EXAMINING FEDERAL ADVANCED MANUFACTURING PROGRAMS

HEARING

BEFORE THE

SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY

COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY

HOUSE OF REPRESENTATIVES

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Tuesday, September 10, 2013

EXAMINING FEDERAL ADVANCED MANUFACTURING PROGRAMS

TUESDAY, SEPTEMBER 10, 2013

HOUSE OF REPRESENTATIVES,
SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY,
Washington, D.C.

The Subcommittee met, pursuant to call, at 10:11 a.m., in Room 2318 of the Rayburn House Office Building, Hon. Larry Bucshon [Chairman of the Subcommittee] presiding.

LAMAR S. SMITH, Texas
CHAIRMAN

EDDIE BERNICE JOHNSON, Texas
RANKING MEMBER

Congress of the United States
House of Representatives
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
2321 RAYBURN HOUSE OFFICE BUILDING
WASHINGTON, DC 20515–6301
(202) 225–6371
www.science.house.gov

Subcommittee on Research and Technology

Examining Federal Advanced Manufacturing Programs

Tuesday, September 10, 2013
10:00 a.m. to 12:00 p.m.
2318 Rayburn House Office Building

Witnesses

Dr. Alan Taub, Professor, Material Science and Engineering, University of Michigan

Dr. Thomas Baer, Executive Director, Stanford Photonics Research Center, Stanford University

Mr. Mark Muro, Senior Fellow and Policy Director, Metropolitan Policy Program, Brookings Institution

U.S. HOUSE OF REPRESENTATIVES
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Examining Federal Advanced Manufacturing Programs

Tuesday, September 10, 2013
10:00 a.m. – 12:00 p.m.
2318 Rayburn House Office Building

Purpose

On Tuesday, September 10, the Subcommittee on Research and Technology will hold a hearing to examine federal advanced manufacturing programs, with a focus on research and development programs at the National Institute of Standards and Technology, and to review H.R. 1421, the "Advancing Innovative Manufacturing Act of 2013" sponsored by Committee Ranking Member Eddie Bernice Johnson.

Witnesses

- **Dr. Alan Taub**, Professor, Material Science and Engineering, University of Michigan
- **Dr. Thomas Baer**, Executive Director, Stanford Photonics Research Center, Stanford University
- **Mr. Mark Muro**, Senior Fellow and Policy Director, Metropolitan Policy Program, Brookings Institution

Background

Manufacturing has been a significant part of American productivity since the industrial revolution. Manufacturing's share of gross domestic product is approximately 11 percent, and manufacturing output has risen by 13 percent in the last several years. However, organizations such as the Information Technology and Innovation Foundation (ITIF) and the Council on Competiveness have expressed concern that U.S. manufacturing competitiveness might be declining relative to other industrialized countries.[1,2] These concerns were shared by the President's Council of Advisors on Science and Technology (PCAST) in a June 2011 report.[3]

While these organizations outline a range of priorities, they agree that advanced manufacturing will be a key driver in preserving American economic competitiveness.

The PCAST defines advanced manufacturing as "a family of activities that (a) depend on the use and coordination of information, automation, computation, software, sensing, and networking, and/or (b)

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[1] S. Ezell and R. Atkinson, "The Case for a National Manufacturing Strategy," April, 2011, The Information Technology and Innovation Foundation. http://www.itif.org/files/2011-national-manufacturing-strategy.pdf
[2] Council on Competitiveness Report, Make: An American Manufacturing Movement, December 2011, http://www.compete.org/publications/detail/2064/make/
[3] "Report to the President on Ensuring American Leadership in Advanced Manufacturing," June 2011. The President's Council of Advisors on Science and Technology, http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-advanced-manufacturing-june2011.pdf

make use of cutting edge materials and emerging capabilities enabled by the physical and biological sciences."[4]

This hearing will examine federal advanced manufacturing programs with a particular focus on current and proposed programs at the National Institute of Standards and Technology. The hearing will also review H.R. 1421, the "Advancing Innovative Manufacturing Act of 2013."

National Institute of Standards and Technology

The National Institute of Standards and Technology (NIST) is a non-regulatory agency within the Department of Commerce. Originally founded in 1901 as the National Bureau of Standards, NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. By working closely alongside industry, NIST has become recognized as a provider of high-quality information utilized by the private sector.

NIST supports U.S. manufacturing through a combination of measurement science research programs conducted through NIST Scientific and Technical Research Services and through extramural manufacturing programs, including the Manufacturing Extension Partnership and the Advanced Manufacturing Technology Consortia Program.

Scientific and Technical Research and Services

NIST currently operates six laboratory units, under the Scientific and Technical Research and Services (STRS) line in the budget, which conduct research and development for measurement science, standards, and technology. Research at the NIST laboratories is intended to advance the agency's mission of promoting US innovation and industrial competitiveness by developing and supplying test methods, measurement tools and know-how, and scientific data that are embedded in the processes, products and services of nearly every U.S. manufacturing industry, as well as the nation's service sector. NIST measurement research and services support advances and applications in a comprehensive range of technologies, materials, devices, information networks, and other areas.

NIST STRS is funded at $579.8 million for Fiscal Year 2013.

Manufacturing Extension Partnership

NIST's Hollings Manufacturing Extension Partnership (MEP) works with small and mid-sized U.S. manufacturers to help them create and retain jobs, increase profits, and save time and money. The nationwide network provides a variety of services, from innovation strategies to process improvements to green manufacturing. MEP also works with partners at the state and federal levels on programs that put manufacturers in position to develop new customers, expand into new markets and create new products.

MEP field staff has over 1,300 technical experts – located in every state – serving as trusted business advisors, focused on solving manufacturers' challenges and identifying opportunities

[4] Ibid.

for growth. MEP provides resources in five key areas: technology acceleration, supplier development, sustainability, workforce and continuous improvement.

MEP was funded at $119.4 million for Fiscal Year 2013.

Advanced Manufacturing Technology Consortia Program

The Advanced Manufacturing Technology Consortia (AMTech) Program, initially proposed by the Administration in the FY 2012 budget without explicit legislative authorization, is designed to incentivize the formation of and provide resources to industry-led consortia that will support basic and applied research on long-term, pre-competitive and enabling technology development for the U.S. manufacturing industry. The objective of AMTech is to establish and strengthen technology consortia, driven by industry, to identify and prioritize research projects addressing long-term U.S. industrial research needs.

AMTech received initial funding of $14.2 million for Fiscal Year 2013.

Advanced Manufacturing National Program Office

In June 2011, the Administration launched the Advanced Manufacturing National Program Office (AMNPO), an interagency office that includes the Department of Commerce (through NIST), the Department of Defense, the Department of Energy, NASA and the National Science Foundation. The AMNPO does not have its own line item in the budget, but rather is supported through participant agency appropriations.

Housed at NIST, the AMNPO is intended to provide coordination of federal advanced manufacturing activities. It is tasked with identifying opportunities for investments in R&D, precompetitive collaboration, and shared infrastructure to support U.S. manufacturing. It is also intended to build links to technology and innovation partnerships involving U.S. manufacturers, universities, state and local governments, and other organizations.

The National Network for Manufacturing Innovation (NNMI)

The President's FY13 and FY14 budget requests included a proposal for a one-time mandatory fund of $1 billion to establish the National Network for Manufacturing Innovation, a public-private partnership of competitively-selected institutes that would each concentrate on a particular area of advanced manufacturing technology development. According to background information provided by the Administration, the goal of the institutes is to "bring together industry, universities and community colleges, federal agencies, and regional and state organizations to accelerate innovation by investing in industrially relevant manufacturing technologies with broad applications, and to support manufacturing technology commercialization by bridging the gap between the laboratory and the market."[5]

The Administration envisions the NNMI to be the foundation of a U.S. innovation infrastructure of linked regional hubs of manufacturing excellence. The NNMI also includes an emphasis on education and workforce development in advanced manufacturing skills. The Administration

[5] National Network for Manufacturing Innovation http://www.manufacturing.gov/amp/nnmi.html

proposes up to 15 institutes are proposed across the country, with the federal support to last 5-7 years. The Committee on Science, Space and Technology held a hearing (http://science.house.gov/hearing/technology-and-innovation-subcommittee-hearing-assembling-facts-examining-proposed-national) to review the Administration's NNMI proposal in the 112th Congress.

In August 2012, the Administration announced a pilot manufacturing institute, the "National Additive Manufacturing Innovation Institute (NAMII)," based in Youngstown, Ohio to accelerate and integrate additive manufacturing technologies to the U.S. manufacturing sector and to increase domestic manufacturing competitiveness. The pilot institute was established by reprogramming $30 million in appropriations for the Department of Defense (DOD), the Department of Energy (DOE), NASA, NSF and other federal agencies. In the 2013 State of the Union Address, the President announced plans for three additional manufacturing institutes to be funded through DOD and DOE appropriations.

In early August, Rep. Tom Reed (NY) and Rep. Joe Kennedy (MA) introduced H.R. 2996 the "Revitalize American Manufacturing and Innovation Act of 2013," (http://congress.gov/cgi-lis/query/z?c113:H.R.2996:) to authorize the creation of a Network for Manufacturing Innovation Program, based on the President's proposal except that the fund would authorize $600 million instead of $1 billion. Sen. Sherrod Brown (OH) and Sen. Roy Blunt (MO) introduced a companion measure, S. 1468, the "Revitalize American Manufacturing and Innovation Act of 2013," in the Senate.

H.R. 1421, "The Advancing Innovative Manufacturing Act of 2013."

The Advancing Innovative Manufacturing Act of 2013 would authorize the AMTech program at NIST, to develop industry-led, public-private consortia to identify, prioritize, and address long-term, precompetitive industrial research needs in the area of advanced manufacturing, including through the use of technology roadmaps and transfer of technology platforms and infrastructure.

It also requires the NIST Director to carry out a pilot program through the award of competitive, merit-reviewed grants, cooperative agreements, or contracts to small- or medium-sized manufacturers to enhance the innovative capabilities and competitiveness of such manufacturers through support for research and development that will promote the field of advanced manufacturing and lead to the commercialization of new products, processes, or technologies.

The bill directs the Secretary of Commerce to establish an innovation voucher pilot program to accelerate innovative activities and enhance the competitiveness of small- and medium-sized manufacturers, which shall: (1) foster collaborations between such manufacturers and research institutions, and (2) enable the manufacturers to access technical expertise and capabilities that will lead to the development of innovative products or manufacturing processes.

The bill authorizes the National Science Foundation to revise the program of grants for education and training in advanced manufacturing so that such grants are provided to community colleges for the development and implementation of innovative education reforms for advanced manufacturing workforce training.

H.R. 1421 includes the following authorization amounts for Fiscal Years 2014 - 2018:

FY 2014: $140,000,000
FY 2015: $155,500,000
FY 2016: $169,750,000
FY 2017: $172,250,000
FY 2018: $180,000,000

Issues for Examination

Witnesses have been asked to: assess Federal advanced manufacturing research and development programs, including research and development programs at the National Institute of Standards and Technology; provide recommendations to policy makers for prioritizing spending on advanced manufacturing research and development programs in the current budget environment; and to provide thoughts on H.R. 1421, the "Advancing Innovative Manufacturing Act of 2013."

Members will also be interested in examining how to prevent duplication of federal manufacturing programs, and how to define appropriate roles for the Federal government and for the private sector in advanced manufacturing research and development programs.

Chairman BUCSHON. Good morning. The Subcommittee on Research and Technology will come to order.

Good morning again. Welcome to today's hearing titled "Examining Federal Advanced Manufacturing Programs." In front of you are packets containing the written testimony, biographies and Truth in Testimony disclosures for today's witnesses. I now recognize myself for an opening statement.

Again, I would like to welcome everyone to today's hearing where we will examine federal advanced manufacturing programs, including research and development programs at the National Institute of Standards and Technology, and review H.R. 1421, the "*Advancing Innovative Manufacturing* Act of 2013" sponsored by the Ranking Member of the Full Committee, Ms. Eddie Bernice Johnson.

Manufacturing plays a critical role in American economic competitiveness. Manufacturing represents approximately 11 percent of the American economy, and manufacturing output has risen by 13 percent over the last several years. Manufacturing also has the greatest multiplier effect of any major sector of the American economy, and nearly 60 percent of all U.S. exports are in manufactured goods.

While there are areas in decline in American manufacturing, such as labor-intensive, low-skilled manufacturing activities, there are also significant opportunities of growth in knowledge and technology-intensive advanced manufacturing. For example, the semiconductor industry boasts nearly 250,000 high-paying direct jobs in the United States alone, while supporting an additional 1 million jobs indirectly.

The President's Council of Advisors on Science and Technology or PCAST, defines advanced manufacturing as "a family of activities that, A, depend on the use and coordination of information, automation, computation, software, sensing, and networking, and/or B, make use of cutting-edge materials and emerging capabilities enabled by the physical and biological sciences."

With a technical knowledge base supported by our excellent universities and research institutes, and with innovation leadership supported by our private industries, both large and small, the United States has the opportunity to lead the world in advanced manufacturing competitiveness.

However, it is incumbent upon us as policymakers to create an environment that will enable American advanced manufacturing to thrive. Unfortunately, I am concerned that we have not lived up to our end of the bargain.

While all of our major global competitors have been lowering their corporate tax rates, ours is essentially unchanged for the past 20 years. Rising costs in health care, regulatory compliance and energy all discourage manufacturing from thriving domestically, and uncertainty about our future debt inhibits private-sector investment in future growth.

It is critical that we focus on the policies that will make America the most competitive country in the world to start or grow a business. Given our current budget crisis, it is crucial that we maximize our investments to ensure the greatest return for our hard-working taxpayers' dollars. We cannot continue to spend endless

amounts of borrowed money to create programs or sustain programs without making cuts elsewhere. Prioritization is crucial.

I look forward to hearing our witnesses' thoughts on measurement science conducted at the NIST laboratories, the Hollings Manufacturing Extension Partnership, the Advanced Manufacturing Technology Consortium program, and the Administration's proposal for the National Network of Manufacturing Innovation. We also look forward to hearing our witnesses' thoughts on the Ranking Member's bill and about improvements and prioritization that can be made to our federal advanced manufacturing R&D programs.

I would like to thank our witnesses for being here today, and we look forward to your testimony.

[The prepared statement of Mr. Bucshon follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY CHAIRMAN LARRY BUCSHON

I would like to welcome everyone to today's Research and Technology Subcommittee hearing entitled "Methamphetamine Addiction: Using Science to Explore Solutions."

The problem of methamphetamine, or meth, abuse is a serious problem facing our country today. The main compound from which meth derives is pseudoephedrine, known as PSE, which is also a common drug used to treat nasal and sinus congestion. Unfortunately, criminal dealers have discovered new, easier ways to make more potent forms of meth that require the use of chemicals such as PSE. As our witnesses will testify today, meth poses significant public safety and health risks, in addition to financial burdens to local communities where these toxic and dangerous labs are found.

According to a 2013 Government Accountability Office report titled "State Approaches Taken to Control Access to Key Methamphetamine Ingredient Show Varied Impact on Domestic Drug Labs," the number of meth lab incidents declined significantly after 2004 when state and federal regulations on PSE product sales were implemented. Since 2007, however, these numbers have significantly increased, reflecting the emergence of smaller-scale production facilitated by a new method called smurfing, where individuals purchase the legal limits of PSE at multiple stores that are then combined for meth drug production.

But more than figures and statistics, meth addiction is a problem that personally hits home for many Americans. As a medical doctor and physician, I personally know the devastation that addiction can cause and even after meth addicts kick their habit, research shows these addicts experience permanent damage. From January to July of this year, over 65 meth labs have been dismantled in the biggest county in my district, Vanderburgh County, making it the number one county for meth labs in the state. This is extremely close to my home next door in Warrick County and where we have had TWO meth lab explosions within a two mile radius of my house. In November of 2011, a meth lab exploded down the street from my house burning a house to the ground and causing over $25,000 in damage to houses around it.

Despite the grim realities of meth addiction, science can provide valuable insights to this problem. Basic science agencies like the National Institutes of Health have spent over $68 million in FY 2013 to understand the neurological basis of meth addiction. NSF also supports fundamental non-medical basic science research, in particular behavioral research behind the psychology of addiction.

Our witnesses today reflect the wide spectrum of work and research regarding the various facets of the meth problem. Witnesses will introduce the extent of the meth problem, and will discuss a wide range of topics on how science can help us understand the prevention and treatment of meth as well as how technology can be used to stop unauthorized purchases of PSE.

I would like to thank the witnesses for being here today and taking time to offer their perspectives on this critical topic for our communities. I'd also like to thank Ranking Member Lipinski and everyone else participating in today's hearing.

Chairman BUCSHON. At this point I now recognize the Ranking Member, the gentleman from Illinois, for an opening statement.

Mr. LIPINSKI. Mr. Chairman, thank you for calling this hearing to examine federal advanced manufacturing programs and legislation introduced by the Ranking Member of the Full Committee, Ms. Johnson. I can't think of a better way to start out our post-break session here.

