



NATIONAL NETWORK FOR
MANUFACTURING INNOVATION
PROGRAM
STRATEGIC PLAN

Executive Office of the President
National Science and Technology Council
Advanced Manufacturing National Program Office

February 2016



About this Document

This document is the strategic plan for the National Network for Manufacturing Innovation (NNMI) Program, as required by the bipartisan Revitalize American Manufacturing and Innovation (RAMI) Act of 2014.¹ The strategic plan describes the vision and goals that support the program's purposes as first articulated by the President and then enacted into law. Informed by feedback and recommendations from a broad array of stakeholders, this strategic plan represents the consensus of the participating agencies and industry leaders regarding the goals that should be pursued for at least the next three years to achieve the NNMI Program's purposes. The plan identifies the methods by which these goals will be achieved and the metrics by which the program will be assessed.

The *NNMI Program Strategic Plan* is complemented by the *NNMI Program Annual Report*, which each year will describe: 1) the activities of the institutes participating in the NNMI Program; and 2) the activities of the network during the previous year in achieving the goals described in the strategic plan.

Copyright Information

This document is a work of the U.S. Government and is in the public domain (see 17 U.S.C. § 105).

¹ Consolidated and Further Continuing Appropriations Act, 2015, Title VII — Revitalize American Manufacturing and Innovation Act of 2014, codified at 15 U.S.C. § 278s.

NATIONAL NETWORK FOR MANUFACTURING INNOVATION PROGRAM STRATEGIC PLAN

Executive Office of the President
National Science and Technology Council
Advanced Manufacturing National Program Office

February 2016





Interagency Working Team Participants

The individuals listed below dedicated considerable time and expertise to write and produce the 2015 *NNMI Program Strategic Plan*.

Advanced Manufacturing National Program Office

Dannielle Blumenthal
Rolf Butters
Kevin Chou
Lisa Jean Franczek
Frank W. Gayle
Shreyes N. Melkote
Michael F. Molnar (*DOC Sponsor*)
Frank Pfefferkorn
Margaret Phillips
Robert Rudnitsky (*Strategic
Plan Leader*)
Michael Schen
Gloria Wiens

Department of Commerce

John (Jack) Cobb
Mary Ann Pacelli (*Goal 3 Leader*)
Erin Sparks
Dana Smith
Benjamin Vickery

Department of Education

Gregory Henschel
Robin Utz

Department of Defense

Michelle Bezdecny
Jack Butler
John (JC) Christensen
(*Goal 2 Leader*)
Ralph Day
Scott Frost
Tracy Frost
Mark Gordon (*Goal 2 Leader*)
Abhai Kumar
Scott Leonard (*Goal 4 Leader*)
Andrew (Drew) Nord
John Olewnik
Adele Ratcliff (*DOD Sponsor*)

Department of Energy

David Hardy (*Goal 1 Leader*)
Rob Ivester
Mark Johnson (*DOE Sponsor*)
Steve Nunez
Dev Shenoy
Mark Stuart
Andrew Steigerwald

National Aeronautics and Space Administration

Frank Ledbetter
LaNetra Tate (*NASA Sponsor*)
John Vickers

National Science Foundation

Bruce Kramer (*NSF Sponsor*)
Zhijian (ZJ) Pei
Mihail C. Roco

U.S. Department of Agriculture

Todd Campbell (*USDA Sponsor*)
Hongda Chen
William Goldner
World Nieh
Valerie Reed
Samuel Ridders
Cynthia West



THE SECRETARY OF COMMERCE
Washington, D.C. 20230

Message from the Secretary of Commerce

The Department of Commerce is laser-focused on helping American companies grow by nourishing and supporting our innovators and our entrepreneurs.

We know that innovation is the lifeblood of our economy, supporting one-third of our economic growth. Manufacturers are responsible for 75 percent of private sector research and development. They employ two-thirds of the nation's R&D workforce and hold the vast majority of all the patents issued by the Department of Commerce. Indeed, having a cutting-edge manufacturing sector that remains a step ahead of the global competition is not simply nice to have — it is a “must have” for our country to thrive, now and in the future.

Recognizing that America's competitiveness is at stake, President Obama created the National Network for Manufacturing Innovation. This initiative breaks down silos between the U.S. private sector and academia, encouraging them to collaborate on taking industry-relevant technologies from lab to market over the near term.

In the NNMI institutes, everyone with an interest in manufacturing — from large companies to their smallest suppliers; from major research institutions to community colleges — work together to make breakthrough technological advances and commercialize those advances to benefit an entire region's manufacturing base.

In today's advanced manufacturing industries — those that make the highest-value goods, pay the highest wages, and export all over the world — product and process innovation are two sides of the same coin. Inventing, designing, making, and improving happen in concert, which requires a collaborative environment that brings together researchers and companies throughout the supply chain.

America has all the essential ingredients to form innovation ecosystems including universities and government labs that excel at basic science and technology research, top-flight original equipment manufacturers, capable suppliers, enterprising start-ups, and a new generation of workers. To maximize the benefits from our advanced manufacturing institutes, the RAMI Act tasked the Department of Commerce, working with the Departments of Defense and Energy, to integrate the institutes into a nationwide network in order to coordinate and leverage their individual and collective strengths.

The NNMI Program assembles our diverse competitive assets — the people, organizations, and resources — necessary for the United States to stay at the head of the pack in the global race to out-innovate, and to out-produce, the competition.

Now is the time to work together to ensure the NNMI Program is a success and lays the foundation for American manufacturing competitiveness for generations to come.

A handwritten signature in blue ink that reads "Penny Pritzker". The signature is fluid and cursive, with a prominent "P" and "R".

Penny Pritzker
U.S. Secretary of Commerce

This page intentionally left blank.



Executive Summary

The vision of the National Network for Manufacturing Innovation is U.S. global leadership in advanced manufacturing. It is a vision of a network of institutes that bring U.S. industry, academia, and government together to solve cross-sector manufacturing challenges that each sector simply cannot solve alone.

Each institute is the manufacturing technology development and workforce training leader for a specific technical area. The institutes focus on transforming promising early-stage research into proven manufacturing capabilities that are ready for adoption by U.S. manufacturers. The institutes provide small, mid-sized, and large manufacturers with access to state-of-the-art facilities and equipment. In addition, each institute provides critical workforce training and skills development in these new technologies. By bringing to the table the entire supply chain associated with a particular developing technology, an innovation community emerges that will later form the basis of mature larger-scale manufacturing supply chains located within the United States.

