Testimony of

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Before the
United States House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Energy
Subcommittee on Research and Technology

"Revitalizing American Leadership in Advanced Manufacturing"

March 26, 2019

Thank you, Chairwoman Stevens, Chairman Lamb, Ranking Member Baird, Ranking Member Weber, and members of the Subcommittees. I am Mike Molnar, Director of the Office of Advanced Manufacturing at the U.S. Department of Commerce's National Institute of Standards and Technology (NIST). In this capacity, I also serve as the Director for the interagency Advanced Manufacturing National Program Office (AMNPO). Thank you for the opportunity to testify today about the Manufacturing USA initiative, early successes, and opportunities for even greater impact for U.S. manufacturing and the nation's competitiveness.

Background Need and Origin of Manufacturing USA

A strong U.S. manufacturing sector is essential to our economic and national security. American manufacturers contribute more than $2.4 trillion to the U.S. economy.[1] Manufacturing also makes up 8.5 percent of U.S. nonfarm employment[2] and 11.4 percent of U.S. GDP [3] yet drives 60 percent of exports[4] and an astounding 70 percent of private-sector research and development (R&D).[5] Manufacturing and the strength of the U.S. manufacturing supply chain also are critical to national security.[6]

There are not enough workers with the right skills to fill current and future manufacturing jobs. Deloitte and the Manufacturing Institute report that, over the next decade, nearly 3.5 million new manufacturing jobs will be needed;[7] with 2 million of those jobs expected to go unfilled due to the shortage of skilled workers.

In addition, the United States has been a net importer of advanced technology products since 2002.[8] This trade deficit in advnaced manufacturing is historically unprecedented for a nation that leads the world in science and technology research. Our country has a great culture of discovery and innovation. And manufacturing is where innovation happens. While the United States leads the world in invention and discovery, other nations have focused on developing these emerging technologies for production. Capitalizing on U.S. inventions and promoting the training of an effective workforce is Manufacturing USA's mission.

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[1] Bureau of Economic Analysis, U.S. Department of Commerce, https://apps.bea.gov/iTable/iTable.cfm?reqid=51&step=51&isuri=1&startyear=2018&table_list=1&series=q&endyear=2018&valuationtype=b&thetable=1&codelist=31gva

[2] U.S. Department of Labor, Bureau of Labor Statistics, (2019), https://data.bls.gov/timeseries/CES0000000001 and https://data.bls.gov/timeseries/CES3000000001.

[3] Bureau of Economic Analysis, U.S. Department of Commerce https://apps.bea.gov/iTable/iTable.cfm?reqid=51&step=51&isuri=1&startyear=2018&table_list=5&series=q&endyear=2018&valuationtype=b&thetable=1&codelist=31gva

[4] International Trade Administration, U.S. Department of Commerce (2017), http://tse.export.gov/tse/TSEOptions.aspx?ReportID=2&Referrer=TSEReports.aspx&DataSource=NTD.

[5] McKinsey Global institute, Making it in America: Revitalizing U.S. Manufacturing, S. Ramaswamy, J. Mayika, G. Pinkus, K. George, J. Law, T. Gambell, and A. Serafino, McKinsey Global Institute pgs. 75 (2017), https://www.mckinsey.com/~/media/McKinsey/Global%20Themes/Americas/Making%20it%20in%20America%20Revitalizing%20US%20manufacturing/Making-it-in-America-Revitalizing-US-manufacturing-Full-report.ashx. Nov 2017

[6] *National Security Strategy of the United States of America*, Executive Office of the President, pgs. 55 (2017), https://www.whitehouse.gov/wp-content/uploads/2017/12/NSS-Final-12-18-2017-0905-2.pdf.

[7] Deloitte and the Manufacturing Institute, The skills gap in US manufacturing: 2015 and beyond, C. Giffi, J. McNelly, B Dollar, G. Carrick, M. Drew, and B. Gangula, Deloitte Development LLC, p. 5, (2015) http://www.themanufacturinginstitute.org/~/media/827DBC76533942679A15EF7067A704CD.ashx

[8] Producing Prosperity: Why America Needs a Manufacturing Renaissance; Harvard Business Review Press 2012

Advanced manufacturing is a top priority for this Administration and is included as one of four Industries of the Future. The race for leadership in advanced manufacturing hinges on innovation, and transitioning those innovations into production, which both creates and requires good jobs. Innovation is an American strength. Competitor nations have significantly increased their efforts in and support of applied research, often leveraging discoveries originally made by U.S. researchers. Our investments in production innovation can help restore our technological competitive edge in manufacturing and promote the manufacture of U.S. technological innovations in the United States.

