

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

**Examining Federal Advanced Manufacturing Programs**

**Expert Testimony by**

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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.

<sup>1</sup> *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 21<sup>st</sup> 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 21<sup>st</sup> 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.