This is the first strategic plan for the National Network for Manufacturing Innovation (NNMI) Program. It describes the vision of the program and its goals. The plan identifies the methods by which these goals will be achieved, including the program's investment strategy, the mechanisms by which investments made by federal agencies will be coordinated, and the metrics by which the program will be assessed.

U.S. economic growth after World War II was driven by manufacturing. Innovation was not an activity isolated to the research community, but rather it occurred throughout the economy, in complete domestic innovation ecosystems. As new products and services were developed, they were scaled up, commercialized, and distributed to eager consumers all over the world.

For decades, we have seen the movement offshore of production facilities. This trend began with furniture, clothing, and textiles and has more recently expanded to advanced manufacturing. The trade balance in advanced technology manufactured products — long a relative strength of the United States — shifted in 2001 from surplus to deficit, and that deficit has grown in subsequent years.² A domino effect has occurred. As fewer things were commercialized here, the capacity to commercialize them also diminished. This only served to shift more production overseas.³

In 2011, a report by the President's Council of Advisors on Science and Technology (PCAST) highlighted the risks this situation has caused for the United States. In 2012, building on the previous findings, the Advanced Manufacturing Partnership (AMP) Steering Committee highlighted the essence of the problem: the U.S. private sector faces technical and financial limitations in translating promising early-stage research into cost-effective, high-performing domestic manufacturing capability and into new products.

Beginning in 2012, the Administration established the first manufacturing innovation institutes, starting with America Makes in Youngstown, OH. The experience of launching the first manufacturing innovation institute helped refine the initial concept. Additionally, the public provided input at regional workshops and in response to a formal Request for Information. The result was the "National Network for Manufacturing Innovation: A Preliminary Design," released in 2013.

² U.S. Census Bureau, Foreign Trade Statistics, Advanced Technology Products, on the internet at www.census.gov/foreign-trade/balance/c0007.html (visited on January 5, 2016).

³ *Restoring American Competitiveness*, Gary P. Pisano and Willy C. Shih, Harvard Business Review, July 2009.



In fall 2014, PCAST officially recommended a concerted, whole-of-government effort in advanced manufacturing. The initiative involved all federal agencies whose missions contribute to or are affected by advanced manufacturing. The NNMI was seen as playing a critical role in this whole-of-government effort.

Congress responded as well. On December 16, 2014, the Revitalize American Manufacturing and Innovation (RAMI) Act was officially signed into law, thereby formalizing the NNMI Program. This law provides the Secretary of Commerce with the authority to establish and coordinate the NNMI institutes and to collaborate with federal agencies whose missions are affected by advanced manufacturing, such as the Departments of Defense and Energy, to guide the efforts of the NNMI Program.

This strategic plan is submitted in response to the legislative call to action. It is the result of an interagency effort aimed at distilling the legislation, together with the experience of the existing institutes, into a durable long-term direction for the NNMI Program.

The NNMI Program has four major goals:

- Goal 1: Increase the competitiveness of U.S. manufacturing.
- Goal 2: Facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing capabilities.
- Goal 3: Accelerate the development of an advanced manufacturing workforce.
- Goal 4: Support business models that help institutes to become stable and sustainable.

The backbone of the NNMI Program is the understanding that America is at its strongest when we work together and make full use of our human resources. Connected through each institute and through the larger network of institutes, communities of researchers enable cutting-edge production technologies to be readied for use by industry. These talented, knowledgeable, experienced professionals provide real-world training for the next generation of our industrial workforce — who will then, in turn, gain access to high-paying advanced manufacturing jobs.

The institutes leverage the talents of their members. But they also do more. Because the institutes act as manufacturing innovation hubs that are regional in nature but nationally connected, they support the collective vision of global leadership of the United States in advanced manufacturing.

The NNMI Program will enable the United States to rebuild the dense networks of manufacturing capabilities that it lost in recent decades. Bringing large, mid-sized, and small manufacturers together with academia and the appropriate agencies can allow the United States to reinvent itself as the world's leading manufacturer. In doing so, the United States will not only strengthen its industrial competitiveness, but will also increase its prosperity and national security.



Table of Contents

Interagency Working Team Participants	iv
Message from the Secretary of Commerce.....	v
Executive Summary	vii
List of Tables.....	x
List of Figures.....	x
The National Network for Manufacturing Innovation.....	1
Introduction.....	1
About the National Network for Manufacturing Innovation Program	4
About the Institutes.....	4
About the Network.....	7
NNMI Program Goals and Objectives	9
Vision	9
Mission	9
Goals and Objectives	9
Goal 1: Increase the competitiveness of U.S. manufacturing	10
Goal 2: Facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing capabilities	12
Goal 3: Accelerate the development of an advanced manufacturing workforce	16
Goal 4: Support business models that help institutes to become stable and sustainable	20
Program Coordination and Assessment.....	25
NNMI Program Management: Structure and Responsibilities.....	25
Program Assessment	27
Program Reporting	30
Appendix A. Current Network-Level Functions of the NNMI Program.....	33
Appendix B. Federal Agencies Participating in the NNMI Program.....	35
Appendix C. Abbreviations.....	42



List of Tables

Table 1. Technology Readiness Levels and Manufacturing Readiness Levels	6
Table 2. Federal Departments and Agencies Participating in the NNMI Program	8
Table 3. Overview of Various Evaluation Methods.....	29
Table 4. Common Institute Metric Categories.....	30
Table 5. Current Network Functions.....	33

List of Figures

Figure 1. Timeline for the Creation of the NNMI Program	3
Figure 2. Interrelated NNMI Program Goals.....	10
Figure 3. Drivers of Manufacturing Competitiveness.....	11
Figure 4. Transforming and Transitioning Promising Manufacturing Capabilities to the U.S. Industrial Sector	13
Figure 5. Supporting Public-Private Workforce Development Partnerships	17
Figure 6. The Institute Ecosystem — Major Stakeholder Groups and their Interconnections.....	21
Figure 7. Illustration of Various Approaches for Performance Metrics at Different Stages of Timeline....	28



The National Network for Manufacturing Innovation

The National Network for Manufacturing Innovation (NNMI) Program is the U.S. Federal Government program for coordinating public and private investments to improve the competitiveness and productivity of U.S. manufacturing through the creation of a robust network of manufacturing innovation institutes, each focused on a specific and promising advanced manufacturing technology area. The NNMI Program advances American manufacturing innovation by creating an effective research and development, technology transition, workforce training and education outreach infrastructure for U.S. industry and academia to solve industry-relevant manufacturing problems.