The Role of Our Network

With passage of the bipartisan Revitalize American Manufacturing and Innovation (RAMI) Act,[9] Congress authorized the establishment of the National Network for Manufacturing Innovation Program, or Manufacturing USA. This law authorizes the Secretary of Commerce to establish and coordinate manufacturing innovation institutes and to collaborate with federal departments and agencies whose missions contribute to, or are affected by, advanced manufacturing.

The Manufacturing USA program is about helping industry move discoveries from the Nation's universities and research laboratories to the domestic production floors that are equipped with the necessary skilled workforce.

The federal role in these public-private partnerships serves to create a "neutral convening ground" where industry and academia collaborate on applied research, addressing the most important opportunities facing U.S. manufacturers. Manufacturing USA institutes have a mission to develop both game-changing manufacturing technology and to train workers with the skills needed for future U.S. manufacturing.

As shown in Table 1, 14 Manufacturing USA institutes are sponsored by the Department of Defense (DOD), the Department of Energy (DOE), and NIST at the Department of Commerce. The program is coordinated by the Advanced Manufacturing National Program Office, located at NIST, which works with the other two institute-sponsoring agencies, DOD and DOE, along with the Departments of Agriculture, Education, Labor, and Health and Human Services, the National Aeronautics and Space Administration, and the National Science Foundation in the broader interagency team. This is truly a team effort.

It is important to note that the RAMI requirements are applicable only to institutes established by DOC/NIST; institutes sponsored by DOD and DOE were established under separate legal authorities and NIST has no role in the management of the institutes sponsored by other agencies. NIST does have the responsibility to convene the network of institutes, communicate about the work of the network to the public, facilitate information and knowledge-sharing among the network, scale workforce efforts, and deliver a report on the network's performance to Congress each year.

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[9] Consolidated and Further Continuing Appropriations Act, 2015, Pub. L. 113-235, Title VII – Revitalize American Manufacturing and Innovation Act of 2014, codified at 15 U.S.C. § 278s, http://uscode.house.gov/view.xhtml?req=(title:15 section:278s edition:prelim).

What the Institutes Do and Why it Matters

There are currently 14 Manufacturing USA institutes. Collectively, the institutes:[10]

- Reach 1,291 member organizations (of which 844 are manufacturing firms and 65 percent are small- and medium-sized manufacturers);
- Work on over 270 major research and development collaboration projects of priority to broad industry sectors;
- Attract $2 billion in private investment;
- Leverage $1 billion in federal funds; and
- Equip more than 200,000 people with advanced manufacturing skills.

Key goals of the Manufacturing USA institutes are to: 1) increase the competitiveness of U.S. manufacturing; 2) facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing capabilities; and 3) accelerate the development of a skilled advanced manufacturing workforce.

The institutes focus on developing a broad range of manufacturing capabilities in promising new advanced technologies that have the potential for high impact on the economy, on national security, and on the workforce of the future. Bringing together the best minds from industry, academia, and government to tackle tough manufacturing challenges helps to strengthen and expand the manufacturing base of the nation.

Serving Small- and Medium-Sized Manufacturers

Manufacturing USA also works with the NIST Manufacturing Extension Partnership Program to serve small and medium-sized manufacturers, which are 99 percent of all manufacturers, critical to local economies, and an integral part of the U.S. supply chain. MEP equips small- and medium-sized manufacturers with the resources needed to grow and thrive—working side-by-side with manufacturers to reduce costs, improve efficiencies, develop the next generation workforce, create new products, and find new markets.

Federal Agency Connections

Each institute has a sponsoring federal agency working in partnership with the institute consortia on direction and management. Through our interagency approach, other federal agencies are engaged with Manufacturing USA institutes in significant supporting roles. For example, NIST laboratory programs have technical collaborations with, and provide subject-matter experts to, all 14 Manufacturing USA institutes. NIST has a senior scientist acting as a technical lead for each institute, who coordinates with NIST laboratory resources and aids in standards and technical roadmapping activities.