I would also like to thank the witnesses for being here today and I look forward to your testimony.

Today's hearing is an important follow-up to the hearing we held in July on my bipartisan American Manufacturing Competitiveness Act. I am glad that we are taking an in-depth look at these issues as we seek to identify the best federal policies that will facilitate the growth of manufacturing and job creation. Despite all the attention being focused on other important issues right now, the American people are still focused on the fact that more must be done to encourage the creation of good-paying jobs in our country.

A vibrant manufacturing sector is critical for America's economic growth and the success of the middle class. Unfortunately, since the 1970s we have seen a less vibrant manufacturing sector with the number of manufacturing jobs shrinking, from 20 million in 1979 to fewer than 12 million today. The recent recession hit workers in the manufacturing sector especially hard and contributed to the stagnation of middle-class wages. In addition, our trade deficit in advanced technology products is growing, and China is now the world's biggest exporter of high-tech goods.

But there has been some good news recently, with American manufacturing showing signs of a comeback. In fact, a report last week by the Institute for Supply Management found that economic activity in the manufacturing sector expanded for the third consecutive month. Despite these positive signs, significant challenges do remain.

Our position as the global leader in technology is being threatened as developing countries build up their capabilities to become not only the world's assembly line, but also the creator of new and innovative technologies. They are investing heavily in manufacturing and innovation and they are doing so in a much more comprehensive way than the United States.

Right now, the Federal Government has countless departments, agencies, programs and policies that affect manufacturing, from our tax code and energy policies to programs related to research and development and education and workforce, but these efforts are not well coordinated, to say the least.

Through legislation I introduced earlier this year, an interagency committee would conduct a comprehensive analysis of the U.S. manufacturing sector, examining the impact that government policies are having on manufacturing and how we can be more efficient and effective. By improving the coordination of various government agencies, and more importantly, coordination with the private sector, we can develop concrete goals and objectives and implement policies that create the best condition for American manufacturers to thrive.

Today, we are going to focus largely on the advanced manufacturing activities of NIST and the programs and activities proposed in H.R. 1421.

Although NIST is a relatively small agency, it is an extremely important player in federal efforts to spur manufacturing, innovation and economic prosperity. For more than a 100 years, NIST has supported the competitiveness of U.S. industry by advancing measurement science, standards and technology. Their work in biomanufacturing, nanomanufacturing and smart manufacturing will provide the foundation for future U.S. market growth, competitiveness, and the creation and retention of high-skilled, well-paying jobs.

Furthermore, NIST's broad and deep technical expertise as well as the ability to serve as a bridge to U.S. businesses is unparalleled. This connection to industry is essential. I strongly believe we cannot move American manufacturing forward without building more bridges between the public and private sectors.

H.R. 1421 encourages the formation of public-private partnerships and the development of technology roadmaps to address the research needs of industry.

I look forward to hearing from our witnesses about how the Federal Government can help promote deep and long-lasting public-private sector collaboration in manufacturing. I am also interested in learning more about how the Federal Government can help our small- and medium-sized manufacturers become more competitive in the global marketplace.

Mr. Chairman, we must adopt smart policies that encourage innovation, entrepreneurship, efficiency and investment in American manufacturing. American manufacturing equals American jobs and a strong economy. We simply can't afford to lose our capacity to manufacture the breakthrough technologies and products of tomorrow. I look forward to working with you to advance legislation on this important topic.

Thank you again for holding this hearing, and I yield back the balance of my time.

[The prepared statement of Mr. Lipinski follows:]

PREPARED STATEMENT OF SUBCOMMITTEE ON RESEARCH AND TECHNOLOGY
RANKING MINORITY MEMBER DANIEL LIPINSKI

Mr. Chairman, thank you for calling this hearing to examine federal advanced manufacturing programs and legislation introduced by the Ranking Member of the full Committee. I'd also like to thank the witnesses for being here this morning. Today's hearing is an important follow-up to the hearing we held in July on my bipartisan American Manufacturing Competitiveness Act. I'm glad that we are taking an in-depth look at these issues as we seek to identify the best federal policies for promoting manufacturing and job creation. Despite all the attention being focused on other important issues right now, the American people are still focused on the fact that more must be done to encourage the creation of good-paying jobs in our country.

A vibrant manufacturing sector is critical for America's economic growth and the success of the middle class. Unfortunately, since the 1970s we have seen a less vibrant manufacturing sector with the number of manufacturing jobs shrinking, from 20 million in 1979 to fewer than 12 million today. The recent recession hit workers in the manufacturing sector especially hard and contributed to the stagnation of middle-class wages. In addition, our trade deficit in advanced technology products is growing & China is now the world's biggest exporter of high-tech goods.

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Furthermore, NIST's broad and deep technical expertise, as well as its ability to serve as a bridge to U.S. businesses, is unparalleled.

This connection to industry is essential and I strongly believe we cannot move American manufacturing forward without building bridges between the public and private sectors. H.R. 1421 encourages the formation of public-private partnerships and the development of technology roadmaps to address to the research needs of industry. I look forward to hearing from our witnesses about how the Federal Government can help promote deep and long-lasting public-private sector collaboration in manufacturing. I am also interested in learning more about how the Federal Government can help our small and medium-sized manufacturers become more competitive in the global marketplace.

Mr. Chairman, we must adopt smart policies that encourage innovation, entrepreneurship, efficiency, and investment in American manufacturing. American manufacturing equals American jobs and a strong economy and we simply can't afford to lose our capacity to manufacture the breakthrough technologies and products of tomorrow. I look forward to working with you to advance legislation on this important topic.

Chairman BUCSHON. Thank you, Mr. Lipinski.

I now recognize the Ranking Member of the Full Committee, Ms. Johnson, for her opening statement.

Ms. JOHNSON. Thank you very much, Mr. Chairman, and thank you for holding this hearing today, and I want to thank our witnesses for being here to review the current federal efforts in advanced manufacturing as well as to examine legislation that I have introduced to help ensure our manufacturing sector remains competitive and continues to create jobs over the long term.

Some of you may not know, but my hometown, Dallas, Texas is the sixth largest metropolitan economy in the United States, and according to the Brookings Institution, the 12th largest in the world. I mention this only because one of Dallas's strengths is in its manufacturing sector. About 250,000 people were employed in a manufacturing job in 2010, and one-third of these jobs were in a high technology area. These figures show that the Dallas region has the potential to because the hub for advanced manufacturing for years to come, but it is by no means guaranteed.

While the United States is struggling to sustain its leadership, other countries are focusing their full attention on promoting manufacturing and innovation. They are aggressively investing in re-

search and development and shaping their policies and programs to change the competitive landscape in their favor. We simply cannot afford to stand by idly and watch our competitors position themselves to move ahead of us. We need our manufacturing sector to be the most sophisticated in the world, using the largest technologies and the newest, and the most efficient methods and processes.

That is why I introduced the *Advancing Innovative Manufacturing*—or the AIM Act—which can help ensure the survival of our manufacturing sector and our global leadership by making strategic investments in manufacturing research, development and education. First, the AIM Act brings the public and private sectors together to develop research roadmaps and share the costs of conducting the research contained in these roadmaps. It does this by formally authorizing NIST's Advanced Manufacturing Technology Consortium program at a level that will allow the program to fully accomplish its mission of addressing the pre-competitive challenges that American industry faces today.

Next, the AIM Act focuses on a key segment of our society, the small and medium-sized manufacturer. These small businesses drive job growth, but they often lack the technical expertise and capacity needed to transform an innovative idea into a new product or service. My bill creates a pilot program that will provide small and medium-sized manufacturers with vouchers that will allow them to buy R&D or innovation expertise as needed. Innovation vouchers programs have been deployed in more than a dozen countries with encouraging results. For example, a study found that eight out of ten vouchers issued by the Holland government resulted in an innovative product that would not have otherwise been realized.

Finally and maybe most importantly, the AIM Act addresses our workforce needs by providing community colleges with grants that will allow them to prepare our students for the manufacturing jobs of the future.

Mr. Chairman, I would like to end by quoting from a comprehensive National Academies report from last year that I think clearly summarizes where we stand. "The United States, while retaining the vestiges of its leadership position, should recognize that merely maintaining the current policies and programs will lead to continued erosion of our economic capabilities, especially in the high-technology industries that are the basis of future prosperity."

Mr. Chairman, we need to be bold and invest in our future. I look forward to hearing from our witnesses on ways to improve the AIM Act and on what policies and programs should be implemented now to build a productive and job-creating 21st century economy.

Thank you, and I yield back.

[The prepared statement of Ms. Johnson follows:]

PREPARED STATEMENT OF FULL COMMITTEE RANKING MEMBER
EDDIE BERNICE JOHNSON

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to help ensure our manufacturing sector remains competitive and continues to create jobs over the long-term.

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These figures show that the Dallas region has the potential to be a hub for advanced manufacturing for years to come, but this is by no means guaranteed.

While the United States is struggling to sustain its leadership, other countries are focusing their full attention on promoting manufacturing and innovation. They are aggressively investing in research and development and shaping their policies and programs to change the competitive landscape in their favor.

We simply cannot afford to stand idly by and watch our competitors position themselves to move ahead of us. We need our manufacturing sector to be the most sophisticated in the world, using the newest technologies and the most efficient methods and processes.

That is why I introduced the *Advancing Innovative Manufacturing*—or AIM Act—which can help ensure the survival of our manufacturing sector and our global leadership by making strategic investments in manufacturing research, development, and education.

First, the AIM Act brings the public and private sectors together to develop research roadmaps and share the cost of conducting the research contained in those roadmaps. It does this by formally authorizing NIST's Advanced Manufacturing Technology Consortia program at a level that will allow the program to fully accomplish its mission of addressing the precompetitive challenges American industry faces today.

Next, the AIM Act focuses on a key segment of our economy, the small and medium-sized manufacturer. These small businesses drive job growth, but they often lack the technical expertise and capacity needed to transform an innovative idea into a new product or service. My bill creates a pilot program that will provide small and medium-sized manufacturers with vouchers that will allow them to "buy" R&D or innovation expertise as needed.

Innovation vouchers programs have been deployed in more than a dozen countries with encouraging results. For example, a study found that eight out of ten vouchers issued by the Holland government resulted in an innovative product that would not have otherwise been realized.

Finally and maybe most importantly, the AIM Act addresses our workforce needs by providing community colleges with grants that will allow them to prepare our students for the manufacturing jobs of the future.

Mr. Chairman, I'd like to end by quoting from a comprehensive National Academies report from last year that I think clearly summarizes where we stand. "The U.S., while retaining the vestiges of its leadership position, should recognize that merely maintaining the current policies and programs will lead to continued erosion of our economic capabilities, especially in the high technology industries that are the basis for future prosperity."

Mr. Chairman, we need to be bold and invest in our future. I look forward to hearing from our witnesses on ways to improve the AIM Act and on what policies and programs should be implemented now to build a productive and job creating 21st century economy.

Chairman BUCSHON. Thank you, Ms. Johnson.

At this time I would like to submit the statement of Chairman Smith into the record.

[The prepared statement of Mr. Smith appears in Appendix I]

Chairman BUCSHON. If there are other Members who wish to submit additional opening statements—if there are additional Members, your statements will be added to the record at this point.

At this time I would like to introduce our witnesses. Our first witness is Dr. Alan Taub, Professor of Material Science and Engineering at the University of Michigan. Dr. Taub previously served as Vice President of Global Research and Development at General Motors Corporation and currently chairs the NIST Visiting Committee on Advanced Technology. Dr. Taub received his bachelor's

degree in materials engineering from Brown University and his master's and Ph.D. degrees in applied physics from Harvard.

Our second witness is Dr. Thomas Baer, Executive Director of the Stanford Photonics Research Center, and a Consulting Professor at the Applied Physics Department at Stanford University. Dr. Baer has been extensively involved in startup companies in Silicon Valley, and was formally a member of the NIST Visiting Committee on Advanced Technology. Dr. Baer received a bachelor of arts degree in physics from Lawrence University and a Ph.D. in atomic physics from the University of Chicago.

Our third witness is Mr. Mark Muro, Senior Fellow and the Director of Policy at the Metropolitan Policy Program at the Brookings Institution. He previously led the development of a state advanced industries strategy for Colorado and is currently leading the development of a strategy for Tennessee's advanced auto industry. Mr. Muro received a bachelor of arts from Harvard University and a master's of American Studies from the University of California Berkeley.

Thanks again for our really very distinguished panel for being here. As our witnesses should know, spoken testimony is limited to five minutes, after which the Members of the Committee will each have five minutes to ask questions.

I now recognize Dr. Taub for five minutes to present his testimony.

TESTIMONY OF DR. ALAN TAUB, PROFESSOR, MATERIAL SCIENCE & ENGINEERING, UNIVERSITY OF MICHIGAN

Dr. TAUB. Thank you. Good morning, Mr. Chairman, Ranking Members Lipinski and Johnson, and other Members of the Committee.

As a newly minted academic in my class at the university, I teach two key rules of manufacturing. First, if you cannot measure it, you cannot manufacture it with quality and reliability; and second, if you don't have standards in place, you will be hindered in widespread commercialization.

For over a century, the measurement services and standard programs of NIST have ensured the accuracy and reliability of nearly every measurement in this country. We tend to take for granted our ability to perform even the most basic measurements such as length and weight. The reality is, the NIST services provide the measurement standards that allow industry to use products efficiently throughout the entire supply chain with reliability.

It is important to recognize that NIST's ability to successfully deliver high-quality measurement services to the Nation's industry is grounded in their world-class measurement science capability. What might appear to the non-expert as fundamental research without application is actually the foundational cure that allows NIST to deliver state-of-the-art tools to its industrial partners.

NIST is also participating with other Federal agencies to launch the new advanced manufacturing initiative that will help bridge the gap from basic research to product implementation. These programs will enable the Federal Government to catalyze the integration of efforts across the national laboratories, universities and in-

dustry so that we will have access to advanced manufacturing technology. The AMTech consortia described in section 2 of H.R. 1421 together with the National Network of Manufacturing Innovation Institutes will create—and this is important—industry-driven roadmaps that will then target joint investment in pre-competitive advanced manufacturing research. It is important that these programs remain industry-driven and that they are fully integrated and coordinated. Equally important is that creating these institutes gets accelerated and we overcome the present funding constraints.

H.R. 1421 also includes an innovation voucher pilot program. This program is a novel approach, and it will enable small and medium companies to access leading-edge technology at universities and national laboratories that today they have a barrier to access. However, given the size of each voucher, it is critical that the program be streamlined in its administration so that the overhead is minimized. I think what the Secretary should consider is incorporating the pilot within an existing outreach organization such as the MEPs, which have a long history of serving small and medium companies.

As our manufacturing processes become ever more sophisticated, the reality is, companies are finding it increasingly difficult to access a workforce trained with 21st century manufacturing skills. As described in section 5 of H.R. 1421, the efforts need to be inclusive of community colleges, advanced manufacturing certification programs, private-sector partnerships, and other activities. In those technology areas, which will be covered by the National Network of Manufacturing Innovation, the institutes can serve as the focal point for those programs.

Given our present hard economic times, we clearly need to focus on making good investments that will have the greatest payoffs. It is in fact global competition that requires us to make these investments in measurement and standards, advanced manufacturing technology, small company outreach, and workforce development so that our domestic manufacturing enterprise will remain globally competitive. I suggest that upon study, a highly positive return on this investment in the key manufacturing pillars will be found as measured in manufacturing jobs and balance of trade. The support is needed in a number of parallel, complementary activities that taken together will maintain the world's most efficient and innovative manufacturing ecosystem. Thank you.

[The prepared statement of Dr. Taub follows:]

U.S. House of Representatives Committee on Science, Space and Technology Subcommittee on Research and Technology

Examining Federal Advanced Manufacturing Programs

Expert Testimony by

Alan Taub

Tuesday, September 10th, 2013

Good afternoon, Mr. Chairman, Ranking Member, and members of the Committee. Thank you for inviting me to speak with you today about federal advanced manufacturing programs at the National Institute of Standards and Technology (NIST) and the "Advancing Innovative Manufacturing Act of 2013," that is sponsored by Ranking Member Johnson. I am currently a Professor of Material Science and Engineering at the University of Michigan after retiring from General Motors as the Vice President of Global Research and Development. I also currently serve as the Chair of the Visiting Committee on Advanced Technology for NIST.

I would like to begin today talking about the importance of manufacturing as it relates to the success of this nation. It is critical that the United States retain its leadership in advanced manufacturing technology. Manufacturing companies in the U.S. are responsible for over two-thirds of the industrial research and development and employ the majority of domestic scientists and engineers. Furthermore, the benefits of manufacturing R&D is far reaching and, for example, is the dominant source of service-sector technologies such as those provided by engineering and modeling companies.

