Academy's input on how we can do it better."

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MEP Roundtable

Group Discussion on Industrial, Policy and Operational Challenges Facing the MEP

Chair:
Philip Shapira
University of Manchester and Georgia Institute of Technology

Rob James, National Research Council, Canada
James Griffith, MAGNET and Timken Company
Luis Proenza, University of Akron
Phillip Singerman, National Institute of Standards and Technology

Beth Colbert said that she had felt a disconnect between research about manufacturing, how to create a policy for manufacturing, and actually having a policy. Phillip Singerman responded that "the nation has not had a manufacturing policy before." With the economy in disarray, he said, the country is "finally getting around to it. There's been a major imbalance in our private sector and particularly in our federal investments in technology, which are focused on defense, sometimes on energy, and of course health. But there has not been an investment in manufacturing technology for decades."

This began to change with the America Competes Act, he said, in 2007, but the Act was not fully implemented.[29] The Obama administration has recognized this, Dr. Singerman said, and a manufacturing strategy has emerged not from the need to stimulate the economy, but from the innovation agenda alluded to throughout the meeting. There has been a strong recognition that in order to maintain our innovation ecosystem, the nation needs a strong manufacturing sector. "It's not sustainable to think we can design it here and it

[29]Congress passed the America Creating Opportunities to Meaningfully Promote Excellence in Technology, Education, and Science (America COMPETES) Act of 2007 with the overall goal of increasing federal investment in scientific research to improve U.S. economic competitiveness. U.S. Government Accountability Office, *NIST Manufacturing Extension Partnership Program Cost Share*, GAO-11-437R, op. cit.

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can be built overseas. We cannot design it here if it's built overseas, and this is an important recognition."

GREATER SCRUTINY FOR THE ROLE OF MEP

The PCAST report on advanced manufacturing, he said, was a step forward in that process. The administration is interested in an Advanced Manufacturing Partnership that brings together major research universities and global corporations. NIST will have a central role in implementing this policy initiative, he said, and the writings of Dr. Tassey of NIST have influenced the thinking of the administration. The role of MEP is receiving greater scrutiny in large part because manufacturing has risen to the top of the administration's agenda.

THE UNITED STATES' 'LAISSEZ-FAIRE' MANUFACTURING POLICY

Dr. Singerman then asked Mr. Griffith whether he, as a corporate leader, would favor a national manufacturing policy, or whether he would prefer that the federal government not intervene in manufacturing activities. Mr. Griffith replied that the United States, in the absence of a formal policy, has a laissez-faire policy. "Our great need as a company is to maintain a level playing field, so there is fair competition. And once there is fair competition, we want to be able to win or lose based on that competition. The reality is that today there isn't fair competition among countries. So there has to be activism on the part of the government to be sure that more leveling occurs between countries in terms of currencies, hidden subsidies, market access."

That concern, Mr. Griffith said, is different for Timken than it is from an MEP point of view. For SMEs, the major issues are the infrastructure within which they must work. In different regions of the world, he said, these infrastructures are different. Where manufacturing is strong today, it is usually accompanied by universities that are strong in engineering and technology and able to spin off benefits for the private sector. On the other hand, regions where manufacturing was strong in the past are more likely to have complex tax structures, labor laws, and regulations that were designed for a world with workforces of 20,000 or 40,000 people and large fixed assets. The concern for such regions in the past was to balance the tax revenues between the inner cities and the suburbs.

A NEED FOR MORE FLEXIBLE REGULATION

"The problem with government regulation from that point of view," Mr. Griffith said, "is that they are not very flexible. We have been stuck with inner cities that are dying because the entrepreneurs won't move into them. So the challenge for MEP and for those of us who are trying to build a world in

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which SMEs can be successful is to revive that infrastructure and recognize where history has created barriers to the success of small business."

ARGUMENTS FOR A 'HOLISTIC' MEP

Robert James of the Canadian National Research Council said he sensed that a several-tiered policy is emerging in the United States, but at a local level where local agencies are building competitiveness. He said he agreed with Mr. Griffith on the importance of community mobilization and the need for a private-sector champion who acted above self-interest in leading a community to achieve that kind of collaboration. He said that the MEP also plays a larger role in the nation's competitiveness framework, but it needed a holistic approach to form strong partnerships with other elements of the innovation system. A challenge was to bring together the MEP program with sources of capital, clusters, and universities across the nation to develop an environment that is difficult to replicate. "That's where the sustained competitive edge, I believe, will be found over time. If you focus solely on lean manufacturing, competitors can over time replicate that with greater ease. The mix of disciplines in these partnerships is really good footing for a long-term, sustained competitive advantage."

THE NEED FOR A BROADER INNOVATION MODEL

Dr. Singerman added "a footnote" to the comments of the two previous speakers about a level playing field and a broader innovation agenda. The good news, he said, is that "manufacturing is connected to the innovation agenda." The bad news is that we have a skewed notion of what innovation is. The current models are the biotech and IT model. The IT model is Hewlett-Packard or Apple, where "two guys in a garage build the world's best company." For biotech, the model begins with hundreds of millions of dollars of NIH investment in university academic medical centers, and technology is licensed to large pharmaceutical companies or intermediary biotech companies fueled by venture firms. Our policies and attention at the federal level has been narrowly focused on those two models, he said. Obviously, innovation varies by industrial sector; it looks very different from these two models in energy, materials science, and other fields. "So I think the challenge for the manufacturing community is to develop a more sophisticated and nuanced model of innovation for the policy discussion at the federal level."

Joseph Houldin, of the DVIRC, said he agreed with Dr. Singerman and urged the manufacturing community to speak more forcefully and coherently as a group. He observed that many had voiced the assumption that universities and federal laboratories have major roles to play, and "I think that should be challenged" to "clearly articulate what their role should be." In our "little world of SMEs in southeastern Pennsylvania," he said, "there is minimal involvement with universities and labs, yet innovation occurs."

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THE AKRON MODEL: CREATING RELEVANCE, CONNECTIVITY, AND PRODUCTIVITY

Dr. Proenza said he would comment on the Akron model for university and company involvement in regional development. He said he was impressed by the fact that the Timken Company, together with MAGNET, had taken a strong interest in the health of an economy that "many other companies chose to abandon," some of them moving their corporate headquarters elsewhere. The universities, he continued, cannot move, and the University of Akron some years ago decided that unless it assumed leadership in the redevelopment of the economy, "it was going to die along with the large firms." He said the university also decided to challenge the notions that "academic is synonymous with irrelevant," that universities are not part of the community, and that the attributes of academic excellence are expense and lack of productivity.