Industry Advances in Technology Enabled by Manufacturing USA Institutes

The collaborative innovation enabled by the Manufacturing USA institutes has resulted in products that assist workers, make buildings safer, consume less energy, and save lives. Some examples of the hundreds of ways in which Manufacturing USA institutes create research

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[10] Manufacturing USA Annual Report, Fiscal Year 2017, Advanced Manufacturing National Program Office, National Institute of Standards and Technology, Department of Commerce (2018), https://doi.org/10.6028/NIST.AMS.600-3.

collaborations that enable member companies and their partners to produce innovative products in the United States include:

- **Modernizing Factories by Digitizing Legacy Equipment at Low Cost:** Manufacturers seeking to digitize their operations often need to incorporate data from expensive legacy manufacturing equipment into new, innovative processes without disrupting production, creating failure points, or voiding equipment warranties. A project with the Digital Manufacturing and Design Innovation Institute (DMDII), led by the University of Cincinnati, is developing an open source framework for computer vision-enabled cameras to recognize and read a variety of legacy digital displays and analog dials to produce information in the increasingly accepted MTConnect format. The final software and hardware toolkit will cost less than $1,000 per machine, enabling even the smallest manufacturing company to update its processes without replacing costly legacy equipment. Other project participants include Raytheon, Faurecia, ITI, and TechSolve (part of the Ohio MEP Center).

- **Comfortable, Wearable Medical Devices Provide Continuous Real-Time Information to Healthcare Providers:** GE Global Research partners with NextFlex to make it easier for patients to get the care they need by creating comfortable, wearable medical devices that provide continuous monitoring. NextFlex has enabled this technology, which promises to improve patient outcomes and bring down healthcare costs by allowing patients' health to be monitored from home rather than in the hospital.

- **Detecting Viral and Bacterial Contaminants:** Two National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL) projects led by Carnegie Mellon University and Accugenomics focus on advanced methods for rapid inline detection of bacterial or viral contaminants present during drug manufacturing to ensure safe, high-quality medicines for the U.S. public. These tests will replace laborious, off-line methods that can necessitate discarding up to three weeks of production due to the time they take to complete.

- **Gluten-free Cheerios:** General Mills worked with the Clean Energy Smart Manufacturing Innovation Institute (CESMII) to implement digital systems to monitor their supply chain, ensuring that their gluten-free products were truly gluten free—from the harvest field, to shipment containers, to various storage containers, and finally to the manufacturing of the Cheerios.

- **Delivering Life Saving Technology to Firefighters:** Lightweight Innovations for Tomorrow (LIFT) successfully aided Lifeline Firehose with the production of a state-of-the-art technology that makes it possible for a firehose to deliver both breathable air and water/foam simultaneously. The technology is being launched initially on a Grand Ledge Area Fire Department truck in Grand Ledge, Michigan, allowing firefighters to battle fires longer, as well as get critically needed air to downed personnel and victims. The Michigan fire department became the first-ever to deploy innovative firehoses helping first responders save lives and fight fires more efficiently. The groundbreaking technology uses a patented coupler system, which LIFT engineers helped prototype, to

deliver both air and fire suppressants to the end of the nozzle utilizing equipment firefighters are already trained on.

- **PowerAmerica Keeps the U.S. a Leader in LED Technology:** John Palmour, CTO and Founder of CREE, a leading company in LED lighting and power electronics, shared that "*PowerAmerica creates an ecosystem where technology can thrive and shows that the impossible is possible.*" CREE started when a small group working on semiconductor material, silicon carbide, commercialized the new technology. His company has grown into a large, international manufacturing company with over 4,500 workers in the United States, with products that focus on saving energy. He joined PowerAmerica because the institute helps de-risk innovative technology that companies cannot support on their own because the market is too far away. The work members are doing together in this space shows the viability of manufacturing that technology in the United States.

Developing an Advanced Manufacturing Workforce for the Future

In a healthy economy, workers are trained for new, higher-paying, advanced manufacturing jobs in emerging technology-driven manufacturing sectors. Advanced manufacturing has been the cornerstone of a robust economy and a solid middle class in the United States over the past century.

These new jobs require a workforce with new skills suitable for advanced manufacturing, so workforce development and education is a priority for Manufacturing USA and directly support's the Administration's priorities in science, technology, engineeirng, and mathmatics (STEM) education. Institutes partner with educational organizations and industry partners to teach advanced manufacturing technologies through workshops, courses, internships, and apprenticeships in order to create the workforce of the future.

The Manufacturing USA Education and Workforce Development Team has more than 50 members, including institute education and workforce directors, human capital and STEM-educational experts, and representatives from seven participating federal agencies.[11] The group develops partnerships and shares lessons learned, success stories, and initiative updates. It provides a cohesive platform for newer institutes to partner with older institutes and to develop processes based on proven models. The team's sharing of roadmapping models has led to project partnerships and to the creation of advisory committees across many of the institutes. The team's collaborative online portal, provided by AMNPO, allows for knowledge management, including sharing of hundreds of items, such as institute workforce assessment reports, project call guides, presentations, meeting reports, and industry reports.