Efficient manufacturing of complex goods lies at the heart of successful export economies and the re-invention of manufacturing and manufacturing jobs in America has to be considered fundamental to future economic growth. It is worth noting that when the industrial revolution occurred, the U.S. did not abandon agriculture. We became the most productive farmers in the world, enabled by leadership in technology for developing new crops and production processes. As we transition to the new "knowledge economy", it is critical that we follow the same approach and remain on the cutting edge of manufacturing technologies.

Leadership in advanced manufacturing encompasses more than the development of technologies for the production of new materials and products. In my experience, the "ecosystem" needed to sustain the lead in new materials and systems has to build on a strong base that manufactures existing materials and products in the most efficient manner. This fundamental capability is critical to

ensure the U.S. not only leads in the discovery of new materials but to insure that we are also the nation that develops and implements the manufacturing processes that enable production of these new products.

The 2011 report by the President's Council of Advisors on Science and Technology (PCAST) and subsequent studies have emphasized the critical importance of advanced manufacturing in driving innovation in the United States. The PCAST researched the current state of manufacturing and concluded that U.S. leadership in manufacturing is declining, and that this is detrimental to the well-being of the Nation overall.

1 *Report to the President on Ensuring American Leadership in Advanced Manufacturing,* PCAST Report, June 2011, http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-advanced-manufacturing-june2011.pdf

A core element of the PCAST recommendations was the need for a more coordinated R&D effort in partnership with industry. There is a critical role for the Federal government in maintaining U.S. leadership in advanced manufacturing research and development by supporting programs that serve the needs of U.S. industry by leveraging the capabilities of our university and national laboratory resources.

The various national laboratories bring strong competencies to the development of advanced manufacturing technology. Having served on the Visiting Committee on Advanced Technology for NIST since 2008, I am very familiar with both the laboratory and extramural NIST programs.

NIST's mission, to promote U.S. innovation and industrial competitiveness, positions it to play a central role in the advancement of manufacturing within the nation. NIST is the only agency with a broad mandate to support manufacturing. Other agencies that support manufacturing research do so in a mission-centric vertical manner. NIST on the other hand plays a horizontal role in the manufacturing domain to broadly benefit the nation's economic well-being.

NIST is structured to respond to the various needs of the U.S. manufacturers through its diverse portfolio. With its broad range of programs, NIST provides a wide set of products and services that are designed to aid U.S. manufacturers accelerate their research and development as well as enabling productionization of the technology. Specifically, the NIST laboratory programs conduct research that advances the nation's technology base and is needed by U.S. industry to continually improve products and services. In my class at the university, I teach two key rules in manufacturing:

1. If you cannot measure "it", you cannot manufacture "it" with quality and reliability; and,
2. If you don't have standards in place, widespread commercialization is hindered. since your customer cannot use the product robustly

Improvements in manufacturing process and product technology depend on NIST's fundamental scientific and engineering research to develop the precise and accurate measurement methods and measurement standards needed to improve quality and reliability. This work is critical for U.S. industrial competitiveness.

An important mechanism by which NIST fulfills its measurement mission is through the development and delivery of measurement services. These measurement services include:

- The development and dissemination of validated measurement methods and protocols;
- The development and dissemination of new measurement instruments;
- The provision of Standard Reference Data, Standard Reference Materials (SRMs), and calibration services to ensure that industry-performed measurements are traceable to NIST standards; and
- The development of testing protocols and the support of laboratory accreditation programs

For over a century, the measurement services programs of NIST have ensured the accuracy and reliability of nearly all measurements in the United States. NIST measurement services directly impact U.S. industry. The complexity of today's manufactured goods depends on the ability to integrate components received from a wide range of suppliers. We tend to take for granted our ability to insure that even the most basic length and weight measurements are done uniformly. The reality is that these measurement standards and tracing capabilities serve as the fundamental basis by which products can be used efficiently and often with greater interoperability throughout the entire supply chain to final Original Equipment Manufacturer (OEM) product in almost every U.S. industry. For temperature, instrument vendors, as well as pharmaceutical, chemical, aerospace, microelectronic, and petroleum industries rely on NIST's thermometry and humidity measurement services to establish accuracy needed to enable the manufacturing and sale of their products in national and international markets. For electric power measurements, NIST - traceable calibrations ensure the accuracy of over 100 million electric power meters in the United States that measure the cost of over $300 billion worth of electricity annually.

NIST distributes over 1200 different Standard Reference Materials (SRMs) that assure the accuracy of millions of measurements made daily in manufacturing plants and industrial labs throughout the United States. For example, NIST SRMs for sulfur in fossil fuels enable fuel producers to more efficiently formulate products that meet the varying regulatory requirements of different markets. NIST calibrations are also critical for all state weights and measures agencies. In 2006 and 2007, 16 NIST calibrations for mass, volume, temperature, and length underpinned more than 360,000 calibrations done by state laboratories.

It is important to recognize that NIST's ability to successfully deliver high-quality measurement services to the nation is fundamentally grounded in NIST's world-class measurement science expertise. What might appear to the non-expert as fundamental research without application is actually the foundational core of scientific capability at the NIST laboratories in areas from DNA metrology to atomic, molecular, and optical physics that enables NIST to deliver state of the art tools to meet the future needs of U.S. industry. The NIST Laboratories address increasingly complex measurement challenges, ranging from the very small (nanoscale devices) to the very large (vehicles and buildings), and from the physical (renewable energy sources) to the virtual (cybersecurity and cloud computing). Research at NIST is underway to develop and deliver the measurement science tools that will support advanced manufacturing technologies, including materials modeling and simulation, nanomanufacturing, biomanufacturing, smart manufacturing, robotics, and other enabling technologies.

The development of standards is another key industrial need provided by NIST. Interoperability standards and tools allow manufacturers and researchers to lower costs and accelerate innovation. Standards and other guidance tools open up access to information about shop floor equipment, assist in supply chain management, and support the development of a secure cyberinfrastructure. NIST is providing industry with support for open, consensus-based standards and specifications that define technical and performance requirements, with associated test methods for conformity. Some NIST standards also have the benefit of enabling interoperability among disparate systems or competitively produced products, enabling consumer choice and multiple sources of supply. NIST also represents U.S. interests in the development of international standards aiding our domestic industry to compete in the global marketplace.

Another key role of the NIST laboratories is providing unique, cutting edge user facilities support innovation in materials science, nanotechnology discovery and fabrication, and other emerging technology areas. The NIST Center for Neutron Research, which provides world-class neutron measurement capabilities to the U.S. research community, and the NIST Center for Nanoscale Science and Technology, which supports nanotechnology development have a long history of utilization by U.S. industry.

The Department of Energy national laboratories also provide shared user facilities. Under the new MDF Technology Collaborations Program, industry can leverage world-leading capabilities and expertise in short-term collaborative projects on the path to commercial implementation of advanced manufacturing and materials technologies. A good example of this is the recent construction at Oak Ridge National Laboratory of a Carbon Fiber Technology Facility (CFTF) - a 42,000 square foot innovative technology facility. The CFTF offers a highly flexible, highly instrumented carbon fiber line for demonstrating advanced technology scalability and producing market-development volumes of prototypical

carbon fibers, and serves as the last step before commercial production scale. That facility will enable U.S. researchers to develop the technology needed to reduce the cost of carbon-fiber with applications across a number of industry sectors including energy storage, transportation and other lightweight structures.

NIST also operates a number of programs outside of the laboratories that are critical for U.S. industry.

The Hollings Manufacturing Extension Partnership (MEP) is supporting technologies and practices that increase the competitiveness and resilience of our nation's small and medium manufacturing base. With about half of the U.S. manufacturing jobs being in small and medium enterprises, it is important that those companies get access to leading edge technologies and best practices. A federal-state-local partnership, MEP is enabling future growth with a long-term focus on encouraging cultures of continuous improvement, accelerating the adoption of new technology to build business growth, responding to evolving supply chains, implementing environmentally sustainable processes, and supporting a strong workforce.

- MEP, in partnership with other organizations, is developing the National Innovation Marketplace (NIM) to facilitate connections between original equipment manufacturers (OEMs) and potential suppliers. Through the NIM, sellers, buyers, investors, and distributors across industries are connected through an approach incorporating training, business opportunity forecasting, and access to manufacturers.

The bill sponsored by Ranking Member Johnson, H.R. 1421 and called the "Advancing Innovative Manufacturing Act of 2013," includes an Innovation Voucher Pilot Program. This program is a novel approach to enabling small and medium companies to access leading edge technologies at universities and national laboratories. It has the potential to overcome a critical barrier to providing access to capabilities that are typically not easily available to these companies. Given the size of each voucher, as stated in the bill, it is critical that the program be streamlined in administration so that the overhead is minimized. The Secretary should consider incorporating the pilot within an existing outreach organization such as the MEP program that has a history of effectively supporting small companies.

NIST is also participating with other Federal agencies to launch a new advanced manufacturing initiative to help bridge the gap in bringing manufacturing technology from basic research to implementation readiness. Two programs, the National Network of Manufacturing Innovation (NNMI) and AMTech are being designed to provide support for underserved portions of the R&D infrastructure needed to support a robust advanced manufacturing sector. The AMTech consortia will create industry-driven roadmaps to catalyze and target joint investment in precompetitive R&D advanced manufacturing technologies. The NNMI will help ensure that manufacturers have access to critical expertise and

facilities needed to deliver those technologies. The programs are also designed to serve the needs of both large and small companies.

These programs, which are now launching, will enable the federal government to integrate the efforts across national laboratories, universities and industry to develop advanced manufacturing technologies to improve the competitiveness of U.S. industry. They build on the principles of previously successful industry/government collaborations such as SEMATECH, Semiconductor Research Corporation's Nanoelectronics Research Initiative (NRI) and USCAR. The technology priorities are set by the industrial partners and encompass the needs of the full supply chain. A key enabler for implementation is the parallel development of precompetitive research, coupled with the ability to also perform proprietary technology development that builds on the shared results.

The Advanced Manufacturing Technology Consortia program described in section 2 of H.R. 1421 is consistent with the needs outlined by PCAST as I've mentioned above. It is important that these programs are fully integrated and coordinated. Equally important is that the initiative of creating these Institutes gets accelerated in its implementation, which has been hindered by funding constraints.

In addition to technology development, the new Manufacturing Innovation Institutes have a charter for education and workforce development. This critical need is described in section 5, Advanced Manufacturing Education, of this same bill. As our manufacturing processes become ever more sophisticated, companies are finding it increasingly difficult to access a workforce trained with 21st century manufacturing skills. The programs encompass building the pipeline with improved K-12 STEM initiatives through workforce retraining and development. As described in the Advancing Innovative Manufacturing Act, the efforts need to be inclusive of community colleges, advanced manufacturing certification programs, private sector partnerships and other activities. In the technology areas covered by the National Network of Manufacturing Innovation Institutes, those Institutes can serve as a focal point for these programs.

Insuring that we have a world class manufacturing capability in the U.S. is critical for both economic well-being and maintaining our domestic capability to produce key equipment for defense. Investments in measurement and standards, advanced manufacturing technology, small company outreach and workforce development are all necessary elements to delivering domestic manufacturing that is globally competitive in cost and quality. In these hard economic times when policy makers have to make tough decisions on how to prioritize spending, we need to focus on making good investments that will have the greatest payoffs. I suggest that upon study, a highly positive return on federal investment in these key manufacturing pillars will be found as measured in manufacturing jobs and balance of trade.

In summary, the Federal government has a key role in supporting advanced

manufacturing technology development to maintain the economic health and well-being of our country. This support is needed in a number of parallel, complementary activities that taken together will maintain the world's most efficient manufacturing "ecosystem." The national laboratories and federally funded research at universities form the foundation for the technology development. The new Manufacturing Innovation Institutes will serve to build on that foundation and bridge the innovation gap from basic research to commercialization by catalyzing the integration of industry and those research institutions. The Manufacturing Innovation Institutes, together with other outreach activities like MEP, will insure that small and medium manufacturers are able to access this leading-edge technology and participate fully in the supply chain. Finally, support is needed to prepare the U.S. workforce with the skills needed for the 21st century factory. All three of these activities are needed to insure that the U.S. maintains its leadership position in producing new and existing products in the world's most efficient factories.

Alan Taub

Professor, Materials Science and Engineering
College of Engineering
University of Michigan
Ann Arbor, MI

Retired Vice President
GM Global Research and Development
General Motors Company

Alan Taub joined the faculty of Materials Science and Engineering at the University of Michigan in the Fall of 2012. In this role, Taub is conducting research in advanced materials and processing and leading a new initiative to establish an Advanced Manufacturing Center within the College of Engineering.

Taub retired from General Motors in April 2012. Prior to his retirement, he was vice president, Global Research & Development, leading GM's advanced technical work activity, seven science laboratories around the world, and seven global science offices. He joined GM R&D as executive director in 2001 and was named vice president in 2009.

Taub serves on the boards of several small companies: Nine Sigma, CellEra and Brightway Vision.

Before joining GM, Taub spent 15 years in research and development at General Electric, where he earned 26 patents and authored more than 60 papers. He also worked at Ford Motor Company for eight years.

Taub received his bachelor's degree in materials engineering from Brown University and master's and Ph.D. degrees in applied physics from Harvard University. Taub was elected to membership in the National Academy of Engineering in 2006. He is currently Chair for the Visiting Committee on Advanced Technology (VCAT) for the National Institute of Standards and Technology (NIST) and is a member of The Minerals, Metals & Materials Society (TMS) Energy Materials Blue Ribbon Panel. He also serves on advisory boards for the Massachusetts Institute of Technology, Northwestern University, and the University of California, Berkeley.

Taub received the 2011 Acta Materialia Materials & Society Award. In 2010, he was awarded the Charles S. Barrett Medal from ASM International's Rocky Mountain Chapter. He received the Materials Research Society's Special Recognition Award in 2004 and Woody White Service Award in 2002. He also received the Brown University Engineering Alumni Medal in 2002.

Chairman BUCSHON. Thank you very much.
I now recognize Dr. Baer for his testimony.

TESTIMONY OF DR. THOMAS M. BAER,
STANFORD PHOTONICS RESEARCH CENTER,
STANFORD UNIVERSITY

Dr. BAER. Good morning, Chairman Bucshon, Ranking Members Johnson and Lipinski, and Members of the Subcommittee on Science, Space, and Technology. Thank you very much for giving me the opportunity to speak to you about the importance of advanced manufacturing to the United States government and U.S. citizens.

Although my early training in scientific research was in physics, I have spent most of my career working in the private sector in the field of biotechnology and biomedicine. I have been a founder and senior manager of several high-technology companies in Silicon Valley where advanced manufacturing was a critical corporate focus.

In my opinion, it is not an exaggeration to state that manufacturing has been the foundation of the economy of the United States for the past 150 years. The technology behind the cotton gin, the steam locomotive, electric lighting, the airplane, the automobile, the transistor, the laser, television, liquid crystal displays and the Internet were primarily invented in the United States and first introduced commercially here by developing advanced manufacturing technologies domestically.

Moreover, we have emerged victorious from several worldwide conflicts, in large part due to our manufacturing expertise. However, this is not a prowess that we should take for granted.

The United States has the largest number of world-class research universities, the best government laboratories and the highest level of private-sector entrepreneurial activity and technological innovation in the world. However, other nations are doing more than the United States to encourage interaction between these three sectors, providing effective programs that directly incentivize collaboration focusing on developing advanced manufacturing technologies. I am very pleased to see that the U.S. government is taking action to develop comparable programs, and I encourage you to give these programs the highest priority possible.

I recommend that special attention be paid to funding newer industries where high growth is expected. Often companies participating in these industries are in their initial growth phases and lack the financial resources to explore new manufacturing methods. Examples of such industries are renewable energy through solar power, solid-state lighting, efficient and lighter-weight batteries for electric vehicles, expanding our information technology bandwidth through silicon photonics. Internet bandwidth demands are increasing at 60 percent per year. That means a factor of one hundred fold increase in demand over the next decade, and we presently do not have the technology to service that demand. It needs to be developed. Advanced manufacturing will play a key role in that area.

Another area of growth is developing new transformative manufacturing methods in the fields of protein engineering and synthetic

biology. Over the next decade, these nascent industries are expected to add hundreds of billions of dollars to our economy and thousands of new jobs. It is to industries such as these that government programs can provide great benefit and a large return on investment to U.S. citizens.

These new programs in advanced manufacturing will also provide great opportunities for progress in basic science. Invention and innovation often precede and stimulate new science. The steam engine was invented and optimized prior to the development of the basic theory of thermodynamics that described its operation. The electric light bulb was demonstrated and developed prior to the theory of black-body radiation, and it was due to the inability of classical theories to describe radiation from a light bulb accurately which led to current day modern quantum theories and physics. High-temperature superconductors were discovered 30 years ago, and physicists are still debating different theories describing their operation. The laser, the transistor and satellite communications are all further examples of technologies that were incompletely understood when they were first demonstrated, and the ensuing exploration of their operation and the development of advanced manufacturing processes led to many scientific advances.