What is Advanced Manufacturing?⁴

Advanced manufacturing involves new ways to create existing products and the creation of new products, emerging from the use of new technologies.

Introduction

Manufacturing is fundamentally important to the national security and economic strength of the United States. It provides working knowledge that stimulates further innovation and provides essential goods and equipment for the military, the intelligence community, homeland security agencies, and the nation at large. The country's globally competitive manufacturing sector translates inventions, research, discoveries, and new ideas into better or novel products and processes, resulting in economic growth. Within the manufacturing sector, advanced manufacturing is an important source of domestic sales and exports. Manufacturing increases the demand for materials, construction, and services.⁵ It can provide American workers with high-quality, well-paying jobs while also increasing demand for jobs throughout the supply chain.

Manufacturing is Critical to the U.S. Economy and to National Security

Manufacturing plays an outsized role in the U.S. economy. While it constitutes only twelve percent of gross domestic product, manufacturing accounts for over two-thirds of private sector research and development, two-thirds of the nation's R&D personnel, the vast majority of awarded patents, and the majority of U.S. exports. Employees in manufacturing typically earn fourteen percent higher total compensation than their non-manufacturing peers. Manufacturing also has a high economic multiplier effect both nationally and locally: each manufacturing job supports 1.6 jobs outside of manufacturing. The

⁴ *Report to the President on Ensuring American Leadership in Advanced Manufacturing*, Executive Office of the President, President's Council of Advisors on Science and Technology (PCAST), June 2011, www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-advanced-manufacturing-june2011.pdf.

⁵ *Manufacturing's Multiplier Effect Is Stronger than Other Sectors' - Facts About Manufacturing*, The Manufacturing Institute, October 9, 2015, www.themanufacturinginstitute.org/Research/Facts-About-Manufacturing/Economy-and-Jobs/Multiplier/Multiplier.aspx.

effect is greatest in advanced manufacturing: each advanced manufacturing employee supports an additional five jobs nationally.⁶

America's Leadership in Manufacturing Faces Challenges

The nation's historic leadership in manufacturing is now at risk. While the United States has a longstanding reputation for being a global leader in basic research, many of our research discoveries have not been translated into U.S.-based manufacturing capabilities or products. The major reasons for this include the technical complexity of manufacturing and the associated high investment risk that cannot be borne solely by the private sector, particularly by small and mid-sized manufacturing firms. Also, there is a need to strengthen the foundational knowledge and the commonly shared technical, design, and operational capabilities within individual industries. The barriers between basic research and production impede the ability of companies to develop new manufacturing processes and new products.

Furthermore, maintaining technological superiority in advanced manufacturing is a national security issue and is critically important for sustaining U.S. global competitiveness. A strong manufacturing sector not only ensures a ready supply of defense and commercial goods and services, but also ensures the integrity of these goods, especially electronics and other mission critical items. It also entails the products and advanced manufacturing technologies that our nation requires for its energy security, food security, health security, cybersecurity, and economic security.

History of the NNMI Program

Recognizing the importance of advanced manufacturing to the U.S. economy, in 2011, the Federal Government initiated the Advanced Manufacturing Partnership (AMP), a national effort that brought together industry, universities, the Federal Government, and other stakeholders to identify emerging technologies with the potential to create high-quality domestic manufacturing jobs and enhance U.S. global competitiveness. In the resulting 2012 *Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing*, the AMP Steering Committee made recommendations for improving the manufacturing competitiveness of the United States. Key among these was the recommendation that the United States establish a "national network of manufacturing innovation institutes" as public-private partnerships to foster regional ecosystems in advanced manufacturing technologies.⁷

At the request of the President, and using existing authorities, the pilot manufacturing innovation institute was established in 2012, with the Department of Defense (DoD) acting as the lead funding agency. Additional institutes were created in 2014 and 2015 using the lead funding agency authorities and appropriations of the DoD and the Department of Energy (DOE).

In December 2014, Congress passed the Revitalize American Manufacturing and Innovation (RAMI) Act,⁸ which instructed the Secretary of Commerce and the Administration to establish the Network for Manufacturing Innovation Program, generally called the NNMI Program.

⁶ *The Case for a Manufacturing Renaissance*, Gene Sperling, The Brookings Institution, July 2013, www.whitehouse.gov/sites/default/files/docs/the_case_for_a_manufacturing_renaissance_gene_sperling_7-25-2013_final_p....pdf.

⁷ *Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing*, Executive Office of the President, President's Council of Advisors on Science and Technology (PCAST), July 2012, www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_amp_steering_committee_report_final_july_17_2012.pdf.

⁸ Consolidated and Further Continuing Appropriations Act, 2015, Title VII — Revitalize American Manufacturing and Innovation Act of 2014, codified at 15 U.S.C. § 278s.

THE NATIONAL NETWORK FOR MANUFACTURING INNOVATION

With the announcement in August 2015 of the seventh manufacturing innovation institute, the DoD and the DOE have committed to invest over \$500 million, which has led to over \$1 billion in matching commitments of non-federal funds. These large matching investments by industry, academia, and state and local governments demonstrate the strong demand for these unique public-private partnerships for advancing U.S. manufacturing capabilities.



Figure 1. Timeline for the Creation of the NNMI Program

About the National Network for Manufacturing Innovation Program

The NNMI Program was created to improve the competitiveness of U.S. manufacturing by accelerating innovation and implementation of advanced manufacturing capabilities. Activities and accomplishments of the NNMI Program consist of two essential components: 1) those associated with a single manufacturing innovation institute⁹ (referred to as an “institute” in this document), and 2) those associated with the entire “Network for Manufacturing Innovation” (referred to as the “network” in this document).¹⁰

The NNMI Program consists of an expanding network of manufacturing innovation institutes. Each institute focuses on addressing pre-competitive technical and workforce challenges in order to scale up manufacturing in a specific application area that is important for economic competitiveness or national security. Collaborative research and development occurring in the institutes has the goal of integrating and introducing new manufacturing capabilities and technologies into supply chains. The institutes also support education, training, and workforce development programs and work to transfer technology to meet industry’s needs.

About the Institutes

The institutes are the core of the NNMI Program. They provide resources and facilities to allow industry and academia to cooperate to solve industry-relevant problems that bridge the gap between basic research and production. They bring together industry, academia (including universities, community colleges, technical institutes, etc.), federal laboratories, and federal, state, and local governments to address high-risk challenges in advanced manufacturing and to assist manufacturers in retaining or expanding industrial production in the United States. Institutes are established with initial funding from the lead funding agencies under their statutory authorities.