Instead, he said, the university "created a model that is focused on relevance, connectivity, and productivity." This model embraces not only the biotech or IT industries, but touches the economy wherever it can, including SMEs to "make a difference that will be felt incrementally, gradually." He said the university would not restrict its economic development activities to its tech transfer office or commercialization group. The university as a whole would be available as a platform or tool chest to engage every discipline in whatever way is appropriate, sometimes by collaboration.

"What we've done over the years," Dr. Proenza said, "is to develop first of all a very low-cost model that we think is sustainable. We look at our community and try to assemble assets that in isolation are weak and perhaps not even usable. But in combination they begin to make a difference." An asset might be space or equipment that a company isn't using, he said, or people who have lost positions or retired and are eager to be involved as "entrepreneurs in residence."

"In working with companies like Timken," Dr. Proenza continued, "we recognize that the only winning strategies are strategies in which both of us can win and reduce our cost. For example, we've just started a program with Timken in which they are bringing a small group into the university to work side by side with our own researchers and thereby have a synergistic model of technology development. This ultimately will spin out, either back into Timken or into a startup with some form of joint ownership."

Grace Hu, of the Office of Management and Budget, asked whether the new U.S. patent law, allowing "first-to-file" patent rights, would favor small firms, as advertised, or larger firms, which have the "deep pockets" to file

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numerous patent applications.[30] Mr. Griffith replied that there is no simple answer because manufacturers do not all speak with one voice. "If you're at a meeting of the National Association of Manufacturers," he said, "you'll see different factions sitting and wrestling. I could even hear some say, 'I don't care about U.S. industrial policy because I run a global manufacturing company, and if the United States doesn't do the policy well, I'll pack it up and move to India or France or Brazil.' " On the other hand, he said, some very large manufacturing companies do invest in the United States, and have a different view of free trade treaties, tariff barriers, dumping suits, and other policies.

A KEY FOR THE STUDY: WHAT DO SMES NEED MOST

The small manufacturers tend to be divided in the same way, Mr. Griffith continued. Some think of small manufacturers as being regional and domestic, and not engaged in the global marketplace, but that image is not accurate. One MAGNET board member, he said, runs a $17 million manufacturer that has a factory in Taiwan and does technology development in China. "So as you think about MEP policy for small business innovation and development," he said, "you have to be very specific about the policy issue you're going to support, and then determine what it takes to make it happen. It's like saying I'd like to have a balanced federal budget. It's not going to happen, so now let's talk about what it is that we really have to have. I think that has to be the key for this study as we think about MEP: What things do we need to drive a generation of innovation in SMMs. Then we can go after that from the point of view of federal and state funding."

DRAWING UNIVERSITIES OUT OF ISOLATION

Paul Wright, of the University of California at Berkeley, asked Dr. Proenza whether he thought the MEP centers, as they sought to move in the direction of innovation and new technology, would benefit from being placed adjacent to or even inside a research university. Dr. Proenza said that the kind of partnerships between the University of Akron, Timken, and others might suggest that. He said there is room for different models, but that the MEPs might be connected not just to universities but to other sources of R&D and technology development, even outside the home community or region. "There is just a great need for partnerships. Universities are one part of those, and certainly they

[30]The America Invents Act, signed in September 2011, overhauls parts of U.S. patent law. One change is the "first to file" clause that awards patent rights to the first party to file. Existing law requires a more expensive and time-consuming process proving "first-to-invent" status, and allows a claimant to gain a patent already held by another by proving that an invention was made prior to one already on file.

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should not be isolated. But they have to be committed to improving the economy and collaborating with industry and the community."

A CONTINUING SEARCH FOR NEW MODELS

Mr. Griffith added that he hadn't experienced a desire from the marketplace for MEP to be driving innovation. "I think what you hear is a need among small and medium manufacturers to have a way to drive innovation. Today, MEP has insufficient funds to support that. We have heard about a lot of people searching for the right partnerships to leverage existing resources to generate innovation, whether it comes out of MEP, universities, or the foundation world. We're all looking for what those models are."

Dr. Wright asked whether there was a "gaping hole" between the high-tech research supported by the Advanced Manufacturing Partnership (AMP) announced by President Obama and the lower-tech, business-oriented consulting of the MEP. Mr. Griffith agreed that no one is offering help that would bridge that middle ground. "The OSTP has recognized that they need to broaden the participation both of large firms and universities and especially of smaller and medium-size manufacturing firms to be able to take full advantage of the resources and the energy that will flow from the development of this new AMP initiative."

THE CANADIAN MODEL: MORE DIRECT SUPPORT

Dr. Wessner asked Robert James, of the Canadian National Research Council, for an assessment of how the Industrial Research Assistance Program (IRAP) of Canada compares to the MEP. Mr. James said that as MEP is evolving, it has come to resemble IRAP more closely, except that IRAP emphasizes direct funding. He said that IRAP is housed in the National Research Council, and was created in the early 1960s to promote innovation and entrepreneurship across Canada. "It is highly recognizable and highly cherished by both politicians and private sector people alike for many different reasons," he said.

IRAP is focused on how to spur innovation, he said. Its presence extends to about 100 cities via roughly 260 industrial technology advisors who provide a range of business advice, technical advice, and funding, depending on a company's needs. This support is intended to help position the SME to move to the next stage of its development.

He said that IRAP is similar to MEP in a several ways. Both are geographically dispersed and have their own consultants and advisors. A difference, he said, lies in Canada's federal transfer payment policy. This means that when the federal government make a contribution agreement and transfers monies to an external organization, those organizations are "on the hook—in this case to the National Research Council"—to report back every five years on the impact of the program and the details of expenditures. "The federal

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government takes advantage of those contribution agreements," he said, "to lever a certain set of core principles across the country."