The discovery research that will be a necessary component of programs in advanced manufacturing will be important, challenging and transformative. The National Institute for Standards and Technology has the appropriate historical mission, a very experienced and talented manufacturing staff, and superb facilities. It is the logical choice to lead the advanced manufacturing initiatives.

Thank you again for this opportunity to discuss these initiatives with you today, and I would be glad to answer any questions. Thank you, Mr. Chairman.

[The prepared statement of Dr. Baer follows:]

U.S. House of Representatives Committee on Science, Space and Technology
Subcommittee on Research and Technology

Examining Federal Advanced Manufacturing Programs

Summary of Major Points of Expert Testimony by

Thomas M. Baer, Ph.D.

- The Federal government can best assist the needs of US industry by leveraging the exceptional capabilities found in US universities and government labs.
- The US has the world's best university educational system, the best system of national laboratories, and the highest level of private sector entrepreneurial activity and technological innovation.
- However, other nations appear to do more to encourage interaction between these three sectors, and provide effective programs that directly incentivize collaborations focusing on advanced manufacturing technology.
- Within the US government NIST is uniquely positioned to provide a wide range of support for advanced manufacturing within US industry.
- Although almost all industrial sectors in the US could benefit from these government programs, industries that would benefit the most are those in early rapid growth phases, where financial resources are typically not as readily available to explore new manufacturing methods.
- Special attention should be paid to deploying adequate resources specifically in high growth areas such as renewable energy generation and storage, batter technology for electric vehicles, expanding our long and short haul information technology bandwidth capabilities, and new transformative areas of manufacturing incorporating protein engineering and synthetic biology.
- Federal funding of advanced manufacturing in the US, programs such as the NNMI and AMTech, are well conceived, providing much needed funding to enhance US leadership in manufacturing. I encourage you to give these programs highest priority.

U.S. House of Representatives Committee on Science, Space and Technology Subcommittee on Research and Technology

Examining Federal Advanced Manufacturing Programs

Expert Testimony by

Thomas M. Baer, Ph.D.

Tuesday, September 10th, 2013

Good morning, Chairman Bucshon, Ranking Member Lipinski, and members of the Committee. Thank you for inviting me to speak with you today about federal advanced manufacturing programs specifically those at the National Institute of Standards and Technology (NIST). As an introduction, I am currently the Executive Director of the Stanford Photonics Research Center and a Consulting Professor in the Department of Applied Physics at Stanford University. Prior to my tenure at Stanford University I was CEO and founder of Arcturus Bioscience, a company that developed biomedical instrumentation for cancer diagnosis and life science research. Throughout my career I have been involved with a number of high technology companies in Silicon Valley where advanced manufacturing technology was a critical corporate focus.

I have had a long, productive association with NIST, serving six years during the 1990s on the NRC review panels for both the Physics and the Chemical Science and Technology Laboratories. I have also served for the past six years on the Visiting Committee for

Advanced Technology (VCAT). I want to state clearly that in my testimony today I am presenting my own perspective on the topic being discussed, and I am not speaking on behalf of the VCAT committee or Stanford University.

My colleague, Professor Alan Taub, has described in his testimony the important role NIST and the US government can play in supporting federal programs in advanced manufacturing. I agree with and strongly endorse his position that the Federal government can best assist the needs of US industry by leveraging the exceptional capabilities found in US universities and government labs. In my view, the US has the world's best university educational system, the best system of national laboratories, and the highest level of private sector entrepreneurial activity and technological innovation. However, other nations appear to do more to encourage interaction between these three sectors, and provide effective programs that directly incentivize collaborations focusing on advanced manufacturing technology. I believe the programs we are discussing at this hearing would enhance US industrial competitiveness and in short order increase the number of high quality jobs available within the US.

Within the US government NIST is uniquely positioned to provide a wide range of support for advanced manufacturing within US industry. NIST capabilities include its expert staff and standards programs in the Material Measurement Labs (MML), its world-class facilities in the National Measurement Laboratories (NML), and the specialized instrumentation that is part of the user facilities in both the Center for Nanoscale Science and Technology (CSNT) and the Center for Neutron Research (CNR). These assets plus its broad charter to support US industrial competitiveness position NIST to be the optimal choice as the focal point for federal programs in advanced manufacturing.

I have been asked to assess Federal advanced manufacturing research and development programs, including research and development programs at NIST. Several programs are currently being planned and implemented including the NNMI, AMTech, and MEP programs already well described by Professor Taub in his testimony. HR 1421, "Advancing Innovative Manufacturing Act of 2013" is an additional program directing funding to this important area. Even after reading through the descriptions of these various programs, the similarities and differences between these separate initiatives are not terribly clear to me. Given the current status of the federal budget and the need for careful allocation of precious federal resources it will be very important to coordinate and possibly combine these programs in order to eliminate duplication and optimize implementation efficiency. It also quite important that the specific activities funded by these initiatives be optimized

by getting input from US industry. The current leadership at NIST, specifically Director Dr. Patrick Gallagher and Associate Director of Laboratory programs Dr. Willie May, are very experienced, successful managers of government programs with proven track records of working constructively with US companies. I urge the oversight committees to allow these individuals the freedom and flexibility to decide how to best implement these programs and thus optimize the return on investment of the federal funds allocated to these programs.

Although almost all industrial sectors in the US could benefit from these government programs, industries that would benefit the most are those in early rapid growth phases, where financial resources are typically not as readily available to explore new manufacturing methods. It is in these areas that government programs can provide great benefit and a large return on investment. In my testimony today I would like to focus on several examples where government programs such as the NNMI, AmTech, and the initiative described in HR Bill 1421, "Advancing Innovative Manufacturing Act of 2013", could be pivotal to future US competitiveness in industries at early stages in their development, which will become strategic growth sectors of US industry.

Energy Generation

Advances in manufacturing technology will be critical for expanding the production of electrical power using renewable resources. A recent publication based on the National Academy report states: "While today's solar-generated electrical power represents a small fraction of the world's production capacity — less than 0.5 percent— solar power is the fastest energy generation source in the United States. In 2012, the US market size for solar energy was $11.5 billion, a 34 percent increase over 2011. " (From the National Photonics Initiative, www.lightourfuture.org "Lighting the Path to a Competitive, Secure Future", accessed September 8, 2013.) By 2020 the market size for solar energy is expected to exceed $50B US.(http://about.bnef.com/files/2013/04/Global-Renewable-Energy-Market-Outlook-2013.pdf, accessed September 8, 2013) This growth will be accelerated by reducing manufacturing costs of existing photovoltaic panels and through the development and introduction of new, lower-cost semiconductor materials, manufacturing processes, and panel designs. Solar energy can provide a sustainable energy source to meet a significant portion of the nation's total projected energy needs, but component and production costs must be reduced in order to be competitive with other existing fossil fuel based energy sources.

For example, new photovoltaic materials provide the potential to employ high- volume, reel-to-reel manufacturing techniques to dramatically reduce the cost of manufacturing. These new materials can be applied in thin films to flexible substrates decreasing the overall panel weight, cost, and time of manufacture. Although laboratory demonstrations of highly efficient operation of small scale devices have been published, challenges remain to fully exploit the commercial potential of these new approaches. These challenges include: improving the crystalline quality of the deposited material, optimizing the deposition process, and developing high-speed, post deposition cutting and scribing necessary for electrical isolation of individual solar cells. Expanding federal funding in support of collaboration among government laboratories (e.g., NIST and NREL), US companies, and university research groups focusing on developing manufacturing technology in this area would greatly facilitate progress towards achieving cost-parity of solar energy with conventional fossil fuel based energy sources and reduce the overall production of green-house gases produced in the US.

Energy conservation

Advances in manufacturing technology are also essential for improving energy conservation in the US. Roughly 20% of the electrical power generated in the US is used for lighting. Light emitting diodes (LED) or solid-state (SS) lighting are 5 times more efficient than incandescent lamps currently in use. Moreover, LEDs last up to 20 times longer than incandescent bulbs. The overall market size for these new light sources is expected to grow rapidly with improvements in manufacturing. "The global solid-state high-brightness LED market was $13.7 billion in 2012. .With continued improvements in performance and reductions in manufacturing cost, LEDs should begin to dominate general lighting, with an estimated market of $84 billion by 2020. By 2030, the forecasted energy savings from the use of LED lighting in the United States is about 45 percent — a savings of $30 billion at today's energy costs. " (From the National Photonics Initiative, www.lightourfuture.org "Lighting the Path to a Competitive, Secure Future p. 21). In addition, a National Academy report concludes: "Cost is the main issue preventing widespread adoptions of SS lighting, but substantial progress is being made in lowering the cost of light-emitting diodes (LEDs).... The cost of white LEDs is still very high due to the lack of scalability in the manufacturing processes. "("Optics and Photonics: Essential technologies for our Nation", p. 130,155, National Academy Press, http://www.nap.edu/catalog.php?record_id=13491, accessed September 8, 2013.)

Current prices for LED lamps are roughly 10 times higher than comparable incandescent bulbs, a significant barrier to their wide-spread adoption. Advances in manufacturing methods could substantially improve semiconductor yields and lower the cost of power conversion electronics, and other necessary components for cost-competitive LED lighting.

Personal Transportation

Electric automobiles are one of the fastest growing segments of the automotive industry; sales have doubled this past year and are expected to continue to grow rapidly over the next decade. (http://electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952) The US is currently the world's largest producer of electric cars and the leader in electric car technology. US manufacturers were the first to win the prestigious Car of the Year award given by Motor Trend: the GM Volt in 2011 and the Tesla Model S in 2013. Plug-in hybrid and fully electric cars are the future of personal transportation technology. They are 3 times more efficient than gasoline powered automobiles in delivering power from the energy source to the wheels, and they have the potential for much lower maintenance due to the very large reduction in the number of engine components and engine complexity.

A major impediment to wide-spread commercial adoption of electric vehicles is the cost of manufacture of the batteries, which are primarily responsible for the increased price of an electric car compared to its gasoline powered equivalent. Batteries are the most expensive component in an electric car, adding about 20% to the cost of the electric automobile. Reducing the cost of battery manufacture by three fold would make the cost of ownership of an electric vehicle comparable or less than its gas powered equivalent. " In the United States, with gasoline prices at or above $3.50 a gallon, automakers that acquire batteries at prices below $250 per kWh could offer electrified vehicles competitively, on a total-cost-of-ownership basis, with vehicles powered by advanced internal-combustion engines . " http://www.mckinsey.com/insights/energy_resources_materials/battery_technology_charges_ahead

Future battery technology will use components made from nanostructured materials providing lighter weight, more efficient ion and electrolyte flow, as well as improvements in overall efficiency and life time. (Jun Chen and Fangyi Cheng, Combination of Lightweight Elements and Nanostructured Materials for Batteries, Accounts of Chemical Research 713-723 June 2009 Vol. 42, No. 6.) These new materials will require advanced manufacturing methods to be developed and new methods for measuring quality and performance of these nanostructured materials. NIST has exceptional, world-class facilities for assisting in

the development of these capabilities within the National Measurements Laboratory and the Center for Nanoscale Science and Technology.

Overall performance of electric vehicles will also be greatly improved by reducing the weight of the vehicle. As mentioned by Professor Alan Taub in his testimony, the Oak Ridge National Laboratory Carbon Fiber Technology Facility (CFTF) is well positioned to assist US car manufactures in developing the manufacturing process by incorporating these light-weight materials in their designs. "The next generation of carbon-fiber composites could reduce passenger car weight by 50 percent and improve fuel efficiency by about 35 percent without compromising performance or safety -- an advancement that would save more than $5,000 in fuel over the life of the car at today's gasoline prices." (http://www.fueleconomy.gov/feg/evtech.shtml, accessed September 8, 2013)

Information Technology and the Internet

The Information and Communication Technology (ICT) sector has evolved to become an essential infrastructure for a major fraction of the US economy. The global ICT system includes smartphones, laptops, the internet long-haul backbone, and computer-server farms that drive search engines (Google and Yahoo, for example) and internet services such as YouTube, Facebook, and Amazon. Demand for ICT data bandwidth is growing at 60%/year implying a 100 fold increase in 10 years. Sustaining this growth is a major challenge since ICT already consumes approximately 5% of the total electrical power generated world-wide. (D8.1: Overview of ICT energy consumption, http://www.internet-science.eu/sites/internet-science.eu/files/biblio/EINS_D8%201_final.pdf, accessed September 8, 2013) It is generally recognized that semiconductor technology used in present day data centers requires too much power to sustain the predicted growth rates in data demand. (*Device Requirements for Optical Interconnects to Silicon Chips – D. A. B. Miller,* Proceedings of the IEEE (Volume:97 , Issue: 7) (1165-1185))

A typical computer processor used in data centers requires roughly 200 W of power and most of this ends up as generated heat. (As a point of comparison, the heat generated per square centimeter in a typical computer processor exceeds that of a clothes iron.) A data center can contain 100,000 such processors, requiring many megawatts to operate; enough power to sustain a small city.

Much of the power consumed in today's processors and data centers is due to the amount of energy required to transfer data from one point to another within the data center. Currently data is transferred primarily by moving electrons over copper wires. Replacing these copper wire electrical interconnects with optical interconnects using photons and guided wave structures has the potential to greatly increase power efficiency. The NRC HLII report states: "As data communications increase at an exponential rate, the power consumption by the communication infrastructure is growing rapidly. Moreover, it has been well known that although electronic power consumption scales with increased data rate, the power consumption of photonics does not." ("Optics and Photonics: Essential technologies for our Nation", p. 83 National Academy Press, http://www.nap.edu/catalog.php?record_id=13491, accessed September 8, 2013)

Laboratory demonstrations of integrated optics devices indicate that major energy efficiencies can be achieved using optical interconnects within the microprocessors, between chips on a circuit board, and separate computer servers within a data center. Current road maps for integrated circuit development state: "Despite these problems of wiring and the arguments in favor of optics for interconnects to or even on the silicon chip, there is essentially no such use today. There are many possible reasons for this absence of short-distance optical interconnects, but certainly cost targets for introduction of optics at short distances are extreme because wires on chips and boards are very inexpensive. Being able to make the necessary optical and optoelectronic components in a low cost process compatible with silicon electronics may well be essential for any commercial introduction of optical interconnects." (*Device Requirements for Optical Interconnects to Silicon Chips – D. A. B. Miller.* Proceedings of the IEEE (Volume:97 , Issue: 7) (1165-1185))

Moreover, cost effective, volume manufacturing of these optoelectronic components has not been demonstrated. Recent estimates are that "...Developing silicon photonics process is at least a multi-million dollar endeavor... " However, "A number of organizations around the world including A*STAR Institute of Microelectronics (IME), CEA-Leti, IMEC and others, have now developed processes with various levels of capabilities..." (It should be noted that these organizations are located in Singapore, France, and Belgium. respectively.) (Optics and Photonics News, September, 2013, p.34, Optical Society of America.) Development of US manufacturing capability of photonic integrated circuits compatible with industry standard, silicon CMOS processes will be critical to maintaining US leadership in the semiconductor industry. Moreover, domestic supplies of these devices, soon to be critical components in data centers, may very well be essential to ensuring the security of data traveling through and residing in US data centers.

The Evolving Bioeconomy

A recent report on The National Bioeconomy states: "Decades of life-sciences research and the development of increasingly powerful tools for obtaining and using biological data have brought us closer to the threshold of a previously unimaginable future: "ready to burn" liquid fuels produced directly from CO_2, biodegradable plastics made not from oil but from renewable biomass, tailored food products to meet specialized dietary requirements, personalized medical treatments based on a patient's own genomic information, and novel biosensors for real-time monitoring of the environment." The report goes on to state that: "According to the USDA, US revenues in 2010 from genetically modified crops were approximately $76 billion. [2] Beyond agriculture, based on the best available estimate, 2010 US revenues from industrial biotechnology—fuels, materials, chemicals, and industrial enzymes derived from genetically modified systems—were approximately $100 billion. [3] The growth of today's U.S. bioeconomy is due in large part to the development of three foundational technologies: genetic engineering, DNA sequencing, and automated high-throughput manipulations of biomolecules."
(http://www.whitehouse.gov/sites/default/files/microsites/ostp/national_bioeconomy_blueprint_april_2012.pdf)

The US has been the leader in developing much of the technology that has enabled this biotechnology revolution. To continue our world leadership position the US will need to establish itself as a leader in developing high volume manufacturing methods for safe and efficient production of the organisms necessary to produce these extraordinary new products.