The institutes function as public-private partnerships, with the requirement that non-federal resources must equal or exceed the federal contribution during a five to seven year initial funding period. Institutes will become self-sustaining following this initial funding period.

What is a Manufacturing Innovation Institute?

A manufacturing innovation institute is a public-private partnership of companies, academia, state and local governments, and federal agencies that co-invest in developing world-leading technologies and capabilities. Each institute creates the necessary focus and provides the state-of-the-art facilities needed to allow collaborative, mostly pre-competitive development of promising technologies. An institute provides workforce education and training in advanced manufacturing. An institute promotes the creation of a stable and sustainable innovation ecosystem for advanced manufacturing.

⁹ The terms “Centers for Manufacturing Innovation” (the term used in RAMI), “Manufacturing Innovation Institutes (MIIs)”, “Institutes for Manufacturing Innovation (IMIs)”, and “Clean Energy Manufacturing Innovation Institutes” have all been used in different framing documents to refer to institutes in the NNMI Program.

¹⁰ The Secretary of Commerce has charged the Advanced Manufacturing National Program Office at NIST with overseeing and carrying out the tasks assigned by RAMI to the “National Office of the Network for Manufacturing Innovation Program” (also called the “National Program Office”).

Creating Manufacturing Innovation Ecosystems

The institutes create dynamic and highly collaborative environments that spur manufacturing technology innovation and technology transfer. The institutes are expected to reduce risks and uncertainty in costs of production scale-up and commercialization while at the same time strengthening vital U.S. manufacturing innovation ecosystems.

To create these innovation ecosystems, each institute establishes a trusted environment for collaboration by forming an agreement among its members that defines rules for appropriately protecting and sharing each member's intellectual property. Next, members from government, industry, and academia identify their respective requirements. The members collaborate to develop research and development investment roadmaps and workforce development programs.

Institutes then typically conduct project calls that solicit competitive proposals from members that self-organize into integrated project teams. This approach maximizes the opportunity for activities in research and development or workforce development that: 1) are highly aligned with both government and industry priorities; 2) are competitively awarded; 3) are conducted by integrated project teams that represent multiple levels in the supply chain; and 4) establish clear paths for successful commercialization from the start. This project funding model enhances the manufacturing innovation ecosystem by lowering barriers, coordinating investments, and reducing waste.

Preparing an Advanced Manufacturing Workforce

In addition to advancing technology, the institutes prepare current and future workers to use the latest manufacturing methods and technologies. Each institute serves as a hub for advanced manufacturing and provides shared infrastructure and facilities where its members can learn new skills and can collaborate on pre-competitive technical challenges.

NNMI PROGRAM STRATEGIC PLAN

Manufacturing Readiness Levels and Technology Readiness Levels

Manufacturing readiness levels (MRLs) and technology readiness levels (TRLs) are used by the Department of Defense, other federal agencies, and industry to assess the maturity of new technologies. For consistency, the MRL scale will be used throughout the document.

The manufacturing innovation institutes are expected to help transition ideas from MRL 4 through MRL 7. When a new system, subsystem, or component has been developed to MRL 4, it is capable of being produced in a laboratory environment. At MRL 7, it has been demonstrated to be capable of being manufactured in a production representative environment.

Table 1. Technology Readiness Levels and Manufacturing Readiness Levels

	TRL 1: Basic principles observed and reported		MRL 1: Basic manufacturing implications identified
	TRL 2: Technology concept or application formulated		MRL 2: Manufacturing concepts Identified
	TRL 3: Experimental and analytical critical function and characteristic proof of concept		MRL 3: Manufacturing proof of concept developed
NNMI Target	TRL 4: Component or breadboard validation in a laboratory environment		MRL 4: Capability to produce the technology in a laboratory environment
	TRL 5: Component or breadboard validation in a relevant environment		MRL 5: Capability to produce prototype components in a production relevant environment
	TRL 6: System or subsystem model or prototype demonstrated in a relevant environment		MRL 6: Capability to produce a prototype system or subsystem in a production relevant environment
	TRL 7: System prototype demonstration in an operational environment		MRL 7: Capability to produce systems, subsystems, or components in a production representative environment
	TRL 8: Actual system completed and qualified through test and demonstration		MRL 8: Pilot line capability demonstrated; ready to begin low rate initial production
	TRL 9: Actual system proven through successful mission operations		MRL 9: Low rate production demonstrated; capability in place to begin full rate production
			MRL 10: Full rate production demonstrated and lean production practices in place

About the Network

As a part of the strategy to revitalize American manufacturing, the RAMI Act authorizes the Department of Commerce to establish and convene a nationwide network comprised of the individual manufacturing innovation institutes in order to enhance their impacts and further strengthen America's global competitiveness. For example, as part of the network's activity, institutes in the network can work to share best practices; identify and address gaps in America's manufacturing technology base; identify common interests and activities that can help to train the next-generation of skilled workers; share information about newly developed technologies and processes; and leverage expertise across multiple manufacturing domains.

There are currently nine manufacturing innovation institutes in various stages of maturation: seven have been stood up, one is scheduled to be awarded soon, and one is in the proposal solicitation stage. These nine institutes are, in chronological order:

1. America Makes, The National Additive Manufacturing Innovation Institute (additive manufacturing/3D printing), August 2012.¹¹
2. DMDII: Digital Manufacturing and Design Innovation Institute (digital manufacturing and design), February 2014.¹²
3. LIFT: Lightweight Innovations for Tomorrow (lightweight metals manufacturing), February 2014.¹³
4. PowerAmerica — The Next Generation Power Electronics Manufacturing Innovation Institute (wide bandgap power electronics manufacturing), December 2014.¹⁴
5. IACMI: Institute of Advanced Composites Manufacturing Innovation (fiber-reinforced polymer composites), June 2015.¹⁵
6. AIM Photonics — American Institute for Manufacturing Integrated Photonics (integrated photonics manufacturing), July 2015.¹⁶
7. NextFlex | America's Flexible Hybrid Electronics Manufacturing Innovation Institute (thin flexible electronic devices and sensors), August 2015.¹⁷
8. Revolutionary Fibers and Textiles — Institute for Manufacturing Innovation (award anticipated in Fiscal Year 2016).¹⁸
9. Manufacturing Innovation Institute on Smart Manufacturing: Advanced Sensors, Controls, Platforms and Modeling for Manufacturing (in solicitation).¹⁹

¹¹ americamakes.us.