Mr. James added that the Canadian R&D system itself was at that moment undergoing some significant changes. Within the last year, the Minister of Industry, who has overarching policy authority for science, technology, and innovation, had commissioned an external panel of private sector and university leaders to examine the workings of the federal R&D system. Amongst its recommendations, the Panel suggested a restructuring of the National Research Council of Canada and a possible revision of the largest federal S&T program in Canada, the Scientific Research and Experimental Development Program. This is an indirect tax credit program which awards some $3.4 billion annually to industry, and is "very, very popular, as you can imagine, across the country. It's been largely untouchable for a quarter of a century until this year.

THE ISSUE OF PENETRATION

Dr. Helper asked a question of the center directors and staff: Why, if the services of the MEP are as useful as they sound, are there not more clients? "Is it that so many SMEs are 'lifestyle businesses'? Or that CEOs don't know how to allocate their time, or don't trust MEP?" Mr. Kill agreed that among SMMs, the "bottom 70 percent at least are lifestyle businesses." In his state of Minnesota, he said, those are not interested in MEP services or in investing in their business. The top 15 percent, which are very advanced, present the best opportunities. "But the next 15 percent, we call engaged; they want to be advanced; they want to be the suppliers to the Timkens of the world, and would like to be on the high road. So I think the top 15-30 percent is where you can make a difference." The top 15-30 percent also thinks of themselves as innovators, he said, and they compete globally. Mr. Kill cited a disconnect between the way the participants have been using the word innovation and the way those clients use the word. "When I talk with the people at the NAM, or to our senators who are engaged with manufacturers, they're focused on innovation as the incremental improvement they do every day to compete. That's not a shiny object in the sky. So it's the top 30 percent that we focus on and I think that we've done the job with those 30 percent."

Dr. Singerman followed up Mr. Kill's description of the structure of SMEs, asking if we should focus limited resources on expanding market penetration, or should we segment and develop the higher-end, more customized projects within the most productive group. Is it depth or breadth where we'll get the most bang for the buck?" Mr. Kill replied that the MEP should do both. The larger clients need depth, but they also need the breadth of services MEP can offer them. "But we have learned to separate companies of under 200 employees from those with 200 to 500. For the larger group, you need project management. They want a long journey; the CEO has bought into it."

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THE COMPLEXITY OF MANAGING MEP CENTERS

Mr. Kill also said that it is hard to charge for the true value of the services delivered by MEP. "These SMEs can't pay what Timken will pay for consultants with our skills," he said. "I grew up in this business, and it is complex: managing the public/private, keeping our head above water, managing the cash flow. It requires more public/private intervention than sometimes we say we do."

Dr. Proenza added that many firms do not know what to ask of MEP, or even to ask at all, so an important activity is to visit parts of the manufacturing economy, learn what the problems are, and explain what is possible. This has to be done free of charge, and followed by a gradual fee structure. This is vital because, he said, because there are so many disconnects in the manufacturing component of the innovation ecosystem. "Somehow we've got to find a way to reduce some of those disconnects, and provide the linkages necessary for success and innovation."

MEP AND THE ISSUE OF MARKET FAILURE

Dr. Singerman said that these points led naturally to the question of market failure. The meeting had not discussed the political environment in Washington, he said, "but even now the question of the role of the federal government in providing services and supporting companies is debated, and certain actions by some federal agencies don't help in that debate." He said that from his position as an observer of the MEP program since its inception, it had uniquely responded during the early 1990s to market failure. This he defined as small firms' lack of time, resources, and expertise to be able to obtain high-quality technical assistance. "The MEP network pivoted and managed to provide that service, and I would say a major metric of that success is the extraordinary revenue that the MEP network as a whole has been able to generate over the years, which is now equivalent to the level of federal funding." As the MEP moves into a new model of innovation, he said, it is faced again with the market failure issue and the need to articulate the strong rationale for the MEP centers to address the market failure in innovation that they found 15 or 20 years ago in quality. He urged the panel to place that need on its list of topics to consider.

Mr. Griffith returned to Mr. Hill's discussion of how many of a region's firms an MEP could hope to reach each year. One estimate of penetration rate was 2 percent to 3 percent per year, which was considered low. However, when Mr. Griffith reviewed the numbers, a different perspective emerged. He recalled Mr. Hill's statement that about 70 percent of the companies are lifestyle companies that are seldom candidates for MEP services. If the MEP reaches 2 to 3 percent of companies every year, it reaches about 10 to 15 percent of companies every 5 years, virtually all of which are in the top 30 percent. "So that's a significant portion of the population," he said. "And if you think about that top 30 percent, there's not much turnover there, so you have

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a fairly fixed population of target firms in a given state, and you actually are touching a lot of them. An interesting strategic question is whether your outreach should be directed more at firms you haven't touched, or firms you already know."

Dr. Shapira called the session and the conference to a close, and thanked all participants and speakers for their time and ideas. "This is really the kick-off workshop for the review, as I mentioned this morning," he said. He closed by urging all participants to "continue to communicate your ideas, suggestions, and comments as our review moves ahead."

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III

APPENDIXES

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Appendix A

Agenda[1]

Strengthening American Manufacturing:
The Role of the Manufacturing Extension Partnership

November 14, 2011

500 5th Street, NW
The National Academies Keck Center
Room 100
Washington, DC

9:00AM	**Welcome** *Charles Wessner, The National Academies*
9:15AM	**The National Academies Evaluation of the Manufacturing Extension Partnership** *Philip Shapira, University of Manchester and Georgia Institute of Technology*[m]
9:30AM	**Revitalizing American Manufacturing** *Sridhar Kota, White House Office of Science and Technology Policy*
10:00AM	**Panel I: Introduction to the Manufacturing Extension Partnership: System Development and Strategic Orientation** *Moderator: Ginger Lew, Three Oaks Investments*[m]
	The MEP in the Innovation Chain *Roger Kilmer, Manufacturing Extension Partnership, National Institute of Standards and Technology*

[1] *m* indicates Member, National Academies Committee on *21st Century Manufacturing: The Role of the Manufacturing Extension Partnership*.