Recognizing the needs of this fledgling industry NIST has initiated several programs to develop the necessary standards, reference materials and safety protocols. A recent report published by NIST summarized their vision: "Despite major breakthroughs and discoveries in recent years, our understanding of biological systems still faces many challenges. Biology is an informational science that depends on accurate measurements and standards. Whether quantifying the amount of protein in a cancer cell or the rate at which an organism converts sugar to alcohol, measurements are the foundation for improving our understanding of biological systems." (**Conference Report Accelerating Innovation in 21st Century Biosciences: Identifying the Measurement, Standards, and Technological Challenges, NIST,** http://www.nist.gov/manuscript-publication-search.cfm?pub_id=903034)

For example, NIST has been working with the NIH and FDA on programs to develop measurement standards for new diagnostic methods and therapies based on advances in our understanding of molecular biology. A major program, the "Genome in a Bottle Initiative" is coordinating the efforts of government agencies and dozens of companies to develop standard reference materials for whole genome sequencing using the latest generation of high throughput DNA sequencing instruments. (http://www.nist.gov/mml/bbd/biomolecular/genome_in_a_bottle_consortium.cfm, accessed September 8, 2013)

Along with colleagues at Stanford University, I have been working with NIST management to establish collaborations with several major US biotechnology companies through a program entitled Advances in Biomedical Measurement Science (ABMS). (http:\\abms.stanford.edu, accessed September 8, 2013) This program was initiated to enable significant improvements in the accuracy and comparability of vital data used to make important research, regulatory, clinical, and manufacturing quality control decisions. The program is co-led by Stanford University (SU) and the National Institute for Standards and Technology (NIST), and involves life science and biotechnology companies, federal and state regulatory agencies, and other interested universities as essential participants. The ABMS program is a good example of a public/private partnership, funded by NIST, Stanford University, and US industry. NIST personnel have been detailed to Stanford University to work with biotechnology companies located in Silicon Valley and with the Stanford University scientific and hospital faculty on problems in medicine where advances in measurement science could substantially accelerate progress. Through the ABMS program NIST can take advantage of access to a leading university research hospital, animal testing facilities, and other capabilities not available at NIST laboratories, as well as proximity to one of the largest concentrations of biotechnology companies in the US located in Silicon Valley.

Conclusion

Federal funding of advanced manufacturing in the US, programs such as the NNMI and AMTech, MEP and HR1421 will provide valuable federal funding to enhance US industrial leadership in manufacturing. I encourage you to give highest priority to allocation of funds to these programs. Coordinating and perhaps combining these programs to avoid duplication and optimize efficiency will be important. Federal programs should be designed to support industry, government lab and university collaboration; taking advantage of our world leading government laboratories, universities, and private sector

research and development. Special attention should be paid to deploying adequate resources specifically in high growth areas such as renewable energy generation and storage, expanding our long and short haul information technology bandwidth capabilities, and new transformative areas of manufacturing incorporating protein engineering and synthetic biology.

Thomas M. Baer

Dr. Thomas Baer is the Executive Director of the Stanford Photonics Research Center, a consulting professor in the Applied Physics Department and an Associate Member of the Stem Cell Institute at Stanford University. His current scientific research is focused on developing imaging and biochemical analysis technology for exploring the molecular basis of human developmental biology and new technologies for protein engineering. He received a B.A. in physics from Lawrence University in 1974, and a Ph.D. in atomic physics from the University of Chicago in 1979, where he studied with Professors Ugo Fano and Isaac Abella. After receiving his Ph.D. he worked with Nobel Laureate John L. Hall at JILA, University of Colorado, performing research on frequency stabilized lasers and ultra-high precision molecular spectroscopy.

Career

Throughout his career Dr. Baer has been extensively involved with startup companies in Silicon Valley. In 2008 Dr. Baer co-founded Auxogyn, Inc., a diagnostic company devoted to advancing women's health by developing technology for assisted reproduction and in vitro fertilization. The technology which formed the basis of Auxogyn products was selected by Time Magazine as one of the top ten medical breakthroughs of 2010. From 1996 to 2005 Dr. Baer was the CEO, chairman, and founder of Arcturus Bioscience, a biotechnology company located in Mountain View, CA, which he established in 1996. Arcturus Bioscience pioneered the area of Microgenomics by developing and manufacturing laser microdissection instrumentation and integrated bioreagent systems. Arcturus developed products that allowed precise genetic analysis of microscopic tissue samples and were integrated into a new generation of cancer diagnostic tests.

From 1992 to 1995 Dr. Baer was Vice-President of Research at Biometric Imaging, a company that developed laser scanning instruments for AIDS diagnosis, bone marrow transplants, and blood supply quality control. From 1981 to 1992 Dr. Baer was at Spectra-Physics, Inc. where he held positions of Vice-President of Research and Senior Research Fellow. While at Spectra-Physics he developed technology that formed the basis for major Spectra-Physics product lines including optical pulse compressors, diode-pumped solid-state lasers, and modelocked Ti:Sapphire lasers.

Awards and Patents held

Dr. Baer holds more than 60 patents and his commercial products have received many industry awards for design innovation. In 1994 he received the Lucia R. Briggs distinguished Alumni Award from Lawrence University and in 2000 he was named Entrepreneur of the Year for Emerging Companies by the Silicon Valley Business Journal. He has been elected to the status of Fellow in two international scientific societies, the American Association for the Advancement of Science and The Optical Society of America (OSA), and served as the President of OSA in 2009. He is a visiting Professor at the University of Strathclyde in Glasgow, Scotland and in 2012 received an honorary Doctorate of Science degree from Heriot-Watt University in Edinburgh, Scotland. In 2012, he was also awarded the Robert E. Hopkins Leadership Award by the Optical Society (OSA).

(Information taken from http://en.wikipedia.org/wiki/Thomas_M._Baer)

Chairman BUCSHON. Thank you.
I now recognize Mr. Muro for his testimony.

**TESTIMONY OF MR. MARK MURO,
SENIOR FELLOW AND POLICY DIRECTOR,
METROPOLITAN POLICY PROGRAM,
BROOKINGS INSTITUTION**

Mr. MURO. Good morning, Chairman, Ranking Members Lipinski and Johnson, and Members of the Subcommittee. I very much appreciate the opportunity to appear before you today.

What I thought I would do since we have some very capable examinations of what NIST can do and the direction of its work, I want to close the testimonies by turning to some fundamental rationale so that we remember what we are doing here, so I first want to consider why manufacturing actually matters so much, why federal policy support is warranted, and then what that might look like, and I will touch at the very end on a few comments on H.R. 1421.

Let us consider first, you know, why manufacturing matters. I am going to be very brief, but I am going to put it in a broader economic context, you know, and I think my group since about 2008 has been arguing very much against the view that there is nothing special about manufacturing, which only 4 or five years ago really was a frequent refrain, motivated by the view, though, that since the 2008 crash we needed to rebalance the American economy away from consumption and imports financed by foreign borrowing and back towards creating real value through innovation, export and outcompeting other nations. But we have argued that manufacturing certainly matters not just for the 11.5 million jobs left in the sector but equally important because it is a major source of technology innovation and because it can make a major contribution to reducing the Nation's trade deficit. You know, manufacturing is only about 11 percent or so of GDP but it is responsible for the overwhelming majority, about 68 percent of it, of domestic R&D spending by companies. This is the main site of innovation, technology innovation, in the private sector.

At the same time, we have noted that manufacturing exports are going to be essential if we are going to reduce the trade deficit. It is theoretically possible to eliminate the trade deficit by increasing exports and reducing the import of services, agricultural products, and natural resources but the task would be much easier if manufacturing were included. So if we want to reduce the deficit, the trade deficit, we need to bear down on manufacturing.

Let us turn to whether or not manufacturing is an appropriate object of policy attention. I will just say there is sound economic reasons for engagement beyond the simple values of manufacturing that we have heard about from my co-panelists. Many economists, perhaps many of you here today, there is the sense that any type of preferential treatment for a single type of investment is off base or distortionary. However, it is essential to remember that standard economic theory justifies government action where there are market failures, meaning situations where the societal benefits or positive spillovers of an activity exceed the private return. In those situations, it is unlikely that a private business will invest at the

optimal level. Hence, my view: The U.S. manufacturing sector is plagued by a number of market failures that merit government attention.

Here are a few of these that pertain to this morning's discussion of H.R. 1421. Manufacturers underinvest in collaborative public-private roadmapping exercises because the collaborations are hard to organize and because they can rarely reap the sole value of the association in their individual bottom lines. Manufacturers, even small ones, also underinvest in R&D because they can't reap the full value of technical advances in their profits. It is a classic example of positive spillovers. And then finally, mapping again into aspects of the bill, manufacturers, especially small ones, often lag in identifying or adopting or developing the latest training and education models. The inability to capture all the benefits again means they are producing value for the economy, value for the society but not always profits for themselves. So in each of these instances, the implication is clear: fundamental market values ensure the Nation will underinvest.

So what kind of policy actions make sense? It is important to note that manufacturing policies should not pick winners and it should improve the overall macroenvironment but it also needs to attack these market failures. So some of the general aspects—and I think I am running over just a little bit—you know, increased public investment in R&D, improve the Nation's tax competitiveness, especially for R&D capital equipment, foster trade, invest in the Nation's STEM workforce, modernize infrastructure, you know, safeguard the Nation's energy windfall of unconventional natural gas, but then policies that attack these particular market problems can be very helpful, and I think that is what this bill does quite skillfully. We like the idea of challenge grants that catalyze both—that make available a grant but catalyze the partnerships between sectors—business, academia and national labs—and I think you have a number of those in this.

I could talk some more about some of the other aspects of the bill but I think the fundamental use of competitive grants here is a very important model for engaging industry, getting that out front in determining and shaping the interventions. So I can go on later in questions, but that is the basic outline. Thank you.

[The prepared statement of Mr. Muro follows:]

BROOKINGS

Congressional Testimony of
Mark Muro
Senior Fellow and Policy Director
Metropolitan Policy Program
Brookings Institution
1775 Massachusetts Ave., NW
Washington, DC 20036-2103
202-797-6000

Presented before the
Subcommittee on Research and Technology
Committee on Science, Space, and Technology
U.S. House of Representatives
United States Congress

Catalyzing Manufacturing Competitiveness with Targeted Responses to Key Market Failures

September 10, 2013

Good morning Chairman Bucshon and Members of the Subcommittee. I very much appreciate the opportunity to appear before you today to talk about a subject of great importance to the nation: the renewed importance of manufacturing to U.S. economic competitiveness.

I also appreciate the chance to say a few words about the best sorts of actions that the federal government can take in order to help sustain the sector. In doing that I'll provide a few comments on H.R. 1421.

As you know it is an opportune time for this hearing inasmuch as the manufacturing sector has been forcing us all to take note of late. With over 500,000 jobs added since the beginning of 2010, the sector has stood out as one of the economy's genuine bright spots. In fact, since then, the sector has grown no less than about twice as fast as overall economy, and in doing so manufacturing industries have significantly out-performed the range of a normal cyclical rebound. Something good is happening.

And yet, for all that, skeptical questions continue to be raised.

Some wonder why all the fuss and ask whether it really matters if the country has a strong manufacturing base.

Others grant that manufacturing matters but doubt whether manufacturing is an appropriate object for public policy.

And finally, views differ on which policy approaches will do the most good.

In view of all this, I want to insist that manufacturing matters, argue that it requires policy interest, and suggest some priorities for that interest. After that, I'll say a few things about the strengths and weaknesses of the bill before you in view of those priorities.

Why manufacturing matters and why policy should support it

Let's first consider why manufacturing matters and why public policy should support it.

To see the importance of manufacturing one only needs to recall one of the central takeaways from the Great Recession: that the U.S. needs to rebalance growth away from consumption and imports financed by foreign borrowing and back toward making things and exporting them.

In this regard, the crisis reminded the nation of the perils of letting the economy tilt too far away from maintaining a healthy presence in the economy of such basics as innovative activities, production, and exports—the true sources of competitiveness and wealth generation. As one consequence of that drift the nation has run a trade deficit in every year since 1976, with the deficit exceeding 2.7 percent of GDP in every year since 1999 and clocking in at $45 billion in May 2013.[1]

So why precisely does manufacturing matter so much? It matters for lots of reasons—including the decent pay and diverse but often accessible jobs it tends to offer. But here I want to stress the sector's importance for reducing the trade deficit and driving commercial innovation—two linchpins of nations' economic well-being.

On the trade side, it is important to recognize that manufactured goods account for about 89 percent of the merchandise exports from the U.S. and about 60 percent of all goods and services exports combined.[2] To be sure, service exports are rising, and should help with the task of improving the trade balance. But even so the fact remains that while it is theoretically possible for the nation to eliminate its trade deficit by increasing the export and reducing the import of services, agricultural projects, and natural resources, the job will be much easier if manufacturing exports grow.[3] The bottom line: Stepping up our manufacturing exports is going to be essential if we want to reduce the trade deficit.

As to the matter of innovation, the simple fact is that manufacturing matters because of its huge role in product and process enhancement. Economists, in this connection, have for decades been very clear that innovation—the creation of new products, processes,

technologies, and business models—hugely influences nations' productivity, competitiveness, and living standards.[4] And yet until recently fewer investigators had looked at the strong links between manufacturing and innovation. However, that has changed in the last few years or so thanks to work by researchers at Brookings, the Information Technology and Innovation Foundation, the Massachusetts Institute of Technology, and Harvard Business School.[5]

Last year, for example, my group at Brookings looked into this carefully and reiterated the basic story: Although manufacturing accounts for only 11 percent or so of U.S. output it is responsible for no less than 68 percent of domestic R&D spending by U.S. companies.[6] Likewise, the sector employs some 35 percent of the nation's engineers and 60 percent of all U.S. R&D workers (despite employing only 9 percent of all workers) and is a major source of U.S. patenting.[7] The crucial point here: Manufacturing is a key site—arguably *the* key site—of the U.S. innovation machine that has in the last 15 years churned out such life-changing inventions as personal GPS devices, the iPhone, and so-called 3-D printing. Lose manufacturing and we may lose much more than just 12 million plant jobs.

Which bring us to the question of policy: Is manufacturing an appropriate priority for public policy action? On this important issue, I would commend to you two well-argued speeches given last year and this summer by Gene Sperling, director of the National Economic Council, which mount some of the right arguments.[8] But for my part, I want to say, right off, that manufacturing absolutely *is* an appropriate focus for policy support. Not only does manufacturing matter but there are sound economic reasons for fostering it.

To be sure, many economists—and perhaps many of you—start from the premise that any type of preferential treatment of any single type of investment is off-base because it is "distortionary." However, it is essential to remember that standard economic theory also justifies government action where there is a "market failure"—meaning, in situations where the societal benefits of an activity exceed the private return—making it unlikely that a private business will invest sufficiently unless government plays a role.

At Brookings we believe U.S. manufacturing is challenged by a number of market failures many of which have to do with the extent to which manufacturing activity generates positive "spillover effects" that the individual firm cannot monetize and that thereby creates a risk of the nation under-investing in areas of societal benefit.[9]

In this regard, many of the market problems result from the very power of the beneficial "co-location synergies" that economist Greg Tassey suggests result when manufacturing firms cluster together in a region. But at any rate, we see a number of serious market problems relevant to this morning's discussion that merit government attention. Specifically:

- Manufacturers underinvest in collaborative public-private roadmapping exercises because the collaborations are hard to organize and because collaborators can rarely reap the full value of the association in their profits. Here we know that when an

economic activity has positive "spillover" effects that an individual firm can't capture we as a society and economy may well under-provide it

- Manufacturers—especially small ones—underinvest in R&D because they cannot reap the full value of technical advances in their profits. This is the classic example of the problem of positive spillovers

- Manufacturers—especially small ones—often lag in adopting or identifying and developing the latest training and education models and practices. Here again the inability of firms to capture all of the benefits of their own investments means they will produce much less productivity-enhancing activity than is optimal for society

In addition we would note that:

- The economic and innovation benefits of regional manufacturing clusters are underappreciated as well as underprovided. Again, clustering generates positive externalities that benefit the overall economy but that can't always be captured by the participating firms[10]

In each of these instances, then, the implication is clear. Fundamental market issues ensure that the nation will under-invest in key aspects of the nation's manufacturing commons if it simply leaves well enough alone. And if we do the nation's manufacturing competitiveness will be further compromised. In sum, policy attention is not just permissible but necessary.

Key components of sound manufacturing policy

But how, then, should policy support be configured? What sorts of policy actions make sense if public policy support for manufacturing is warranted?

To begin with, it's important to note that manufacturing policy would not "pick winners and losers." In fact, a smart pro-manufacturing stance on the part of the public sector would lean away from special treatment of single firms. Instead, well-considered manufacturing policy would undertake two main activities: It would seek to improve the "macro" environment in which all manufacturers operate while at the same time intervening in limited, strategic ways to address specific, demonstrable market failures that affects *groups* of firms. In both cases the thrust of policy would in general move toward improving the lot of large groups of firms or whole industries or sectors.