¹² dmdii.uilabs.org.

¹³ lift.technology.

¹⁴ www.poweramericainstitute.com.

¹⁵ iacmi.org.

¹⁶ aimphotonics.com.

¹⁷ nextflex.us.

¹⁸ grants.gov/web/grants/view-opportunity.html?oppld=276514.

¹⁹ energy.gov/eere/amo/articles/notice-intent-noi-clean-energy-manufacturing-innovation-institute-smart.

NNMI PROGRAM STRATEGIC PLAN

The President's Fiscal Year 2016 budget request called for an additional six institutes to be funded, bringing the total to 15 by the end of 2016. Subject to Congressional appropriations, these new institutes would be sponsored by the Department of Commerce (DOC), the Department of Agriculture (USDA), and the DOE.²⁰

Throughout its growth, the network will continue to be guided by both its public and private members, and the federal agencies with interests in manufacturing, including the DOE, the DoD, the DOC, the Department of Education (DOEd), USDA, the National Aeronautics and Space Administration (NASA), the Federal Aviation Administration (FAA), the Food and Drug Administration (FDA), and the National Science Foundation (NSF).

Planning for Additional Institutes

The President seeks to strengthen America's leadership in advanced manufacturing by providing the resources to fund 15 institutes by the end of 2016 and up to 45 institutes over a decade.

Table 2. Federal Departments and Agencies Participating in the NNMI Program

2 Agencies with Manufacturing Innovation Institutes as of Fiscal Year 2015
Department of Defense (DoD) — five institutes; plans for a sixth institute in Fiscal Year 2016 Department of Energy (DOE) — two institutes; plans for three additional institutes in Fiscal Year 2016 (two initially supported by prior year funds)
2 Additional Agencies with Manufacturing Innovation Institutes planned in Fiscal Year 2016 Budget Request
National Institute of Standards and Technology (NIST), Department of Commerce (DOC) Department of Agriculture (USDA)
5 Other Participating Departments and Independent Agencies and Commissions
Department of Education (DOEd) National Aeronautics and Space Administration (NASA) National Science Foundation (NSF) Federal Aviation Administration (FAA) Food and Drug Administration (FDA)

²⁰ Prior to publication the omnibus appropriations bill passed on December 18, 2015. The appropriations bill includes funding for two DOC institutes.



NNMI Program Goals and Objectives

Vision

The vision for the NNMI Program is *U.S. global leadership in advanced manufacturing.*

Mission

To support this vision, the mission of the NNMI Program is *connecting people, ideas, and technology to solve industry-relevant advanced manufacturing challenges, thereby enhancing industrial competitiveness and economic growth, and strengthening our national security.*

The NNMI Program is designed to: 1) provide a fertile innovation environment for advanced manufacturing; 2) enable vigorous domestic development of transformative manufacturing technologies; 3) promote coordinated public and private investment in pre-competitive advanced manufacturing technology infrastructure; 4) facilitate rapid scale-up and market penetration of advanced manufacturing technologies; and 5) provide leadership and creative solutions to develop the talent necessary to drive innovation through advanced manufacturing enterprises.²¹

The NNMI Program operationalizes the purposes and requirements of the NNMI program as described in the RAMI Act and implements the recommendations made by the President's Council of Advisors on Science and Technology (PCAST). The structure of the NNMI Program is built around the recognition that investment in early stage basic research, while important, is not sufficient to ensure that new technologies progress smoothly from invention to product development or that they will eventually be scaled up for manufacturing in the United States. The NNMI Program aims to promote stable and sustainable domestic innovation ecosystems and the training of a skilled workforce to accelerate the development, scale-up, and deployment of promising advanced manufacturing technologies.

Goals and Objectives

To realize the NNMI Program's vision, the agencies and institutes participating in the NNMI Program collectively work toward achieving these four program goals:

Goal 1: Increase the competitiveness of U.S. manufacturing.

Goal 2: Facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing capabilities.

Goal 3: Accelerate the development of an advanced manufacturing workforce.

Goal 4: Support business models that help institutes to become stable and sustainable.

As the participating agencies work toward realizing the NNMI Program's vision, success will be measured by continual and substantive progress towards meeting each of the four program goals.

²¹ The first four of these purposes were recommended in *A National Strategic Plan for Advanced Manufacturing*, Executive Office of the President, President's Council of Advisors on Science and Technology (PCAST), February 2012, www.whitehouse.gov/sites/default/files/microsites/ostp/iam_advancedmanufacturing_strategicplan_2012.pdf, while the fifth was adopted by the agencies in support of the purposes of the RAMI Act.

NNMI PROGRAM STRATEGIC PLAN

As shown in figure 2, the four NNMI Program goals are interrelated elements of a robust strategy for supporting manufacturing innovation to reduce the gap between early stage research and eventual commercial deployment in manufacturing. They are designed to facilitate the deployment of manufacturing innovations to allow the United States to advance its domestic manufacturing capability and capture the economic and national security benefits stemming from federal and private sector investments in basic research. They are based on the RAMI Act,²² which incorporates the NNMI Program design elements for individual institutes comprising an innovation network as first suggested in a *National Network for Manufacturing Innovation: A Preliminary Design* in January 2013.²³



Figure 2. Interrelated NNMI Program Goals — The four program goals are interrelated elements of a robust strategy for supporting manufacturing innovation in order to reduce the gap between early stage basic research and commercial deployment in manufacturing. They facilitate the deployment of manufacturing innovations in order to advance U.S. manufacturing, allowing the United States to capture the economic and national security benefits stemming from federal and private sector investments in fundamental research.

Goal 1: Increase the competitiveness of U.S. manufacturing

The purpose of Goal 1 is to increase the competitiveness of domestic manufacturing by fostering American leadership in advanced manufacturing research, innovation, and technology development and deployment to increase the production of goods in the United States. Achieving this overarching goal will strengthen American manufacturers' ability to sell their goods domestically and to global markets. For the United States to be an economic leader, it must take a multifaceted approach to enhance competitiveness.

To increase the competitiveness of U.S. manufacturing, the NNMI Program must catalyze the advances in new enabling technologies, production materials, processes, information, and products, as well as development of workforce educational competencies by promoting shared contributions from the public sector, the private sector, and academia. Operating through federal cooperative agreements for their first five years, the institutes work to bridge MRL 4 to MRL 7. Due to the technical and financial difficulty of successfully commercializing proven technologies, the institutes provide a mechanism to advance the development steps necessary for industry to benefit from early stage research.