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Repositioning the MEP System to Meet the Global Manufacturing Challenge
Mark Rice, Maritime Applied Physics Corporation and MEP Advisory Board

11:00AM **Coffee Break**

11:15AM **Panel II: A Differentiated Program: New Center Initiatives**
Moderator: Edward Breiner, Schramm Inc.[m]

James Watson, California Manufacturing Technology Consulting
Petra Mitchell, The Catalyst Connection
Robert H. Kill, Enterprise Minnesota
Beth Colbert, Ohio Department of Development

Discussant: Luis Proenza, University of Akron[m]

12:30PM **Lunch**

1:30PM **Panel III: Small and Medium-sized Enterprises and High-value Manufacturing**
Moderator: Jamieson Brown, Subcommittee on Science and Innovation, House Committee on Science, Space, and Technology

The Manufacturing Imperative
Gregory Tassey, Economics Analysis Office, National Institute of Standards and Technology

The DVIRC Perspective on the Supply Chain
Joseph J. Houldin, Delaware Valley Industrial Resource Center

Building a Competitive Manufacturing Sector: How MEP Could Help
Susan Helper, Case Western Reserve University[m]

The Magnet Story: From Lean Manufacturing to Partnerships for Innovation
James Griffith, MAGNET and Timken Company[m]

2:45PM **Coffee Break**

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3:00PM **Panel IV: Measuring Success—Assessment and the Demands of the New Strategy**
Moderator: Deborah Nightingale, Massachusetts Institute of Technology[m]

The MEP Assessment Mechanisms
Gary Yakimov, Manufacturing Extension Partnership, National Institute of Standards and Technology

Evaluating MEP Evaluation
Daniel Luria, Michigan Manufacturing Technology Center

Discussant: Robin Gaster, The National Academies

4:00PM **The MEP Challenge: Group Discussion on the Industrial, Policy, and Operational Challenges Facing the MEP**
Chair: Philip Shapira, University of Manchester and Georgia Institute of Technology [m]

Rob James, National Research Council, Canada[m]
James Griffith, MAGNET and Timken Company [m]
Luis Proenza, University of Akron[m]
Phillip Singerman, National Institute of Standards and Technology

5:00PM **Adjourn**

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Appendix B

Biographies of Speakers[1]

EDWARD BREINER

Edward J. Breiner serves as president and chief executive officer of Schramm, Inc. Mr. Breiner has 25 years of experience in manufacturing, marketing, and sales of drill rigs and construction equipment. He joined Schramm in 2000. He held several positions with Ingersoll-Rand Company in New Jersey, Texas, and Pennsylvania culminating in his role as Vice-President & Branch Manager of Ingersoll Rand Equipment Sales located in Harrisburg, Pennsylvania. Mr. Breiner has been director of Major Drilling Group International Inc. since June 7, 2006. He serves as director of Schramm board and American Ground Water Trust. He serves as a director on the board of the American Ground Water Trust. He is certified in Production and Inventory Management (CPIM) awarded by APICS, the Association of Operations Management. Mr. Breiner holds bachelor of science degree from Bloomsburg University of Pennsylvania and a Master of Business Administration from the University of Dallas, Texas.

JAMIESON BROWN

Jamie Brown serves as Professional Staff on the House Science Subcommittee on Technology and Innovation. Jamie works on innovation, technology, manufacturing, and cybersecurity issues for the committee. Jamie previously served on the committee staff from 2004 to 2006 and worked in the personal office of former committee Chairman Sherwood Boehlert (R-NY) from 2003 to 2004.

Before returning to the committee in March 2011, Jamie worked at Russ Reid, a marketing and communications firm, where he served as New Business Director for the Russ Reid Washington, DC, office from 2006 to 2011.

[1]As of November 2011. Appendix includes bios distributed at the symposium.

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Jamie focused on expanding Russ Reid's portfolio of STEM education and alternative energy clients. Jamie began his career at Zacks Investment Research, a financial data sales firm based in Chicago.

Jamie earned a Master of Science degree in social policy from the London School of Economics and Political Science and a bachelor of arts degree from Cornell University.

BETH COLBERT

Beth Colbert came to the State of Ohio to manage the Ohio MEP and Edison Programs in 2008, after 25 years in private industry as a Research Engineer and R&D Manager. Beth worked for Dow Chemical, Owens Corning, and Lafarge North America as a research engineer and R&D Manager. She has 12 active patents in new products, applications, and manufacturing processes with Dow Chemical and Lafarge North America.

ROBIN GASTER

Robin Gaster is president of Innovation Competitions, LLC. He is also vice president for research at the Alliance for Science and Technology Research in America (ASTRA) and senior fellow (nonresident) at the Innovation and Information Technology Foundation (ITIF).

Dr. Gaster's primary interests lie in innovation metrics, assessment, and a range of issues related to the innovation capacity of regions in a globalizing economy. His online toolkit for measuring and comparing the innovation capacity of regions is now available online at <*http://www.innovationecologies.com/theindex*>. He is currently working on a book, *The Capital Chasm: Why America's Innovation Ecology is Failing and What to Do About It*.

Dr. Gaster has been lead researcher on the National Academies study of the Small Business Innovation Research Program and has authored many reports and publications covering a wide arrange of topics broadly related to technology, trade, and e-commerce, including a book on trans-Atlantic telecommunications issues, *Bit by Bit*. His work has been published in *Foreign Policy*, and *The Atlantic*.

Dr. Gaster has founded several companies, focused on aggregating and deploying electronic information, targeting local and industry-specific information services. Dr. Gaster received a Ph.D. from U.C. Berkeley (1985), an M.A. from the University of Kent (UK), and a B.A. from Oxford University (UK). His doctoral thesis won a national academic prize.

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

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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. From1996 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.

SUSAN HELPER

Susan Helper is Carlton Professor of Economics at Case Western Reserve University in Cleveland, Ohio.

She is also a research associate of the National Bureau of Economic Research (NBER) and the MIT International Motor Vehicle Program (IMVP). Her research focuses on the impacts of collaborative relationships between suppliers and customers and management and labor. Currently she is studying how globalization of supply chains affects development and innovation in the United States, Mexico, and India. She has published in journals such as *American Economic Review*, *Sloan Management Review*, and *Journal of Economics and Management Strategy*. She has a Ph.D. from Harvard University and a B.A. from Oberlin College. In 2005-2006 she was a visiting scholar at the University of California, Berkeley, and the University of Oxford.

JOSEPH J. HOULDIN

Joseph Houldin is CEO and founder of the DVIRC, an economic development organization established in 1988 to assist advanced manufacturers throughout the Philadelphia region grow business value. Joe has provided the leadership instrumental in the growth of DVIRC as one of the highest performing centers in the country.