In this regard, I will pass rapidly over the most general suite of economy-wide policy stances before focusing on some responses to crucial market problems. Aimed at ensuring that the U.S. is one of the world's most attractive locations for high-value production, the basics of general policy encompass such "macro" topics as technology, taxes, trade, talent, infrastructure, and energy and have been well articulated by Rob Atkinson and Stephen Ezell of the Information

Technology and Innovation Foundation as well as my Brookings colleagues Bruce Katz, Amy Liu, Rob Puentes, Brad McDearman, and Scott Andres who have worked intensively on global exchange and infrastructure issues and advanced industries topics. In brief, it is important that federal policy:

- Increase public investment in R&D and technology development
- Improve the nation's tax competitiveness for high-value industrial investment by reducing its high effective corporate rates, including by increasing the generosity of the R&D tax credit and reducing the effective rate on capital equipment investments
- Foster trade by ensuring that manufacturing firms are well-connected to global markets and capital flows. Export and foreign direct investment promotion are critical but so must the rights of manufacturing firms be protected in international markets even as trade policy emphasizes expanded access to new markets
- Invest in the nation's STEM workforce, particularly to ensure the availability of applied technology engineers and an abundant "middle skills" worker pool
- Modernize the nation's declining highway, rail, and port infrastructure to facilitate exports and speed time to market
- Safeguard the nation's providential energy windfall of unconventional natural gas, ensuring its abundance at low prices for domestic industrial use

Along these lines, much consensus exists about the more general macro policy agenda the nation needs to maintain and expand a competitive manufacturing sector.

But what about public policy agendas that speak more directly to the several market problems I identified earlier?

In this connection, I have argued that in certain situations where the benefits of specific desired activities cannot be contained within or fully monetized by the participating firms, policy intervention is warranted to ensure that relevant good is adequately provided. So what are the kinds of policy responses that would help make up for some of the market problems we are discussing here today: the underproduction of such socially beneficial goods as collaboration to identify long-term industry technology needs; innovative activity among SMEs; and the production and use of top quality manufacturing education?

Here are some thoughts:

Collaborative roadmapping and multi-actor coordinated work to develop shared technology platforms and infrastructure may well be best induced through competitions that call into being multi-actor consortia that must collaborate—and invest on a matching basis—to secure

funding. This strategy—which my group suggested in work that informed the design of the Department of Energy's Energy Innovation Hubs program—is currently being employed in numerous Department of Commerce challenge grants and most prominently in the department's National Network for Manufacturing Institutes (NNMI) initiative.[11] My group likes these challenges because they combine the funding needed to "buy" the under-provided social good with criteria that require and structure the most beneficial sort of collaboration and governance, since collective action problems inevitably accompany the spillover problems associated with technology collaboration.

Turning to mechanisms for increasing innovative activities among SMEs, governments can choose among various tools to incite smaller-firm R&D. They can employ direct grants or competitive contracts again to simply "buy" R&D activity or they can employ indirect fiscal incentives such as R&D tax credits.[12] More recently some states have begun to experiment with the establishment of "innovation vouchers" structured to allow individual firms to "buy" R&D from third-party providers.[13] In thinking about which tool is more appropriate it is worth noting that each tool addresses slightly different market problems. Whereas a direct grant can be directed toward specific types of projects that government deems important, a voucher or tax credit provides a general incentive to all kinds of R&D across the economy and leaves the topic to the firm.

Otherwise, the strategies policymakers might employ for addressing manufacturing education and training problems resemble those they might employ to catalyze collaborative technology roadmappng. Fundamentally a collective action problem suffused with positive externalities for participating firms, education challenges are probably best attacked through a competitive grant strategy that aims to call forth new collaborations between firms and, in this case, community colleges—our leading front-line training organizations. Critical here will be insisting that private sector actors aren't just participants but active leaders of the education initiatives.

In short, for each of these market failures a targeted, bounded, but potentially effective policy response can be designed that will help realign the incentives of firms and institutions to deliver more of the specified socially beneficial activity than the market does now.

Comments on H.R. 1421

So how does H.R. 1421 comport with the elements of good manufacturing policy I have laid out here? I would say it lines up pretty well and addresses several areas of recognized market weakness with reasonable, focused responses.

The advanced manufacturing technology consortia item (Sec. 2) should help overcome the coordination problems that currently limit pooled work on shared technology issues. In doing so, the section will provide a welcome mechanism for better aligning public, private, and university long-term industrial research. By way of advice, I would just suggest that to make the greatest economic impact the consortia should be focused on an accepted list of top "cross-cutting technologies" such as that identified by PCAST in its second report on capturing

advantage in advanced manufacturing.[14] Ranging from advanced materials and sensing to additive manufacturing and robotics these technologies will be pivotal in enabling U.S. competitiveness and are prime candidates for roadmapping.

The Small Manufacturer Innovation Program (Sec. 3) is also welcome as it specifically addresses innovation needs (and besetting market problems) affecting SMEs at a time when most SME policy lags behind modern economic reality. Large original equipment manufacturers are pushing technology needs upstream to their disperse network of SME suppliers so targeted assistance to support SME innovation is needed. Unfortunately, most SME policies currently support basic business development and some skills training with little emphasis on R&D. So, again, the new focus on innovation is extremely welcome, although I would only wonder if a "retail" grants program is the best way to reach thousands of "head down" SMEs with often lower capacity. One thought would be that the pilot ought perhaps to be focused on somewhat larger "middle sized" firms that are more likely "ready to innovate."

At the same time, I applaud the proposed experiment with innovation vouchers in Sec. 4. I like its simplicity and potential speed. I like that it provides a small-dollar tool for spurring innovation in SMEs while providing a mechanism that will give universities and labs an incentive to be more responsive to industry needs and particular companies. In that sense, vouchers strike me as a nimble way to get SMEs "into the game" while engaging universities and research institutions by fomenting more exchange.

Meanwhile, the advanced manufacturing education grants to community colleges hits a particularly relevant issue—the importance of sub-baccalaureate STEM workers. Research from one of my Brookings colleagues has found that half the STEM jobs in the United States require less than a bachelor's degree, with many of these positions in manufacturing.[15] And yet I think the production of relevant workers through collaborations of community colleges and industry is a classic collective action problem, plagued with positive externalities that ensure neither firms nor colleges engage intensely enough. Given that, I think the proposed competitive grants make sense. I would only counsel that the scale of the problem here is enormous and that the criteria for grant awards should stipulate very substantial participation on the part of large and smaller firms in proposals. A serious problem here is that many community colleges remains seriously divorced from industry needs so the grants should require bridging that gap.

Otherwise, I want to make one general comment about what I am somewhat surprised is missing here, which is some reference to the *regional* locus of manufacturing innovation and workforce recruitment. As the policy director of the Metropolitan Policy Program at Brookings I am biased here but I want to stress that geography matters in manufacturing.

Innovation, and its deployment, does not happen just anywhere. It happens in places and most notably, within metropolitan regions where firms and workers tend to cluster in close geographic proximity, whether to tap local supplier networks, draw on a pool of skilled workers, or profit from formal or informal knowledge transfer. If properly channeled, these "co-location

synergies" as Greg Tassey has called them augment the vitality of regional—and therefore national—manufacturing clusters. Nor is this only a "soft" benefit. Such local synergies—accumulated region by region—represent a crucial source of national manufacturing capacity and productivity. Given all this, I would love to see some references in the bill to "regional manufacturing networks" and the participation of "regional industry associations" and so on as I think the best proposals will reflect strong regional involvement in regions that retain what Willy Shih and Gary Pisano call a strong "manufacturing commons" of shared access to webs of technical know-how, operational capabilities, and specialized skills that are embedded in the region's firms, workforce, suppliers, educational institutions, industry associations, and the like.[16] I realize some of these features are reflected in Investing in the Manufacturing Communities Partnership initiative as well as the NNMI but it would be good to prioritize proposals that reflect thought about the local industrial commons.

Conclusion

In conclusion, I will say simply that manufacturing very much matters, that policy interventions are needed, and that competitive grant programs can target key market failures and help to ensure sufficient production of key societal good. HR 1421 addresses several of the relevant problems and so represents a step toward addressing several fundamental challenges the nation faces as it seems to rebuild its regional manufacturing commons.

The views expressed in this testimony are those of the author alone and do not necessarily represent those of the staff, officers, or trustees of The Brookings Institution.

[1] U.S. Department of Commerce, Bureau of Economic Analysis, August, 2013.

[2] U.S. Department of Commerce, TradeStats Express Data Home, 2013.

[3] See, for example, Susan Helper, Timothy Kreuger, and Howard Wial, "Why Does Manufacturing Matter? Which Manufacturing Matters: A Policy Framework" (Washington: Brookings Institution, 2012)..

[4] Innovation refers to the production greater output with the same level or fewer inputs. Economies can grow for a short time by simply adding more (or better-skilled) workers and machinery to the production process, but eventually all inputs, save innovation, reaches diminishing returns. Robert Solow first showed that only innovation was responsible for long-run growth in his seminal work, "A Contribution to the Theory of Economic Growth" in 1954 and since there has been no shortage of economic literature that shows innovation drives long-run growth. For example, Princeton professors Robert Hall and Charles Jones find in a study of 127 nations that "relatively little of the difference between high- and low-performing countries owed to physical and human capital" but instead depended on how countries invested in new technologies to increase productivity explained their success. See Robert Solow, "A Contribution to the Theory of Economic Growth," *The Quarterly Journal of Economics*, 70 (1) 1956.

[5] See, among many others, Helper, Kreuger, and Wial, "Why Does Manufacturing Matter?" as well as Stephen Ezell and Robert Atkinson, "The Case for a National Manufacturing Strategy" (Washington: Information Technology & Innovation Foundation, 2011); Gary Pisano and Willy Shih, *Producing Prosperity: Why American Needs a Manufacturing Renaissance*. (Boston: Harvard Business Review Press, 2012); and Richard Locke and Rachel Wellhausen, "Report of the MIT Taskforce on Innovation and Production" (Cambridge: MIT Press, 2013).

[6] Helper, Kreuger, and Wial, "Why Does Manufacturing Matter?"

[7] Ibid.

[8] See Gene Sperling, "The Case for a Manufacturing Renaissance." Speech at Manufacturing U.S. Prosperity: A Policy Discussion. Washington, DC: Brookings Institution. July 25, 2013 as well as "Remarks at the Conference on the Renaissance of American Manufacturing." Speech at the Second Annual Conference on the Renaissance of American Manufacturing – Jobs, Trade and the Presidential Election. Washington, DC: The National Press Club. March 27, 2012.

[9] Studies have found in general terms that the rate of return to society from corporate R&D is at least twice the estimated rate of return to the company. In addition to spillovers from R&D performed to create new products, there are also significant spillovers from process R&D, which is the R&D conducted to help organizations produce output more efficiently. However, the inability of firms to capture all the benefits of their own investments in R&D and new capital equipment means that, left on their own, they will produce much less innovation than is optimal for society. See: Michael Gort and Steven Klepper, "Time Paths in the Diffusion of Product Innovations" *Economic Journal* 92 (376): 630-653; Charles Jones and John Williams, "Measuring the Social Return to R&D," *Quarterly Journal of Economics* 113 (4): 1119-1135; and Edwin Mansfield, "Social Returns from R&D: Findings, Methods, and Limitations," *Research Technology Management* 34, no. 6 (1991): 24-27. Turning to the manufacturing sector Robert Atkinson and his colleagues at the Information Technology and Innovation Foundation laid on many of the market problems that embroil the manufacturing sector. See, for example, Robert D. Atkinson, "Effective Corporate Tax Reform in the Global Innovation Economy" (Washington: Information Technology and Innovation Foundation, 2009; Stephen Ezell and Robert Atkinson, "The Case for a National Manufacturing Strategy" (Washington: Information Technology & Innovation Foundation, 2011); and Scott Andes, Stephen Ezell, and Jesus Leal, "Benchmarking Manufacturing Extension Services in Latin America and Caribbean Countries (Washington: Information Technology & Innovation Foundation, forthcoming).

[10] See Lee Branstetter, "Are Knowledge Spillovers International or Intranational in Scope? Microeconometric Evidence from the Japan and the United States," NBER Working Paper 5800 (1996) and Wolfgang Keller, "Geographic Localization Of International Technology Diffusion," *American Economic Review* 92 (1,Mar):120-142

[11] For background on the use of competitive grants to call forth applied research "consortia" in the energy industry see Jim Duderstadt and others, "Energy Discovery-Innovation Institutes: A Step towards America's Energy Sustainability" (Washington: Brookings Institution, 2009). For background on the National Network for Manufacturing Innovation see Advanced Manufacturing National Program Office, "National Network for Manufacturing Innovation: A Preliminary Design" (Washington: National Science and Technology Council: 2013).

[12] OECD, "R&D Tax Credits: Rationale, Design, Development." (Paris: 2010)

[13] For background on innovation vouchers see Stephen Ezell, "Lessons from Foreign Countries on how U.S. States Can Spiur Manufacturing." Innovation Files blog.

[14] Advanced Manufacturing Partnership, "Capturing Domestic Competitive Advantage in Advanced Manufacturing" (Washington: President's Council of Advisors on Science and Technology, 2012).

[15] Jonathan Rothwell, "The Hidden STEM Economy," (Washington: Brookings Institution, 2013).

[16] Pisano and Shih, *Producing Prosperity.*

Mark Muro

Mark Muro, a senior fellow and the director of policy at the Metropolitan Policy Program at Brookings, manages the program's public policy analysis and leads its Advanced Industries Initiative. Mark is an expert on regional innovation systems and has published extensively on manufacturing, energy issues, and regional industry clusters.

Muro most recently led the development of a state advanced industries strategy for Colorado and is currently leading the development of a strategy for Tennessee's advanced auto industry. He was also the lead author of "Unify, Regionalize, Diversify: An Economic Development Agenda for Nevada."

Two of Muro's most well-known publications on energy and energy finance topics are: "Sizing the Clean Economy: A National and Regional Green Jobs Assessment" and "Beyond Boom and Bust: Putting Cleantech on a Path to Subsidy Independence."

Mark's state-side work on renewable energy and energy efficiency topics include "Leveraging State Clean Energy Funds for Economic Development" (with Lew Milford and Devashree Saha) and "State Clean Energy Finance Banks: New Investment Facilities for Clean Energy Deployment" (with Ken Berlin, Reed Hundt, and Devashree Saha).

Chairman BUCSHON. Thank you very much for your testimony and all of your testimony. This is a fascinating subject to me, and I think American competitiveness is really—needs to be on the forefront of everything we talk about in Washington, I think, driving the private-sector economy, especially at a time right now when many of our fellow citizens are unemployed or are not employable in the high-tech industry because of lack of skills training and other things that they need to improve on, and we can be helpful if we put the right policies in place.

So thank you for your testimony. I will remind the Members that Committee rules limit questioning to five minutes. The chair at this point, I will recognize myself for five minutes to begin questioning.

This will be a little off script here, but if there is one thing that—one or two things that we could do that would make us more competitive, short answer, what can we do in Washington to make us more competitive? Dr. Taub?

Dr. TAUB. Well, I will stick to the technology aspect of it rather than go into taxes and other incentives. I think in the area of manufacturing, the proposals on the table, whether it is fully funding the NNMI program or the AMTech parallel program, there have been a number of workshops that were done, and here is the key, with industry to help define how those programs could be done. The President's Executive Order has allowed the launch of three of those. But the target was to create 15, and I think the industries have defined what is needed, so I would suggest you fund the NNMI and AMTech work.

Chairman BUCSHON. Dr. Baer?

Dr. BAER. Following along that line, I think establishing programs like the NNMI, like the bill 1421, to promote collaboration between the research universities and the private sector is excellent. It has the advantage of very cost-effective way to supplement the R&D and advanced manufacturing but it also provides incentives for training our students and workforce to solve problems that are relevant to U.S. industry.

Mr. MURO. I would agree with each of these, and I will provide a slightly different reason. The manufacturing institutes, the investing in manufacturing communities, legislation and H.R. 1421 all can help catalyze the kind of technological exchange, the multisectoral engagements of consortia at the regional level, and we think that that is extremely important. The economy is not everywhere; it is in particular places, these intense clusters of technological exchange. So I think we have many of the pieces of architecture on the table but the more it can be tuned to what is happening in Dallas, what is happening in Wichita, you know, and using that to get that bottom-up sense of innovation in the economy is important, and I think that is implied in a lot of the things that are on the table.

Chairman BUCSHON. Dr. Baer, I am going to ask, the 2012 VCAT report recommends that NIST provide more clarity and depth in strategic planning. What recommendations would you have to establish this goal at NIST, and what would be an effective way to provide planning across both the laboratory and research programs and the extramural programs?

Dr. BAER. I served on the VCAT and overlapped with Dr. Taub, and I think one of the most important roles of the VCAT was to provide an ongoing emphasis on strategic planning and to help to guide that process. I think the contributions from the VCAT committee members to provide strategies for putting in place a strategic plan, which were very honestly not part of the culture at NIST, were quite important. So I think one of the ways that NIST could do this effectively is to involve the VCAT members and provide input to the senior management there and the strategic planning process. Maybe Alan has some comments about that.