The NNMI Program works by creating an enduring network of topically focused manufacturing innovation institutes that function as research and development hubs where U.S. industry and academia collaboratively solve complex, government and industry-relevant manufacturing problems. Each institute in the network can include unique shared user facilities otherwise inaccessible to institute members, especially small and mid-sized enterprises. These shared facilities can help lower the financial and

²² Consolidated and Further Continuing Appropriations Act, 2015, Title VII — Revitalize American Manufacturing and Innovation Act of 2014, codified at 15 U.S.C. § 278s.

²³ *National Network for Manufacturing Innovation: A Preliminary Design*, Executive Office of the President, National Science and Technology Council, Advanced Manufacturing National Program Office, January 2013, www.manufacturing.gov/docs/nnmi_prelim_design.pdf.

NNMI PROGRAM GOALS AND OBJECTIVES

technical risks associated with further developing and maturing promising early stage manufacturing technologies, and encourage productive private-sector domestic manufacturing partnerships.

Strengthening domestic innovation ecosystems is critical to national competitiveness. Each institute creates and supports a regional manufacturing ecosystem. Connecting the institutes into a network amplifies their impact on advanced manufacturing, benefitting the entire nation and improving the ability of the United States to compete for manufacturing investment. The network facilitates knowledge transfer between institutes that makes each institute operate more efficiently, and increases the impact of the NNMI Program’s outreach activities. As described in figure 3, the NNMI Program addresses six out of the top ten drivers of competitiveness identified in a 2013 survey asking Chief Executive Officers of companies to rank the key government and market forces that drive manufacturing competitiveness.²⁴

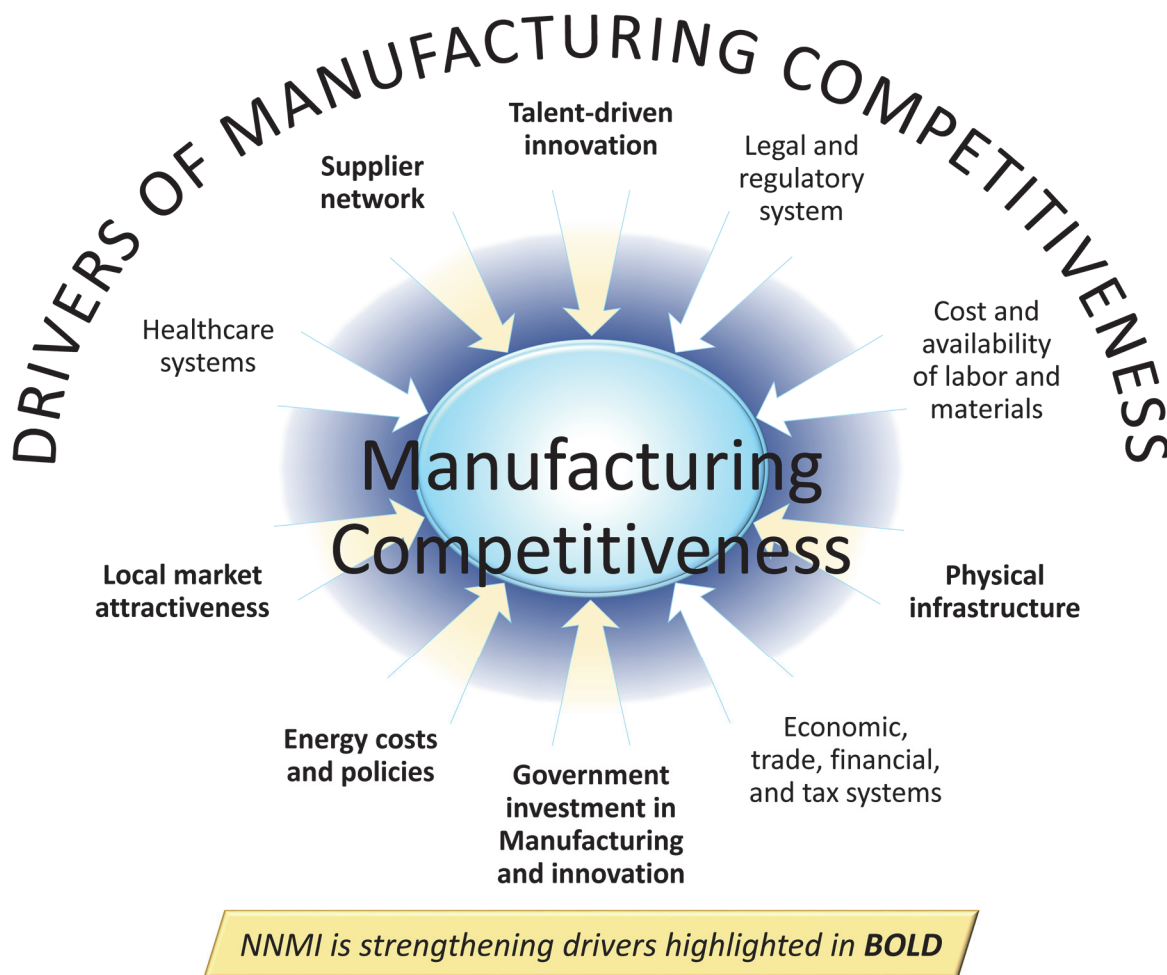


Figure 3. Drivers of Manufacturing Competitiveness — The NNMI Program addresses six drivers of manufacturing competitiveness (shown in bold) out of ten identified by the U.S. Council on Competitiveness.

²⁴ 2013 *Global Manufacturing Competitiveness Index*, Deloitte and the U.S. Council on Competitiveness, November 15, 2012, www2.deloitte.com/content/dam/Deloitte/global/Documents/Manufacturing/gx_2013%20Global%20Manufacturing%20Competitiveness%20Index_11_15_12.pdf.

Objective 1.1 Support the increased production of goods manufactured predominantly within the United States

A crucial aspect of U.S. competitiveness is the ability of domestic manufacturers to increase their manufacturing capabilities and capacities to respond in a timely manner to global market demand. The NNMI Program serves an important role by creating an effective advanced manufacturing research and development infrastructure. The program brings together the private sector, academia, and government at all levels to develop and deploy advanced manufacturing technologies that strengthen the competitiveness of the United States.

The NNMI Program's compounding impact lies in the range of U.S.-based partnerships it encourages. For example, building partnerships with small businesses promotes the broad diffusion of advanced manufacturing technologies throughout the U.S. supply base. This early participation enables the small businesses to participate later on in the technology commercialization and in the manufacturing supply chain. Partnerships with academia and workforce development programs provide a critical pipeline of skilled and knowledgeable workers for U.S. manufacturers. Altogether, the NNMI Program encourages the creation of stronger domestic supply chain networks that, in turn, encourage U.S. manufacturers to produce more products in the United States.