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Committed to the belief that a strong manufacturing sector lies at the heart of a thriving community and convinced that today's global marketplace demands an increasingly more sophisticated workforce, Joe has led the charge to develop the area's "talent pool" through the Applied Engineering Technology (AET) educational program. This initiative, formed in partnership with Pennsylvania's academic, business, and government leaders, has become a national model for Science, Technology, Engineering, and Math (STEM) education. As a result, in 2007, funded by a grant from the National Governors Association, the Philadelphia Navy Yard will soon become home to the area's only STEM Center.

The STEM Center represents only one aspect of DVIRC services to be housed in the Building 100 Innovation Center at the Navy Yard. DVIRC is piloting new services at the Navy Yard that support revenue growth for small and medium-sized manufacturing enterprises (SMEs), including market research, market development, and new product development.

In these efforts, DVIRC is working closely with economic development and private enterprise partners, area universities, federal laboratories, and research institutions to drive economic growth through the development of commercially-viable technologies to SMEs.

Seeing the need for educational leadership in the region around the STEM Center concept, Joe organized the Greater Philadelphia Engineering Deans Economic Development Council. The Council is comprised of engineering deans from the tri-state regions eight engineering schools.

Most recently, Joe has begun to work with private capital firms in order to build solid relationships between the region's manufacturers and the private capital community. In these efforts, he works closely with business, community, and academic leaders, as well as government agencies at the state and federal levels.

Before founding DVIRC, Joe served as vice president of the Philadelphia Industrial Development Corporation (PIDC). He holds a bachelor's degree from Villanova University and a master's degree in city and regional planning from the Catholic University of America.

ROBERT JAMES

Robert (Rob) James is deputy secretary general of the National Research Council (NRC), Canada, serving since late 2009. Prior to being named to this position, Mr. James was director general of the NRC Strategy and Development Branch for four years, including an extended executive interchange as director general, policy, in the Science and Innovation Sector, Industry Canada. Additional prior roles within NRC included director of corporate policy and strategy, and director of policy, planning and assessment.

Over the course of 25 years, Mr. James has held various positions within the Government of Canada, most notably at Natural Resources Canada, Industry Canada, and NRC. He possesses a sound knowledge of science and

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technology as well as innovation policy issues. He has contributed significantly to the design, implementation, and management of NRC's national technology cluster initiatives with a strong focus on commercialization and competitiveness, and he brings broad experience and knowledge in the machinery of government.

Mr. James has developed a strong Canadian and international business network, cutting across the public and private sectors. Since 1985, his functional responsibilities have covered: corporate policy; strategic and operational planning; corporate coordination; national program management and implementation; communications and marketing; international relations; and audit, evaluation, and performance management. Mr. James has also led various departmental/ministerial task forces, committees and secretariats and has been involved in initiatives such as the Rotman Expert Panel on Commercialization.

Mr. James earned a master's degree in international affairs from the Norman Paterson School of International Affairs and a bachelor's of commerce from Carleton University.

ROBERT H. KILL

Bob Kill is president & CEO of Enterprise Minnesota, a statewide consulting organization that works with medium-size and smaller manufacturing companies to help them grow profitably. Enterprise Minnesota's consultants advise clients on business strategy, effective productivity, and market solutions, and coach companies to achieve profitable results.

Kill is recognized as a spokesperson for Minnesota's manufacturing industry and is regularly quoted in state and regional media on manufacturing trends and the industry outlook. Under Kill's leadership, Enterprise Minnesota is the voice of Minnesota's manufacturing industry, where it continues to raise the state's manufacturing profile as an appreciated, highly advanced industry that is a key driver of the state's economy. Each February, Enterprise Minnesota releases the *State of Manufacturing*™, the largest and most comprehensive annual report on the state's manufacturing sector.

Kill's depth of experience comes from serving as chief executive officer of Ciprico Inc., a manufacturer of high-performance data and networking systems and in key management with Northern Telecom Inc. and with Burroughs Corporation.

Kill has served as a board member of numerous technology, manufacturing, and startup companies. Currently he serves as a board member on both the Minnesota Job Skills Partnership and the State of Minnesota's Agriculture and Economic Development Board.

ROGER KILMER

Roger Kilmer is the director of the Manufacturing Extension Partnership (MEP), a program of the Department of Commerce's National Institute of Standards and Technology (NIST). MEP is a nationwide network of

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resources transforming manufacturers to compete globally, supporting greater supply chain integration and providing access to technology. MEP is a $300 million public-private partnership program leveraging federal support by teaming with industry as well as state and local organizations. With nearly 350 manufacturing extension offices located in all 50 states and Puerto Rico, MEP provides companies with services and access to resources that enhance growth, improve productivity, and expand capacity. MEP works with companies that are willing to invest in their future, to make improvements in the short term, and to position themselves to be stronger long-term competitors, both domestically and internationally.

Mr. Kilmer has been with the MEP program since 1993 and with NIST since 1974. Previously, Mr. Kilmer was the MEP deputy director, serving as the chief operating officer and chief financial officer responsible for internal operations, programmatic coordination, and policy review of all activities. From 1990 to 1993, Mr. Kilmer was the deputy division chief of Robot Systems in the NIST Manufacturing Engineering Laboratory. In this position, he was responsible for establishing and managing research programs involving real-time sensor-based control of intelligent machines. Mr. Kilmer was also group leader of Robot Systems Integration, managing research and development programs with manufacturing and military applications including robotic deburring, automated lay up of thermoplastic composites, robotic safety systems, robotic handling of munitions, and unmanned land vehicle operations.

Mr. Kilmer received the Department of Commerce Silver Medal Award for leadership as the NIST-MEP liaison to the interagency Technology Reinvestment Project (TRP) initiative and the Bronze Medal for superior leadership of NIST's unmanned ground vehicle robotics program.

Mr. Kilmer holds a master of science and a bachelor of science in mechanical engineering from Pennsylvania State University.

SRIDHAR KOTA

Sridhar Kota is serving as the assistant director for advanced manufacturing at the White House Office of Science and Technology Policy (OSTP). OSTP advises the President and others within the Executive Office on science and technology policies and their effects on domestic and international affairs. The OSTP also leads interagency efforts to develop and implement science and technology policies and budgets. In his current role at OSTP which began in September 2009, Dr. Kota coordinates federal advanced manufacturing R&D and addresses issues related to innovation, manufacturing competitiveness and technology commercialization. He identifies gaps in current federal R&D in advanced manufacturing, develops policy recommendations and implementation strategies to enhance U.S. manufacturing competitiveness, foster commercialization and U.S.-based manufacturing of emerging technologies.