Last year, we saw tremendous growth in institute-led workforce efforts in advanced manufacturing, educator and trainer instruction, and STEM activities, resulting in over 191,000 workers, students, and educators participating in Manufacturing USA-led workforce efforts. Education and workforce development initiatives include: summer internships for high school, vocational, community college, and university-based students; educational resources for K-12 educators; career workshops for middle and high school students; technology specific workshops

[11] The Departments of Commerce, Defense, Energy, Labor, and Education; the National Science Foundation, and the National Aeronautics and Space Administration.

for manufacturing employees; and programming for upcoming funding opportunities on manufacturing jobs training.

Institutes and national partners are creating programs to train new workers and to retrain existing workers and military veterans, as well as to educate and train students to equip them with the skills they need for high-paying jobs in the modern manufacturing sector. Some of these projects include:

- **Leading Companies Turn to Manufacturing USA to Ensure their Workers are Trained in the Latest Technologies:** Lockheed Martin works with the AIM Photonics institute and its AIM Academy to train its next-generation integrated photonics workforce. Lockheed is a member of many institutes and finds that the project work being done is critical because workers can learn by collaborating on hands-on projects.

- **Inspiring Students to Build a National Talent Pipeline in Advanced Manufacturing:** NextFlex's FlexFactor® program is overcoming common misconceptions among youth about manufacturing careers. FlexFactor uses a project-based learning approach that is integrated into an existing classroom, regardless of subject, incorporating a month of research, product design, and customer discovery work, culminating in students pitching their product and business models to a group of industry professionals in a "shark tank" style setting. Students also participate in two field trips: first to a manufacturing company where they discover what it is like to work in the sector, and then to a college or university where they learn about the education pathways that will help them build skills and experience that will prepare them for their careers.

  In Silicon Valley alone, FlexFactor has trained over 2,000 students. Early in 2018, FlexFactor launched with Lorain County Community College near Cleveland, Ohio, and has since grown from 17 students to over 700 participants in less than a year. The Boeing Company recently partnered with NextFlex and the Alabama Community College System to bring FlexFactor to schools in Northern Alabama where Boeing's manufacturing operations require a variety of technician and technologist talent.

- **Bringing Women into the Next Generation of Manufacturing: Girls of Steel Robotics®:** Girls of Steel Robotics was created at Carnegie Mellon University, which also runs the ARM institute. They offer educational programs, competitions such as FIRST Robotics, and camps for girls. They also bring summer camps to underserved areas to alleviate the transportation challenge for economically disadvantaged families. Girls of Steel has been successful at achieving its mission of "*Empowering women and girls in the pursuit of STEM by exemplifying female success in robotics.*" There have been 65 Girls of Steel alumnae, with 85 percent pursuing STEM fields in college.

- **Teaching Veterans 3D Printing for High-Paying Jobs:** 3D Veterans works with America Makes to expand a life-changing additive manufacturing training program for veterans by introducing new hands-on, projects-based additive manufacturing technology training pilot programs for U.S. veterans in Pittsburgh and Los Angeles. America Makes

provided critical support, linkages with corporate and university sponsors, technical expertise, and curriculum guidance for the training to ensure that veterans gained the 3D printing job skills needed by employers today. Veterans completing the training have gone on to high-paying, high-skill advanced manufacturing jobs.

Global Competition—What Other Countries Are Doing

The United States leads the world in innovation and inventions, yet many U.S. research discoveries are incorporated into manufacturing capabilities and cutting-edge products made in other countries. Global competition has made it unaffordable for most individual companies to transition inventions from the lab to mass production. In countries known for their manufacturing strength, such as China and Germany, this transition is facilitated by coordinated planning and national investments in advanced manufacturing programs, supporting the private sector's push to develop new manufacturing processes and products.[12]

Although the United States has established 14 Institutes, that is many fewer than the German counterpart, Fraunhofer, which has 69 institutes and China's planned 40 institutes. In 2018, Canada awarded $950 million for five innovation "advanced manufacturing superclusters," which are like our consortia of small and large business, academia, and others.[13]

China Manufacturing 2025 is one of China's key policies to reach the goal of "a strong country in manufacturing" or "a global manufacturing power." China Manufacturing 2025 is one of six key national policies that include: Reforming the One-Child Policy; National Defense; Establishing Rule of Law in the Economy; Encouraging Entrepreneurship; and Urbanization. The significance of each of the other policies underscores the importance which China attaches to its manufacturing initiative. The United States is taking strong actions to address the problematic Chinese policies implementing this initiative, which are designed to promote the development of Chinese industry in large part by restricting, taking advantage of, discriminating against or otherwise creating disadvantages for foreign enteprises.