Objective 1.2 Foster the leadership of the United States in advanced manufacturing research, innovation, and technology

The NNMI Program enhances domestic manufacturing and increases the competitiveness of U.S. industry through the work of the institutes. These public-private partnerships are designed to pioneer "leap ahead" advanced manufacturing technologies while creating a highly skilled domestic workforce uniquely trained to manufacture and continually improve products based on these technologies. The combination of workers and technologies, including newly created processes and tools, creates a competitive advantage for U.S. manufactures and small businesses as they develop domestic supply chains to manufacture new products to meet global demand.

Goal 2: Facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing capabilities

To assist in bridging the gap between the promising emerging technologies and the deployment of these technologies in scalable, cost-effective, and high-performing manufacturing, the NNMI Program must enable domestic manufacturers to overcome both technical and economic hurdles. The overall purpose of this goal is to lower the barriers preventing the development of innovations by establishing innovation ecosystems containing sufficient resources and focused on attainable industry markets.

The institutes strive to help industry to overcome barriers due to complexity in advanced manufacturing technologies. The risk associated with this complexity leads to market failures in which promising technologies are not scaled by U.S. manufacturers into products and services. For example, small and mid-sized manufacturers often do not possess the capital, personnel, or available time to pursue innovative technologies at scale; and large manufacturers with existing portfolios tend to be risk averse. Additionally, the manufacturing technologies developed within an institute can be deployed more broadly to U.S. industry via the network. This "one-to-many" amplification of newly developed manufacturing capabilities is a key benefit of having a connected network of institutes.

NNMI PROGRAM GOALS AND OBJECTIVES

Figure 4 depicts the role of the institutes in stimulating the transition of technology to U.S. industry. By focusing on maturing pre-competitive, innovative manufacturing processes, the institutes are expected to reduce the risk of adopting newly demonstrated processes for manufacturing commercial and defense products. While some early transitions may occur at MRL 4 or MRL 5 for promising technologies, most transitions will occur at MRL 6 or MRL 7, when the processes have matured and have been demonstrated in a relevant manufacturing environment beyond initial prototype quantities. The institutes' focus is on transforming these innovative manufacturing processes and technologies to the point of defense and commercial adoption.

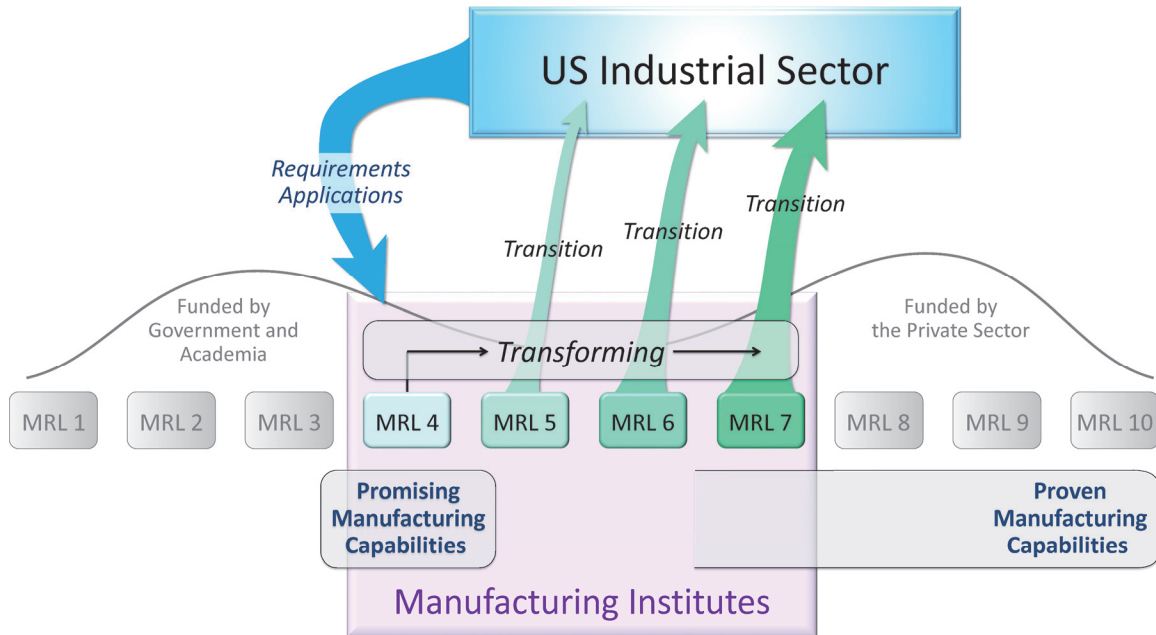


Figure 4. Transforming and Transitioning Promising Manufacturing Capabilities to the U.S. Industrial Sector — The institutes will focus on transforming promising manufacturing capabilities into proven manufacturing methods. The institutes lead the transformation, maturation, and scale-up of early stage manufacturing capability along the MRL scale from the pre-prototype stage (MRL 4) to the production ready stage (MRL 7). Their work is anticipated to increase the availability of scalable, cost-effective, and high-performing manufacturing capabilities for U.S. manufacturers. Institutes also facilitate the transition and transfer of these innovative manufacturing capabilities to U.S. manufacturers. Both functions are crucial for addressing the gap between promising manufacturing capabilities and their deployment, and for improving the competitiveness of U.S. manufacturers. The maturation and scale-up of technologies by institutes and their members lower the technological and financial risks of transforming promising early stage research into proven manufacturing capabilities that are ready for adoption by U.S. manufacturers. The pathways to eventual industrial use that the institutes create will inspire additional early stage (MRL 1 to MRL 3) research geared toward manufacturing applications. As more manufacturing technology is transitioned to industry, a stronger and more competitive U.S. manufacturing sector will emerge.

Objective 2.1 Enable access by U.S. manufacturers to proven manufacturing capabilities and capital-intensive infrastructure

A key function of the institutes is to provide U.S. manufacturers of all sizes with access to innovative technologies, equipment, and technical expertise developed through institute-led activities. In particular, small and mid-sized manufacturers often lack the resources to undertake the technological and financial risks associated with new technology development, scale-up, and adoption. Institutes are expected to reduce the risks substantially by providing industry access to proven capabilities, resulting in regional and national economic benefits.