Dr. Kota is a professor of mechanical engineering at the University of Michigan-Ann Arbor where he has been involved in teaching and research in

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Design and Manufacturing area for 23 years. His teaching and research interests include synthesis of bio-inspired engineering systems, shape-adaptive compliant structures, and electromechanical systems design with applications to manufacturing, automotive, aerospace, and MEMS. He has authored over 200 technical papers including several Best Paper awards, holds over 25 patents, and served as an engineering consultant to numerous organizations. He is the recipient of the ASME Machine Design Award, ASME Leonardo da Vinci Award, and ASME Ruth and Joel Spira Outstanding Educator 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.

GINGER LEW

Ginger Lew is CEO of Three Oaks Investments LLC, a consulting firm that provides advice to emerging companies. Until September 2011, she served as senior advisor to the White House National Economic Council and the Administrator of the Small Business Administration (SBA). She provided economic policy advice on a broad range of matters, including innovation, commercialization, small business, and entrepreneurship policies. In addition, she co-chaired the White House Interagency Group on Innovation and Entrepreneurship.

Prior to joining the Obama Administration, Ms. Lew was the CEO of TDF, a communications venture fund, and was a venture advisor to Amplifier Venture Partners. Under the Clinton Administration, Ms. Lew was the deputy administrator and chief operating officer of the Small Business Administration where she provided day-to-day management and operational oversight of a $42 billion loan portfolio.

Before joining SBA, Ms. Lew was the general counsel at the U.S. Department of Commerce where she specialized in international trade issues. Ms. Lew was unanimously confirmed by the United States Senate for both positions.

For the past ten years, Ms. Lew was chairman and board member of an investment fund based in Europe. She was also a member and co-chair of the NASDAQ Listing Council. She has served on the boards of publicly traded companies, private companies and not-for-profit organizations.

DANIEL LURIA

Daniel Luria is vice president and research director at the Michigan Manufacturing Technology Center (MMTC). One of the 59 member centers of NIST's Manufacturing Extension Partnership (MEP), since 1991 the MMTC has worked with more than 1,000 small and medium-sized Michigan manufacturers in the areas of benchmarking, quality and environmental management systems, cycle time reduction/lean manufacturing/lean office, cost estimation, market

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diversification, and growth planning. Luria directs the MMTC's Performance Benchmarking Service (PBS); for details, see <*http://www.performance benchmarking.org*>. Since 1992, PBS has produced more than 11,600 customized benchmarking reports for more than 5,000 manufacturers. In recent years, the benchmarking effort has also been extended into community hospitals, where MMTC is working to apply lean and Six Sigma approaches; a sample hospital benchmarking report may be downloaded at <*http://www.performance benchmarking.org/hospital.aspx*>.

MMTC's PBS staff also conducts foundation-sponsored policy research on manufacturing issues and regularly briefs policy-makers on its findings. Recent projects include benchmarking Michigan manufacturers' costs vis-à-vis low-wage offshore competitors, estimating the employment benefits of hybrid vehicle tax credits and of energy-saving technologies, and modeling the economic coherence of the Great Lakes region. The Center on Wisconsin Strategy (COWS) is a frequent collaborator in this last line of research.

Prior to joining the MMTC in 1984, Luria spent eight years as chief industry and energy analyst in the UAW Research Department in Detroit working on fuel economy and emissions regulation and employment forecasting, with bargaining assignments at Chrysler and Johnson Controls.

An economist, Luria is a frequent author and commentator on U.S. manufacturing performance. He has co-authored three books; published articles in the *Harvard Business Review, Challenge*, *Research Policy,* and the *International Review of Applied Economics*; and has been interviewed on NBC Nightly News and PBS's Newshour and Morning Edition programs. Luria holds a B.A. from the University of Rochester, an M.A. from the University of Michigan, and a Ph.D. from the University of Massachusetts. He and his family live in Brighton, Michigan.

PETRA MITCHELL

Petra Mitchell joined Catalyst Connection (previously known as the Southwestern Pennsylvania Industrial Resource Center, SPIRC) in 1994. Catalyst Connection is a private, nonprofit corporation dedicated to helping manufacturers compete in a global economy, grow their business, and create jobs. In her role as president and CEO of Catalyst Connection, Ms. Mitchell leads the development and execution of outreach, education, service delivery, and measurement strategies. Personal and business affiliations enable her to be an advocate for small manufacturers. She is a member of the Regional Investors Council of the Allegheny Conference of Community and Economic Development and SMC Business Council. She is also a member of the Board of the Pennsylvania Industrial Resource Center Network, the Board of the American Small Manufacturers Coalition, the Visiting Committee of Cleveland State University School of Urban and Public Policy, and the Board of Directors of the Pittsburgh Branch of the Federal Reserve Bank of Cleveland.

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Ms. Mitchell's experience in manufacturing operations, technology development, and business development stretches back to 1988. Before joining Catalyst Connection, she was employed by GE Aircraft Engines, where she was a selected participant in the Manufacturing Development program, completed comprehensive Advanced Course in Manufacturing, and held positions in manufacturing engineering. She joined Catalyst Connection as a senior operations consultant, focusing on improvements in material flow, production planning and scheduling, facility layout, energy usage, and setup reduction. She moved from a managing director's role, in which she focused on developing Catalyst Connection's business growth services, to a vice president's position, where she forged critical partnerships that advanced our business objectives. She was named president of Catalyst Connection in 2007. She holds a B.S. in mechanical engineering from the University of Dayton and an M.S. in engineering with a concentration in manufacturing management from the University of Cincinnati.

DEBORAH NIGHTINGALE

Deborah Nightingale is professor of the practice of aeronautics and astronautics and engineering systems, director of the Center for Technology, Policy and Industrial Development, and co-director of the Lean Advancement Initiative at the Massachusetts Institute of Technology (MIT). She is a member of the National Academy of Engineering.