Chairman BUCSHON. Yes, Dr. Taub?

Dr. TAUB. Well, I served on the VCAT since 2008, and I now am the chair. I would say probably the best thing NIST did was appoint Pat Gallagher as the Under Secretary. He embraced strategic planning, which, as Dr. Baer points out, was really getting in the way of what was bottom-up work, and he was allowed to restructure the organization. He clearly delineated the extramural and the laboratory programs, and now at the beginning of every VCAT meeting, in fact, they review their updated strategic plans. I am pretty sure in the 2013 report, you won't see that comment after seven years of it showing up.

Chairman BUCSHON. Thank you. I will ask Mr. Muro this: given the broad range of policy proposals being considered, how can we determine what is giving us our best return on investment?

Mr. MURO. I think any and all of these programs ought to be, you know, provided with standard and state-of-the-art performance management. Data collection is essential. It pervades the kind of advanced economies you are concerned with. So I think, you know, it is not a difficult matter to work out some basic performance management that actually should be taken seriously. I mean, I think we all agree that straight grants without a performance content and the ability to sunset some grants and scale up those that are high performers is critical, and that will require careful data collection and advanced, you know, set, standard frameworks.

Chairman BUCSHON. Thank you.

I now recognize Mr. Lipinski.

Mr. LIPINSKI. Thank you. I want to start with a question on international competitiveness. In his testimony, Dr. Baer mentions that other nations appear to be encouraging more interaction between their respective universities, industries, government laboratories in an effort to promote manufacturing. So I want to ask all of you about any insight you have in successful programs or models being pursued in other countries that we might want to consider implementing here in the United States. Let us start with Dr. Taub.

Dr. TAUB. Well, you know, a very good example has been the Fraunhofer Institutes that started in Germany and I think many of the principles of the Fraunhofers were built into the NNMI and AMTech constructs. It is also a question of, in my experience in other countries, there is a more sustained strategic objective for their government funding. They tend to go with a longer time frame horizon which allows the universities to really build the core competency, to build the relationship with their industrial partners so that you can go in and more effectively work over a longer time

frame. You know, funding a strategic program in a deep technology for two years just doesn't cut it anymore. They tend to go with 5- and ten-year plans quite effectively.

Mr. LIPINSKI. Thank you. Dr. Baer?

Dr. BAER. I recently was president of an international scientific society, the Optical Society of America, and I traveled all over the world, met with leading scientific groups and also ministers of science in a number of countries—Japan, China, Taiwan, Germany and Brazil—and all of these countries had programs, I think, which conveyed the message to our universities of the importance of a focus on applied research and manufacturing, and that is almost as important as anything you structure into a bill is just raising awareness of the contribution that the university sector can make to industrial competitiveness in the United States. We have long emphasized here the importance of basic research and scientific research in general. We have not done as well as we could just valuing the contributions that can be made to advanced manufacturing. Putting in place these programs, incentivizing them through competitive grants and matching grants I think will just change the attitude and culture. My institution, Stanford University, is one of the best in the United States at recognizing the value of applied research and a strong interface to local industry around Silicon Valley as well as worldwide, and I think this will be a remarkable change that will take place if these bills are funded and the funds made accessible to the universities.

Mr. LIPINSKI. I just have to add, Dr. Baer, I am very proud to be an alum of Stanford.

Mr. Muro?

Mr. MURO. And I would, very much in the spirit of these comments, note that I think our country lacks the sense of a national strategy in the area. There isn't a clear direction or even to an extent a significant stressing of the importance of this. There is a lack of industry roadmapping, which I think your bill is beginning to try to take on. So these things would give a context for individual, more pointillistic effort such as, you know, the NNMI. And meanwhile, our country hasn't until very recently thought so much about the subnational, you know, nature of the innovation economy, and it hasn't thought so much about the applied aspect. So I think a stronger focus on, you know, regional policy as a part of innovation, and we think again that federal challenge grants to regions are a great way to prompt the kind of collaboration that will generate information exchange and innovation.

Mr. LIPINSKI. I have very little time left. Let us see if we do it very quickly. Any suggestions specifically on improving technology transfer, which I think is one of the most important things that I have focused on since I have been here. We have great research at our universities, our national labs. How do we improve technology transfer to manufacturing? Who wants to jump in? Dr. Baer?

Dr. BAER. I think I will use my institution, Stanford, as an example. The goal of technology transfer is not to earn money for the university through licensing but rather to promote the commercialization of technology that's been co-developed or developed at Stanford University, that attitude where you use the licensing process as a route to commercialization, that being the goal, and

I will tell you that our university reaps the benefits more than tenfold by just generous contributions to the university supporting research and development, and also contributions to the endowment from grateful alums and grateful companies more than ten times the return they get from their licensing processes. So that attitude change, I think, is something that will promote the technology transfer and facilitate it between the universities and the commercial sector.

Dr. TAUB. I would just build on that for 30 seconds. I spent my, you know, 30 years in industry working quite closely with universities in this country and around the world. Getting the statement of work between the university professor and the industrial researcher is normally a 2-day exercise. Working through the intellectual property arrangement can take months. And it is this whole question of the federal investment leading to the invention, leading to the intellectual property, how is the university going to benefit from that. It slows down and in many cases stops progress.

Mr. MURO. If I could add one note, I think one of the weaknesses of our tech transfer activities is, they don't work particularly well for SMEs. The whole structure, the whole licensing process—and this applies in spades to the national laboratories—is oriented towards much larger companies, and I think, you know, the voucher is an interesting way to try to start a more kind of anarchic and maybe productive set of relationships with smaller firms, but I think that is an area that is important to look at, and I think it is excellent that the bill is going to have an experiment with vouchers.

Mr. LIPINSKI. Thank you.

Chairman BUCSHON. Thank you. I now recognize Mr. Collins for his questioning.

Mr. COLLINS. Thank you, Chairman.

I have spent my life in manufacturing and some of it advanced manufacturing. I have got a LEED-certified manufacturing plant, ISO 9000 or 13458, and certainly have Lean Six Sigma alive and well in all my companies, and what I point out is, all of that came through public-private partnerships with universities—State University of New York at Buffalo, the Center for Industrial Effectiveness, RIT, Rochester Institute of Technology, their Center of Excellence and Sustainable Manufacturing—and as a small company, without their knowledge and their assistance, I think it is safe to say as a small company, we would not have had the resources. So, you know, in some cases we are talking about motherhood and apple pie here, the six-to-one job-creating add-on; for every manufacturing job, there are six others, anything we can do to assist small businesses who are always cash-restrained. So just quickly if you could comment on your experience with the small companies and, in this case, use of government funding in supporting these institutions of higher education and then helping these smaller companies implement these critical strategies for their success. Dr. Taub or Dr. Baer?

Dr. TAUB. Well, having spent my career in three Fortune 10 companies, I am now on the board of small companies, beginning to learn that world, I actually don't believe the agenda for the small companies and the large companies is that different. The small

companies enter the supply chain. They become an integral part of an industrial sector. I think part of the issue of small companies accessing the universities and national labs is it is cumbersome. I mean, you know, the companies I was in, we had an office. I had a director that would spend their time opening the doors and seeking out these things. So there has been talk about making the capabilities of the universities and the national labs more available. You know, just who do you go to? With all today's modern IT technology, how do you go there? And then I am very intrigued by this voucher program. You know, at $30,000 to $40,000 per grant, you can get a good start, but let us not do it so it becomes $40,000 of overhead and a full-time person at every small company to get in there. By the way, I have also supported work at RIT.

Mr. COLLINS. Thank you.

Dr. BAER. In contrast to Alan, I have spent most of my time with small startup companies within Silicon Valley and have had very constructive interaction with some universities. I think the University of Rochester, RIT and the State of New York actually does an excellent job of supporting SMEs and growing them, and I think a lot of it is again just attitude, lowering the barriers, encouraging the interaction between the university sector and the private sector, and streamlining the intellectual property process. I think it is very possible for SMEs to interact with universities constructively. I have also had some very disappointing interactions where the expectations were just out of line, and I go back to the idea that the universities, particularly the smaller universities, often look to the licensing process to generate revenue and it is just not a very realistic way to approach that. Incentivizing them through government contracts and government programs like the voucher program to participate with industry without looking to the licensing process could be a key element.

Mr. MURO. And I would add that use of the challenge grant is a way to require really the participation of the full panoply of types of firms. I would suggest that where you have a stipulation for a particular consortium that it includes some provision for SME participation, which many firms want, given that they are part of their supply chain in the first place. So I think you are on the right track with the challenge consortia model but it ought to be, you know, explicit that the SME ought to be part of it.

Mr. COLLINS. Thank you. I think from our experience, without some level of this kind of support, the small companies, as much as they would like to do something, they don't have the resources, and in most cases, certainly up in our part of the world, it is generally a 50/50 spilt between the small business and the university, and you know, it is just what we need to jump-start some of these initiatives.

My time is expired, so I yield back. Thank you very much.

Chairman BUCSHON. Thank you. I now recognize Ms. Johnson.

Ms. JOHNSON. Thank you very much, Mr. Chairman. I think I will pass because I enjoy what I am hearing, and I don't want to mess it up.

Chairman BUCSHON. All right. Mr. Bera, is he here? No. Ms. Esty, you are next.

Ms. ESTY. Thank you very much, and I too am enjoying this. I hail from Connecticut, where this is core to what we do, both with large and small manufacturers, but particularly small manufacturers. So there are a couple of points I want to follow up on, and probably start with you, Mr. Muro, both on vouchers, which we have been talking about, Connecticut is one of those states that with the Connecticut Next program we are test-driving vouchers. So I know you know a little something about that, and if you could share with us what other states are doing around vouchers, what has been the experience so far, what could we learn and incorporate into our legislation to make it more effective. That is question number one.

Question number two, which a number of you have touched on, the importance of regionalization. It is something we are looking to do in Connecticut and in New England in our sectors, both on biotech, biomed and manufacturing. I am increasingly of the view that that interaction between universities, small companies and large companies and our technical high schools, which we haven't even mentioned, and our community colleges, to create an ecosystem for this innovation. So if you could talk about that importance of having them really in fairly tight proximity and what we could look for and what role the Federal Government might play in facilitating those regional hubs without picking winners and losers, which I know we all are very concerned about and yet if you don't have a critical mass, you are not going to get those synergies which frankly the cotton gin came from Connecticut. It was those synergies and water power that helped develop our first industrial revolution. Thank you.

Mr. MURO. First I will note that the major experiments with vouchers have been European to date. You and Iowa are the new experiments in this country, so there is not a lot of U.S. experience to fall back on. We think it is a deeply American solution. We should have piloted and invented this rather than our European competitors because it respects the market aspect, the organic aspect and the fast-moving aspect of, you know, this kind of technology exchange that needs to occur. I would stress simplicity, quickness. You want to—they are a fast—they should be a fast, direct way of getting support to SMEs and, you know, the Administration has to be kept lean and simple, and we know that to some extent Federal Administration doesn't inherently lean that way. So I think that is—but I think it is an important experiment.

I would just say the ecosystem side, this discussion has really blossomed in the last five years, and I think the literature is increasingly confirming that there are innovation and entrepreneurship benefits to density, and I would not—I would stress a couple aspects. I don't think we should think in terms of inventing clusters or creating them. They are an organic fact of how the economy works. So we should acknowledge that they exist and then have policy flow behind that. So I think again, you know, bottom-up, you know, challenges to regions to propose great cluster initiatives and provide the performance management is the way to do this, and I think, you know, we have seen across EDA, across the Department of Commerce and NSF as well, we have seen more and more interest in these challenges to bottom-up regions. So I think we

shouldn't really think of moving firms around. We shouldn't think of creating density but we should think of respecting it and suggesting it as a value. So thanks a lot.

Dr. BAER. I believe clusters and the regional emphasis is absolutely critical. I come from arguably the largest innovation cluster in the world in Silicon Valley and I can encourage my students to join a startup and take a risk because if it does not succeed, there are many other opportunities. The forces of creative capitalists, creative destruction are no more evident than in Silicon Valley. Clusters don't occur spontaneously. I think they do need a seed in which they can grow and I think the government can provide that seed funding, but what is critical is that there be opportunities so that students and employees can take that risk and join small companies that just have a different risk profile than some of the larger companies, so clusters and regional emphasis I think are critical.

Dr. TAUB. Yes, quickly. It has always been intriguing to me that we are in an age of virtual collocation. You know, every company I had, we had ten, 20 engineering and R&D sites around the world, all communicating in webcasts, but if you peel that onion—and I think we all believed, okay, we will have the best people, individuals sitting around the world somehow merging into this coherent entity, and I think that dream did not materialize because we still need some physical presence. And so I think the key to it—and this was part of what came out in the NNMI workshops, have a regional flavor in terms of what you want the proposal to be, but do not pick the technology. Do not pick the industry. Distribute them, let them have national impact, regional flavor but let the particular technology and industry self-assemble. I think the clusters are ready to form.

Chairman BUCSHON. Mr. Hultgren, five minutes.

Mr. HULTGREN. Thank you, Mr. Chairman, and thank you all for being here too. I appreciate your time and your testimony.

For me, there is no question that advanced manufacturing is the way our manufacturing base will continue moving, and our skills in this area are absolutely needed to maintain American competitiveness here and also abroad. The easiest way to ensure that American jobs stay here is by having advanced facilities that cannot yet be replicated elsewhere.

That being said, it is our job as policymakers to plan for this in a fiscally responsible way while also taking into consideration the countless factors that are forcing businesses to move elsewhere or never even begin as a startup here in the United States.

First question, Dr. Taub and also Dr. Baer, in your testimony you discuss the value both at NIST labs and the NIST extramural programs provided to American manufacturers. Given our current budget climate, it is difficult to envision significant increases to certain programs without corresponding cuts elsewhere. I wondered if you could address how you would assess the current allocation of funding for NIST programs between intramural research and extramural programs, and as we look to reauthorize the Institute, should we be looking to rebalance this allocation?

Dr. TAUB. Well, I think in the past several years, the growth at NIST has been more around the extramural activities, building off their strong laboratories, but at the same time, you can—the rea-

son and the value of the extramural activities being under the same umbrella as the laboratories is relatively unique among the agencies. Normally, you know, the Washington office and the labs, if you look at the agencies, don't collocate. So saying that the tradeoff should be between those two, I am not sure is the right way to think about it. I believe you need to go up to the larger R&D investment that the Federal Government makes and give a true look at how much of that pie is going to advanced manufacturing, whether it is at NSF, whether it is at DOE, whether it is at Commerce. The question is, which federal investment in technology is going to lead to jobs and is going to lead to economic well-being rather than the tradeoff within NIST.

Mr. HULTGREN. Dr. Baer?

Dr. BAER. You know, I challenge this distinction between intramural and extramural funding and saying that it is a balancing act. As an example, I have been involved with a program at Stanford called—with NIST called the Advances in Biomedical Measurement Science, which has a distinct advanced manufacturing component associated with it. We now have six NIST people located on Stanford campus, part of the intramural funding that they get, interfacing with local bio technology companies in Silicon Valley and the proximity, as Alan mentioned, is absolutely critical, and this program sort of combines the best of intramural and extramural funding, and it was conceived of by Willie May, the Associate Director of laboratories at NIST, and I think is a tremendous example of how NIST needs to diffuse its borders with U.S. industry and so this idea that somehow we have to judge and decide between intramural and extramural is something I think we should question because I think allowing NIST management the freedom to utilize the resources along this way, given the excellent quality, as Alan has mentioned, of the leadership there right now, will result in optimal use of their total resources.

Mr. HULTGREN. I think that is helpful. My passion still is making sure we are doing what no one else can do, and so that is that question of figuring that out, you know, what can industry do, what do we have to do, and figuring that out.

Let me switch gears a little bit. Mr. Muro, in your testimony you discuss how community colleges remain seriously divorced from the industry needs and that advanced manufacturing education grants could help close this gap. Personally, I am very interested in this. I have got seven great community colleges in my district, but really interested and concerned and passionate about changing this disconnect between community colleges and industry. I wonder what other recommendations you might have to bridge the needs of these two stakeholders.

Mr. MURO. I do think that this is one of the crucial challenges we face if we are going to have a sustainable manufacturing renaissance. We are not in a position presently to fully staff it. I think the fundamental problem is that we have had a disconnect between a whole series of economic development initiatives and then another series of education and training activities that have really, you know, grown quite—that developed their own cultures. They are really quite separate from each other. So I think it is going to take some stressing of the system through, I think, these kinds of

challenge grants that are going to, you know, compel or call out the kind of interactions that need to happen because I think in general, we find that industry has not—is not informing these reforms significantly, meanwhile community colleges are erratic in their ability to reach out. Some of them are developing extremely powerful programs. Many are trapped in inertia. So I think that these kind of challenges and competitive offerings are one way to begin to force the kind of collaboration that is needed.