Just last month, the German government announced a "National Industry Strategy 2030" in which, among other things, the German government may review and reform existing subsidy and competition law, allowing for time-limited subsidies in areas of innovation having a high impact on the economy, as well as company mergers in sectors where size is an absolute necessity for future global economic success.[14]

The Path Forward

In closing, I like to highlight what we often use as somewhat of a Manufacturing USA tagline: "Securing America's Future."

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[12] See Invented in America, Scaled Up Overseas, E. Reynolds and H. Samel, Mechanical Engineering Magazine (2013), https://www.asme.org/engineering-topics/articles/manufacturing-processing/invented-america-scaled-up-overseas and Restoring American Competitiveness, G. Pisano, and W. Shih, Harvard Business Review (2009). https://hbr.org/2009/07/restoring-american-competitiveness.

[13] https://business.financialpost.com/technology/canadas-950-million-bet-on-innovation-gets-set-to-take-the-next-step

[14] https://www.insidesources.com/the-global-emergence-of-national-industrial-strategy-and-americas-response/

In October, the White House released the quadrennial *Strategy for American Leadership in Advanced Manufacturing*, which is based on a vision for American leadership in advanced manufacturing across industrial sectors to ensure national security and economic prosperity.

To achieve this vision, the strategy defines three goals:

1) Develop and Transition New Manufacturing Technologies
2) Educate, Train, and Connect the Manufacturing Workforce
3) Expand the Capabilities of the Domestic Manufacturing Supply Chain

The Manufacturing USA program is working in support of all three of these goals. Collectively, the Manufacturing USA institutes are moving ideas into production and are training workers in the skills needed for tomorrow's high-paying, high-skill advanced manufacturing jobs.

Thank you for the opportunity to testify about NIST's role in coordinating the Manufacturing USA program and the large-scale, collaborative innovations happening across the country at the Manufacturing USA institutes. I will be pleased to answer any questions you may have.

Table 1. Manufacturing USA Institutes cover a broad range of critical technology areas.

Technology	Institute	Lead Funding Agency	Headquarters	Established
Additive manufacturing	America Makes — The National Additive Manufacturing Innovation Institute	DOD	Youngstown, Ohio	August 2012
Digital manufacturing and design	DMDII — Digital Manufacturing and Design Innovation Institute	DOD	Chicago, Illinois	February 2014
Lightweight metals manufacturing	LIFT — Lightweight Innovations for Tomorrow	DOD	Detroit, Michigan	February 2014
Wide bandgap power electronics manufacturing	PowerAmerica — The Next Generation Power Electronics Manufacturing Innovation Institute	DOE	Raleigh, North Carolina	January 2015
Fiber-reinforced polymer composites	IACMI — Institute for Advanced Composites Manufacturing Innovation	DOE	Knoxville, Tennessee	June 2015
Integrated photonics manufacturing	AIM Photonics — American Institute for Manufacturing Integrated Photonics	DOD	Rochester and Albany, New York	July 2015
Manufacturing thin flexible electronics devices and sensors	NextFlex —America's Flexible Hybrid Electronics Manufacturing Institute	DOD	San Jose, California	August 2015
Fiber materials and manufacturing processes	AFFOA — Advanced Functional Fabrics of America Institute	DOD	Cambridge, Massachusetts	April 2016
Smart manufacturing	CESMII — Clean Energy Smart Manufacturing Innovation Institute	DOE	Los Angeles, California	December 2016
Biofabrication and manufacturing	BioFabUSA — Advanced Regenerative Manufacturing Institute	DOD	Manchester, New Hampshire	February 2017
Robotic manufacturing	ARM — Advanced Robotics for Manufacturing Institute	DOD	Pittsburgh, Pennsylvania	January 2017
Biopharmaceutical manufacturing	NIIMBL — The National Institute for Innovation in Manufacturing Biopharmaceuticals	DOC	Newark, Delaware	March 2017
Modular chemical process intensification for clean manufacturing	RAPID — Rapid Advancement in Process Intensification Deployment Institute	DOE	New York, New York	March 2017
Sustainable manufacturing with clean energy and carbon emission reduction	REMADE — Reducing EMbodied-energy And Decreasing Emissions	DOE	Rochester, New York	May 2017