Professor Deborah Nightingale has over 35 years of broad-based experience with academia, the private sector, and the government. Professor Nightingale joined the MIT faculty in 1997 and holds a dual appointment in the Department of Aeronautics and Astronautics and the Engineering Systems Division. At MIT she serves as the co-director of the Lean Advancement Initiative, a joint industry, government, and MIT consortium. Her research interests are focused on lean enterprise integration, enterprise architecting, and organizational transformation. She has led several executive lean transformation engagements in both industry and government.

Prior to joining MIT, Professor Nightingale headed up Strategic Planning and Global Business Development for AlliedSignal Engines. While at AlliedSignal she also held a number of executive leadership positions in operations, engineering, and program management, participating in enterprise-wide operations from concept development to customer support. Prior to joining AlliedSignal, she worked at Wright-Patterson AFB where she served as program manager for computer simulation modeling research, design, and development in support of advanced man-machine design concepts.

Professor Nightingale has a Ph.D. from The Ohio State University in industrial and systems engineering. In addition, she holds M.S. and B.S. degrees in computer and information science from The Ohio State University and the University of Dayton, respectively. She is a past-president and fellow of the Institute of Industrial Engineers. She is a co-author of the book *Lean Enterprise*

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Value: Insights from MIT's Lean Aerospace Initiative. Professor Nightingale serves on a number of boards and national committees, where she interacts extensively with industry, government, and academic leaders.

LUIS PROENZA

Luis M. Proenza is the chief executive officer of The University of Akron (UA). 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.

Under his leadership, the university has financed $625 million in capital construction to completely transform its campus, adding 20 new facilities, 18 major renovations and additions, and 34 acres of new green space, thereby becoming one of the most attractive metropolitan campuses in the nation. Dr. Proenza also led community efforts to create two key enterprises: a University Park Alliance that is revitalizing a 50-block area surrounding its campus, and the $200 million Austen BioInnovation Institute in Akron, a partnership with three area hospitals and a medical school to establish Akron as a center for biomaterials and biomedicine.

In his first 12 years as president, UA's revenue and research portfolio more than doubled and private donations increased to all-time records. In 2007, Dr. Proenza initiated a $500 million comprehensive campaign that garnered more than $620 million in gifts and pledges by the end of 2009. These and other initiatives have distinguished the university nationally and internationally and have made UA a recognized national model for technology commercialization, economic development and corporate and community partnerships.

Dr. Proenza has been involved in national science and technology policy matters since the 1970s when he was study director of the National Research Council-National Academy of Sciences' Committee on Vision. He also served as the University of Georgia's liaison for science and technology policy, a member of the National Biotechnology Policy Board, and advisor for science and technology policy to the Governor of Alaska. In 1992, U.S. President George H. W. Bush appointed Dr. Proenza to the U.S. Arctic Research Commission.

In 2001, President George W. Bush named Dr. Proenza to the President's Council of Advisors on Science and Technology (PCAST), the nation's highest-level policy-advisory group for science and technology. Dr. Proenza co-chaired PCAST's committee on Public-Private Partnerships and worked on panels on U.S. Research and Development Investments, Technology Transfer, Alternative Energy, Energy Efficiency and Advanced Manufacturing, Personalized Medicine, Information Technology, and Nanotechnology. In 2004, the Secretary of Energy appointed him chairman of the Science and Mathematics Education Task Force and, later, to the Secretary of Energy Advisory Board.

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He now serves on the executive committee for the Council on Competitiveness and its Manufacturing Competitiveness Steering Committee and its Regional Leadership Institute Steering Committee, which he chairs. Recently, Dr. Proenza was appointed to the Council of the Government-University-Industry Research Roundtable of The National Academies and to the Technology Innovation Program Advisory Board for the National Institute of Standards and Technology. He also is a member of the Council on Foreign Relations and a board member of the States Science and Technology Institute.

Dr. Proenza is a member of many other professional, scholarly, and honorary organizations; is the recipient of several awards and honors; has written numerous publications in nationally and internationally recognized journals; and edited and co-edited two books. He frequently is invited to speak worldwide, with presentations appearing in *Vital Speeches of the Day* and *The Executive Speaker*. He often is quoted on issues in education, research, economic development, and science and technology policy.

Recognized as one of the most influential leaders in the region, Dr. Proenza's acknowledgements include: selection to the *Inside Business* Power 100, first appearing on its list in 2004 and rising to number 18 in 2011, the 2008 Visionary Award, the 2006 Northeast Ohio Regional Vision Award, the 2005 CASE V Chief Executive Leadership Award, and the 2001 Executive of the Year Award from the Society of Marketing Executives.

After earning a B.A. from Emory University (1965), M.A. from The Ohio State University (1966), and Ph.D. from the University of Minnesota (1971), Dr. Proenza joined the faculty of the University of Georgia in 1971. There, his research in retinal neurophysiology was supported continuously by grants from the National Eye Institute, including a Research Career Development Award.

Prior to his appointment at Akron, Dr. Proenza was vice president for research and dean of the Graduate School at Purdue University. He also served the University of Alaska first as vice chancellor for research and dean of the Graduate School, then as vice president for academic affairs and research.

Dr. Proenza and his wife, Theresa Butler Proenza, enjoy their careers, friends and numerous community activities. Together, they built the 44-foot sailing vessel, Apogee, which they sail on Lake Erie.

MARK RICE

Mark Rice is president of the Maritime Applied Physics Corporation. After working for several engineering firms and U.S. Government laboratories, he formed Maritime Applied Physics Corporation (MAPC) in 1986. MAPC has both R&D and production work with offices in Maryland, Virginia, and Maine. MAPC currently designs and manufactures electro-mechanical systems that range from submarine and surface ship components to commercial motion control systems. The company has recently completed two unmanned surface vessels for the U.S. Navy along with prototype distributed power and water

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systems for use by individual families in Afghanistan. MAPC has had several export contracts supplying ship components to foreign shipbuilders. Mark is a member of the local District Export Council for the Department of Commerce. He has a B.A. in physics from the University of Maine and is a licensed professional engineer.

PHILIP SHAPIRA

Philip Shapira is a professor of innovation, management, and policy at the Manchester Business School, University of Manchester, and professor of public policy in the School of Public Policy at Georgia Institute of Technology and. His interests encompass science and technology policy, economic and regional development, innovation management and policy, industrial competitiveness, technology assessment, and policy evaluation.