Mr. HULTGREN. Well, again, I appreciate you all being here. My time is expired. But this is an interesting conversation and one I hope we can continue. I have some questions I wasn't able to get to so I would ask if you are okay with that if we can follow up with some questions and further dialog.

Thank you, Mr. Chairman. I yield back.

Chairman BUCSHON. Yeah, and you can submit those and they will get written answers.

I recognize Ms. Kelly.

Ms. KELLY. Thank you so much for being here. As many of my colleagues know and many of my districts too that our companies are saying they can't find enough skilled workers, and for me, I represent the south side of Chicago all the way to Kankakee County, and from the Ford plant to BSF, they have said the same thing. We started a STEM council, and in the STEM council, we have the community colleges, we have some of the businesses, some entrepreneurs and tech folks, but one of the things is when some of the companies, to their credit, tried to start internship programs, they couldn't get one person from the high schools to even come to be interns, and so I think that also we need to do a better job, different job in explaining what manufacturing and advanced manufacturer really is, and it seems to me we even need to start at a younger age in, you know, 7th grade and 8th grade to get students more involved because if they are not involved, it doesn't matter what we offer. You know, they are not going to take the subject up anyway. And I was just wondering what you thought about that, how early we need to start, and I am really trying to push for some of my businesses to actually adopt schools or adopt programs. Navistar did it in one of my schools, and it has work out fantastically.

Mr. MURO. I will make one observation quickly, which is that you are right that there has been—I mean, I think the Federal Government has had strong interest in STEM but it has been a STEM definition that presumes postgraduate studies, so it defaults to the training of engineers and Ph.D., which are critical but we have neglected—and we did a recent accounting of federal programs on this. There has been a neglect of sub-baccalaureate STEM, so-called middle skilled-STEM workforce, which is what, you know, GM needs in Tennessee, you know, so there is this huge breakdown for the advanced manufacturing agenda that our cultural focus and the programmatic focus has been towards postgraduate and Ph.D. So I think there needs to be some kind of balancing at the federal level.

Dr. BAER. My wife is a children's librarian, and she has science programs that she has organized for 3- and 4-year-olds, and they do paper chromatograph, she has a section on optics and lasers,

and the excitement of those children is phenomenal even at that age level. You just can't start too early. A large part of it is the attitude and value system established by the President and by you. I remember the excitement as I was growing up about the space program, and that came from here, from Washington, from the President, and if we can establish that as a culture, I think the educational system and the students will just flow into it. It will take some programs. It will take some intelligent legislation, but I think a lot of it is just changing the culture and attitude, and that leadership, I think, is now coming from you with these bills and coming from the President, and I think it is wonderful.

Dr. TAUB. Yeah, I mean, there is no question if you don't hit them in K–12 or I would actually argue in K–8, we have lost them, and we watch other countries where that isn't occurring. At the same time, there are programs that just need to be expanded. I don't know if you have ever been to a robotics or a math competition. It is like going to the football game in terms of the excitement there, but look at the number of children that are in those events versus the sports events versus some of the others. So to the extent—culture change, you know, in this country doesn't happen by aid from above. It happens by catalyzing grassroots events and so again, find a way to have the Federal Government expand those things because we are having trouble. Well, now I am at the university so I guess I am part of the supply chain problem, but the reality is, we have to go overseas to import our engineers. We have to turn that around.

Ms. KELLY. Thank you very much.

Chairman BUCSHON. Well, I thank all the witnesses and the Members for their questions, and I think, Dr. Baer—I am on the Education and Workforce Committee also, and so we could talk about this issue. In fact, Ranking Member Lipinski and I were just talking of exactly what, Ms. Kelly, you were talking about literally seconds before you made your comment, and it is critical that we start at a young age and get people interested in these fields. I have four kids, and I am working on it.

But thanks for the really valuable testimony, and the record will remain open for two weeks for additional comments and written questions from the Members.

At this point the witnesses are excused and the hearing is adjourned. Thank you.

[Whereupon, at 11:21 a.m., the Subcommittee was adjourned.]

Appendix I

Additional Material for the Record

SUBMITTED STATEMENT FOR THE RECORD BY
FULL COMMITTEE CHAIRMAN LAMAR S. SMITH

Thank you, Chairman Bucshon, for yielding me time.

Today's hearing will examine how federal advanced manufacturing research and development programs improve American competitiveness. It is critical that we understand how we can best prioritize among these programs.

I am also pleased that we have an opportunity to review Ranking Member Johnson's bill, H.R. 1421, the "Advancing Innovative Manufacturing Act of 2013."

We must foster innovation so that powerful new technologies are developed here and not overseas. And we must ensure that the United States provides the best environment in which to do business.

While I agree with the Ranking Member that advanced manufacturing is critical to future American competitiveness, I have some reservations about her bill.

In particular, I'm concerned about the authorization of new federal manufacturing programs without identifying cuts elsewhere in the budget to pay for them. We cannot continue to spend more taxpayer dollars for advanced manufacturing without finding offsets from other lower priority programs.

As we look to reauthorize the National Institute of Standards and Technology, I'm hopeful that today's hearing can shed some light on how best to prioritize advanced manufacturing programs at the Institute.

I'm also hopeful that we can identify some common ground for working together across the aisle to improve federal programs to support advanced manufacturing. Again, I thank the Chairman for holding this hearing, and I yield back the balance of my time.

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113TH CONGRESS
1ST SESSION

H. R. 1421

To accelerate research, development, and innovation in advanced manufacturing, to improve the competitiveness of American manufacturers, and for other purposes.

IN THE HOUSE OF REPRESENTATIVES

APRIL 9, 2013

Ms. EDDIE BERNICE JOHNSON of Texas (for herself, Ms. WILSON of Florida, Ms. BONAMICI, Mr. MCNERNEY, Ms. EDWARDS, Mr. LIPINSKI, Ms. LOFGREN, Mr. BEN RAY LUJÁN of New Mexico, and Mr. RYAN of Ohio) introduced the following bill; which was referred to the Committee on Science, Space, and Technology

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A BILL

To accelerate research, development, and innovation in advanced manufacturing, to improve the competitiveness of American manufacturers, and for other purposes.

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled,

SECTION 1. SHORT TITLE.

This Act may be cited as the ''Advancing Innovative Manufacturing Act of 2013''.

SEC. 2. ADVANCED MANUFACTURING TECHNOLOGY CONSORTIA.

Section 33 of the National Institute of Standards and Technology Act (15 U.S.C. 278r) is amended to read as follows:

"SEC. 33. ADVANCED MANUFACTURING TECHNOLOGY CONSORTIA.

"(a) AUTHORITY.—

"(1) IN GENERAL.—The Director shall carry out a program to facilitate the development of and provide support to industry-led consortia that will identify, prioritize, and address long-term, precompetitive industrial research needs in the area of advanced manufacturing.

"(2) PROGRAM OBJECTIVES.—The objectives of the program established under this section include the following:

"(A) To promote collective public-private efforts to develop key technology platforms and infrastructure for advanced manufacturing.

"(B) To enable the prioritization of public research portfolios to be more responsive to the long-term technology development needs of industry.

"(C) To leverage Federal investment in advanced manufacturing with shared investment by the private sector.

"(D) To increase industrial research and development investment in precompetitive technology platforms and infrastructure.

"(E) To accelerate technological innovation in advanced manufacturing.

"(F) To foster broad participation by industry, the Federal Government, institutions of higher education, and State, local, and tribal governments in advanced manufacturing research and development.

"(b) ACTIVITIES.—As part of the program established under this section, the Director shall—

"(1) support the formation of industry-led consortia composed of representatives from industry (including small and medium-sized manufacturers), institutions of higher education, the Federal Government, State, local, and tribal governments, and other entities, as appropriate;

"(2) collaborate with consortia participants in the development of technology roadmaps that identify research needs in the area of advanced manufacturing;

''(3) support precompetitive research directed at meeting the research needs identified in the roadmaps developed under paragraph (2);

''(4) promote the transfer of precompetitive technology platforms and infrastructure resulting from consortia research to the private sector and facilitate open access to the intellectual property underpinning those platforms and technology; and

''(5) facilitate the development of new technologies into commercial products.

''(c) SELECTION CRITERIA.—In selecting applications for awards under this section, the Director shall consider, at a minimum—

''(1) the degree to which the activities proposed under the consortia will broadly impact manufacturing and increase the productivity and economic competitiveness of the United States;

''(2) the level of technical risk to be addressed by the consortia;

''(3) the potential to produce fundamental new knowledge; and

''(4) the likelihood that the consortia will become self sustaining, if appropriate.

''(d) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated for carrying out this sec-

tion $120,000,000 for each of fiscal years 2014 through 2018.''.

SEC. 3. SMALL MANUFACTURER INNOVATION PROGRAM.

The National Institute of Standards and Technology Act (15 U.S.C. 271 et seq.) is amended—

(1) by redesignating section 34 as section 35; and

(2) by inserting after section 33 the following:

''SEC. 34. SMALL MANUFACTURER INNOVATION PROGRAM.

''(a) IN GENERAL.—The Director shall carry out a pilot program to enhance the innovative capabilities and competitiveness of small and medium-sized manufacturers through support for research and development that will promote the field of advanced manufacturing and lead to the commercialization of new products, processes, or technologies for use in advanced manufacturing.

''(b) OBJECTIVES.—The objectives of the program under this section are—

''(1) to accelerate the development of processes and, as appropriate, incremental innovations that will improve how goods are designed, produced, or distributed;

''(2) to advance the development and commercialization of novel products and technologies for use in advanced manufacturing;

''(3) to reduce the technical and economic risks associated with developing new products, processes, or technologies for use in advanced manufacturing;

''(4) to foster cooperative research and development between small and medium-sized manufacturers and research institutions; and

''(5) to promote research and development collaboration among small and medium-sized manufacturers facing similar technical challenges or obstacles, including collaboration along a supply chain.

''(c) PROGRAM.—

''(1) AWARD PHASES.—The Director shall award competitive, merit-reviewed grants, cooperative agreements, or contracts to small or medium-sized manufacturers in the United States through a uniform process having—

''(A) a first phase for determining, insofar as possible, the scientific and technical merit and feasibility of a proposal; and

''(B) a second phase to further develop proposals, including the development of prototypes, for which scientific and technical merit and feasibility was demonstrated in the first phase.

"(2) APPLICATIONS.—A small or medium-sized manufacturer seeking an award under this section shall submit an application to the Director at such time, in such manner, and containing such information as the Director may require.

"(d) STAKEHOLDER INPUT.—In carrying out the program under this section, the Director shall solicit stakeholder input on how best to carry out the program.

"(e) COORDINATION AND NONDUPLICATION.—To the maximum extent practicable, the Director shall ensure that the activities carried out under this section are coordinated with, and do not duplicate the efforts of, other programs within the Federal Government.

"(f) REPORT.—Not later than 4 years after the date of enactment of the Advancing Innovative Manufacturing Act of 2013, the Director shall transmit a report to Congress assessing the program established under this section. The report shall include—

"(1) a summary of the activities carried out under the program;

"(2) an assessment of whether the program is achieving its goals, including a description of the metrics used to determine progress in meeting such goals;

''(3) any recommendations on how the program may be improved; and

''(4) a recommendation as to whether such program should be continued or terminated.

''(g) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Director to carry out this section—

''(1) $15,000,000 for fiscal year 2014;

''(2) $25,500,000 for fiscal year 2015;

''(3) $39,750,000 for fiscal year 2016;

''(4) $42,250,000 for fiscal year 2017; and

''(5) $50,000,000 for fiscal year 2018.''.

SEC. 4. INNOVATION VOUCHER PILOT PROGRAM.

Section 25 of the Stevenson-Wydler Technology Innovation Act of 1980 (15 U.S.C. 3720) is amended by adding at the end the following:

''(d) INNOVATION VOUCHER PILOT PROGRAM.—

''(1) IN GENERAL.—The Secretary, acting through the Office of Innovation and Entrepreneurship and in conjunction with the States, shall establish an innovation voucher pilot program to accelerate innovative activities and enhance the competitiveness of small and medium-sized manufacturers in the United States. The pilot program shall—

''(A) foster collaborations between small and medium-sized manufacturers and research institutions; and

''(B) enable small and medium-sized manufacturers to access technical expertise and capabilities that will lead to the development of innovative products or manufacturing processes, including through—

''(i) research and development, including proof of concept, technical development, and compliance testing activities;

''(ii) early-stage product development, including engineering design services; and

''(iii) technology transfer and related activities.

''(2) AWARD SIZE.—The Secretary shall competitively award vouchers worth up to $20,000 to small and medium-sized manufacturers for use at eligible research institutions to acquire the services described in paragraph (1)(B).

''(3) STREAMLINED PROCEDURES.—The Secretary shall streamline and simplify the application, administrative, and reporting procedures for vouchers administered under the program.

"(4) REGULATIONS.—Prior to awarding any vouchers under the program, the Secretary shall promulgate regulations—

"(A) establishing criteria for the selection of recipients of awards under this subsection;

"(B) establishing procedures regarding financial reporting and auditing—

"(i) to ensure that awards are used for the purposes of the program; and

"(ii) that are in accordance with sound accounting practices; and

"(C) describing any other policies, procedures, or information necessary to implement this subsection, including those intended to streamline and simplify the program in accordance with paragraph (3).

"(5) TRANSFER AUTHORITY.—The Secretary may transfer funds appropriated to the Department of Commerce to other Federal agencies for the performance of services authorized under this subsection.

"(6) ADMINISTRATIVE COSTS.—All of the amounts appropriated to carry out this subsection for a fiscal year shall be used for vouchers awarded under this subsection, except that an eligible re-

search institution performing the services described in paragraph (1)(B) may retain a percentage of any amount received from the Secretary under this subsection to defray administrative costs associated with the services. The Secretary shall establish a single, fixed percentage for such purposes that will apply to all eligible research institutions.

''(7) OUTREACH.—The Secretary may use centers established under section 25 of the National Institute of Standards and Technology Act (15 U.S.C. 278k) to provide information about the program established under this subsection and to conduct outreach to potential applicants, as appropriate.

''(8) REPORTS TO CONGRESS.—

''(A) PLAN.—Not later than 180 days after the date of enactment of this subsection, the Secretary shall transmit to Congress a plan that will serve as a guide for the activities of the program. The plan shall include a description of the specific objectives of the program and the metrics that will be used in assessing progress toward those objectives.

''(B) OUTCOMES.—Not later than 3 years after the date of enactment of this subsection,

the Secretary shall transmit to Congress a report containing—

"(i) a summary of the activities carried out under this subsection;

"(ii) an assessment of the impact of such activities on the innovative capacity of small and medium-sized manufacturers receiving assistance under the pilot program; and

"(iii) any recommendations for administrative and legislative action that could optimize the effectiveness of the pilot program.

"(9) COORDINATION AND NONDUPLICATION.—To the maximum extent practicable, the Secretary shall ensure that the activities carried out under this subsection are coordinated with, and do not duplicate the efforts of, other programs within the Federal Government.

"(10) ELIGIBLE RESEARCH INSTITUTIONS DEFINED.—For the purposes of this subsection, the term 'eligible research institution' means—

"(A) an institution of higher education, as such term is defined in section 101(a) of the

Higher Education Act of 1965 (20 U.S.C. 1001(a));

"(B) a Federal laboratory;

"(C) a federally funded research and development center; or

"(D) a Hollings Manufacturing Extension Center established under section 25 of the National Institute of Standards and Technology Act (15 U.S.C. 278k).

"(11) AUTHORIZATION OF APPROPRIATIONS.—There are authorized to be appropriated to the Secretary to carry out the pilot program in this subsection $5,000,000 for each of fiscal years 2014 through 2018.".

SEC. 5. ADVANCED MANUFACTURING EDUCATION.

Section 506(b) of the America COMPETES Reauthorization Act of 2010 (42 U.S.C. 1862p–1(b)) is amended to read as follows:

"(b) ADVANCED MANUFACTURING EDUCATION.—The Director shall award grants, on a competitive, merit-reviewed basis, to community colleges for the development and implementation of innovative advanced manufacturing education reforms to ensure an adequate and well-trained advanced manufacturing workforce. Activities supported by grants under this subsection may include—

"(1) the development or expansion of educational materials, courses, curricula, strategies, and methods that will lead to improved advanced manufacturing degree or certification programs, including the integration of industry standards and workplace competencies into the curriculum;

"(2) the development and implementation of faculty professional development programs that enhance a faculty member's capabilities and teaching skills in advanced manufacturing, including efforts to understand current advanced manufacturing technologies and practices;

"(3) the establishment of centers that provide models and leadership in advanced manufacturing education and serve as regional or national clearinghouses for educational materials and methods;

"(4) activities to enhance the recruitment and retention of students into certification and degree programs in advanced manufacturing, including the provision of improved mentoring and internship opportunities;

"(5) the establishment of partnerships with private sector entities to ensure the development of an advanced manufacturing workforce with the skills necessary to meet regional economic needs; and

"(6) other activities as determined appropriate by the Director.".

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