Professor Shapira has directed multiple research and policy studies on technology adoption and innovation including assessments of manufacturing extension services, industrial networking and manufacturing technology partnerships, entrepreneurship initiatives, and university-industry research networks and clustering. He leads the Nanotechnology Research and Innovation Systems group at Georgia Tech, which is associated with the Center for Nanotechnology in Society at Arizona State University (CNS-ASU). He evaluated USNET—a pioneering U.S. state and regional program to foster interfirm collaboration, clustering and industrial networking. Professor Shapira is a co-director of the Georgia Manufacturing Survey, undertaken every 2-3 years since 1994 to assess the business and technological conditions of the state's manufacturers and to inform manufacturing assistance programs and regional innovation and sustainability initiatives in Georgia. He has served as an external reviewer for several U.S. manufacturing extension programs. Professor Shapira has served as an expert panelist or advisor for international agencies, including the OECD (regional innovation system reviews) and the World Bank (most recently, serving as an advisor for SME innovation strategies in Turkey). Other studies include the assessment of Czech international R&D linkages; an international analysis of technology extension services for CORFU (Chile); an evaluation of Japan's Advanced Materials Processing and Machining Technology Program; the assessment of intergovernmental research organizations for Forfas, Ireland; the Midsize Cities Technology Development Initiative (a U.S.-European learning network to promote research commercialization and innovation); manufacturing innovation in the United States; knowledge economy measurement in Malaysia; and innovation strategy and governance in the Manchester city-region.

Professor Shapira is a director of the Georgia Tech Program in Science, Technology and Innovation Policy. He has served as a Congressional Fellow with the Office of Technology Assessment of the United States Congress and has held visiting positions at international research institutions including the Japan Institute of Labor (Tokyo) and the Fraunhofer Institute for Systems and

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Innovations Research (Germany). He is currently a director of the Manchester Institute of Innovation Research. Professor Shapira is the author or coauthor of more than 50 journal articles, 30 book chapters, numerous professional and policy studies, and several monographs and edited volumes. His peer-reviewed articles have appeared in leading international journals in research policy, technology transfer, small business, and economic development. He is an editor of *The Theory and Practice of Innovation Policy: An International Research Handbook* (Edward Elgar, 2010). Professor Shapira is a member of the editorial boards of the *Journal of Technology Transfer*, *Research Policy*, *European Planning Studies*, and the *International Journal of Public Policy*, and is an associate editor of the *International Journal of Foresight and Innovation Policy*.

Professor Shapira holds a Ph.D. in city and regional planning from the University of California, Berkeley, and is a Fellow of the Royal Society of Arts.

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; Dr. 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.

Dr. 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.

Dr. 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*.

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Dr. Singerman received his bachelor's 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.

Dr. 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.

GREGORY TASSEY

Gregory Tassey is senior economist for the National Institute of Standards and Technology. His major fields of research are the economics of high-tech industries, strategic planning studies and economic impact assessments of R&D programs, and technology policy analysis. Dr. Tassey has a B.A. in physics from McDaniel College and a Ph.D. in economics from The George Washington University. He has written numerous reports on R&D trends and associated policy implications, published 25 articles in policy and economics journals, and written three books, including *The Economics of R&D Policy*. A new book, *The Technology Imperative*, is in progress.

JAMES WATSON

James Watson is the CEO and president of CMTC. He started at CMTC in 1999 as vice president of business development and transitioned to the position of vice president of operations in 2001, which he has held for the past 10 years. In his role as vice president of operations, he was responsible for the day-to-day operations of CMTC.

Mr. Watson is responsible for crafting the future vision of CMTC, promoting the importance of the manufacturing sector to state and federal legislators and expanding the awareness of CMTC's capabilities throughout Southern California. He will also guide CMTC's Defense Services and Healthcare business units.

With over 30 years of management experience in areas of strategic planning, operations management, organizational design, sales and marketing and cultural alignment, Mr. Watson brings a wide range of knowledge to his position as president and CEO. He started his career with Western Airlines advancing to vice president, passenger and cargo sales, and then was vice president and general manager of SuperShuttleInternational before moving to Anchor Audio as the vice president of sales and general manager, Europe.

Mr. Watson holds a bachelor's degree in political science from California State University, Northridge.

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CHARLES WESSNER

Charles Wessner is a National Academy Scholar and director of the Program on Technology, Innovation, and Entrepreneurship. He is recognized nationally and internationally for his expertise on innovation policy, including public-private partnerships, entrepreneurship, early-stage financing for new firms, and the special needs and benefits of high-technology industry. He testifies to the U.S. Congress and major national commissions, advises agencies of the U.S. government and international organizations, and lectures at major universities in the United States and abroad. Reflecting the strong global interest in innovation, he is frequently asked to address issues of shared policy interest with foreign governments, universities, research institutes, and international organizations, often briefing government ministers and senior officials. He has a strong commitment to international cooperation, reflected in his work with a wide variety of countries around the world.

Currently, he directs a series of studies centered on government measures to encourage entrepreneurship and support the development of new technologies and the cooperation between industry, universities, laboratories, and government to capitalize on a nation's investment in research. Foremost among these is a congressionally mandated study of the Small Business Innovation Research (SBIR) Program, reviewing the operation and achievements of this $2.3 billion award program for small companies and start-ups. He is also directing a major study on best practice in regional innovation programs, entitled *Competing in the 21st Century: Best Practice in State and Regional Innovation Initiatives* as well as a complementary, global analysis entitled *Comparative Innovation Policy: Best Practice in National Technology Programs*. Today's meeting on "Strengthening American Manufacturing: The Role of the Manufacturing Extension Partnership" is held under the auspices of the project entitled, *21st Century Manufacturing: The Role of the Manufacturing Extension Partnership Program of the National Institute of Standards and Technology,* an evaluation of the operation, achievements, and challenges of the Manufacturing Extension Partnership (MEP) program. 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.

GARY YAKIMOV

Gary Yakimov is the manager of policy and research at the Manufacturing Extension Partnership (MEP). Mr. Yakimov's current duties include management of MEP's policy and research team including its reporting and evaluation system, impact metrics, client surveys, economic studies and policy papers. Gary also is coordinating the development of a series of talent management products and services for use by the 60 MEP centers.

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Appendix D

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