NNMI PROGRAM STRATEGIC PLAN

The institutes can organize a range of services and resources, including:

- Manufacturing technology demonstrations.
- Fee-based user facilities that provide access to technical consulting services, equipment, and training.
- Opportunities to collaborate with other institute members and to interact with firms that license technologies.
- Opportunities to collaborate with supply chain intermediaries such as the National Institute of Standards and Technology (NIST) Manufacturing Extension Partnership (MEP) and other small business support networks. These programs facilitate access to resources and technical expertise that can help small manufacturers to transition manufacturing capabilities into production.
- Affordable state-of-the-art rapid prototyping capabilities to allow domestic manufacturers to achieve limited scale production runs to evaluate new manufacturing processes or prototypes prior to committing to full-scale production.

Activities at the network level may include:

- Organizing regional information workshops to increase awareness of the NNMI Program and its broad-based offerings to U.S. manufacturers. These are critically important for informing manufacturers about the potential for the institutes to support their business growth plans.
- Establishing an online portal to connect U.S. manufacturers to institutes in the network and other relevant resources.

Objective 2.2 Facilitate sharing and documentation of best practices for addressing advanced manufacturing challenges

Collaboration between entrepreneurs and industrial manufacturing experts can advance production technology to meet challenges facing the institutes, their members, and the larger U.S. manufacturing sector. The institutes can promote partnerships that include small and mid-sized entities that would benefit from shared access to facilities. The network should share knowledge developed within the institutes with the members of the network and with the broader manufacturing sector.

Activities at the network level may include:

- Convening network members and non-members to share best manufacturing practices. This can include comparing state-of-the-art methodologies from all sources as a potential resource for all.
- Sharing information both within and outside the network about manufacturing advances developed in the institutes.
- Communicating emerging government and industry technology priorities of potential interest to the institutes and their members.
- Spotlighting institute-led activities, products, and services on manufacturing.gov and other websites in order to enable broad-based dissemination of information among U.S. stakeholders.

NIST Shares Network Benefits with Small and Mid-Sized U.S. Manufacturers

The NIST Manufacturing Extension Partnership (MEP) extends the benefits of best practices beyond the institute partners through their national network. As each manufacturing innovation institute has opened, the NIST MEP and its individual MEP Centers have worked in numerous ways to support their activities. For example, in May 2015, NIST MEP and the Department of Defense (DoD) agreed to a memorandum of understanding (MOU) which commits both NIST and the DoD to work to support the DoD-led institutes. The DoD will leverage the assets and resources of the national MEP program to assist DoD-funded NNMI institutes as they strive to enhance their impact on small and mid-sized U.S. manufacturers.

Future MOUs between NNMI institutes and NIST MEP will provide a framework defining how the institutes and MEP Centers can work together to ensure that:

- Small and mid-sized U.S. manufacturers are made aware of the product and process technologies, technical methods, technological approaches, resources, and assets of the DoD-funded institutes.
- Small and mid-sized U.S. manufacturers are involved in the processes and activities associated with informing and developing research agendas of the DoD-funded institutes.
- Small and mid-sized U.S. manufacturers are represented in the conduct of research and development projects occurring through the DoD-funded institutes.
- The results of research and development occurring through the DoD-funded institutes are transitioned to small and mid-sized U.S. manufacturers for implementation.
- Existing government programs and resources are leveraged, including NIST's work in domestic and international standards, to further advance U.S. manufacturing competitiveness in the areas of institute focus.
- Institute-led activities, products, and services are posted on manufacturing.gov and other websites in order to enable broad-based dissemination of information among U.S. stakeholders.
- Small and mid-sized enterprises have opportunities to develop in-house talent in order to increase their ability to leverage new technologies to increase and expand markets, diversify their businesses, and create more jobs.

Objective 2.3 Foster the development of standards and services that support U.S. advanced manufacturing

Development of products and services stemming from the activities of the institutes and the network are essential elements for efficiently transferring technology and expertise to domestic manufacturers and their supply chains. Chief among them are partnership and leadership in standards bodies for developing domestic and international standards, development and promulgation of technical tools that may be used by domestic manufacturers, and a range of technical products and services directly supporting the transition of proven innovative technologies into domestic manufacturing capabilities.

NNMI PROGRAM STRATEGIC PLAN

Activities at the institute level may include:

- Working closely with U.S. industry, standards developers, government agencies, and leaders in the United States and the global standards community to develop standards supporting U.S. innovation and creating opportunities for U.S. manufacturing to thrive.
- Participating in and monitoring standards-related activities across the private sector, with federal agencies, and internationally in order to assess conformity.
- Leadership in the development of technical tools and services for institute members that lay the groundwork for broad-based benefits associated with crosscutting manufacturing technologies. These efforts can include the generation and dissemination of standard reference materials, technical reference data, scientific and engineering databases, software specifically tailored for adoption of advanced manufacturing technologies, and computational services meeting the needs of industry.

Activities at the network level may include:

- Facilitating collaboration among institutes within the network, including sharing of information about lessons they have learned and about successful practices that they have developed that contribute to the efficient transition of innovative technologies to industry.
- Leveraging existing government programs and resources, including NIST's work in domestic and international standards, to further advance U.S. manufacturing competitiveness in the areas of institute focus.

Goal 3: Accelerate the development of an advanced manufacturing workforce

A healthy manufacturing environment includes workforce development, improved job opportunities, and increased economic opportunity that results in higher wages for American workers. This goal defines how the NNMI Program will accelerate the development of an advanced manufacturing workforce, including technicians, skilled production workers, manufacturing engineers, scientists, and laboratory personnel.

Objective 3.1 Nurture future workers for STEM related work

An important component in allowing the United States to accelerate the development of an advanced manufacturing workforce is nurturing the interest of young students in Science, Technology, Engineering, and Mathematics (STEM) topics. Increasing an early sense of excitement about STEM will widen the pipeline of students available for more specialized training and education. Part of the strategy for communications about network and institute activities will include outreach efforts, such as participation in Manufacturing Day, to improve the image of manufacturing careers and to correct inaccurate negative stereotypes about manufacturing employment.

NNMI PROGRAM GOALS AND OBJECTIVES

Supporting Public-Private Workforce Development Partnerships

Workforce development partnerships depend on the committed participation of colleges, schools, governments, and private firms. The institutes can play an important role in convening these partnerships and defining and documenting successful workforce development strategies. With the full roster of partners, local and regional areas can effectively construct clear pathways for students to efficiently transition through various levels of study, attaining the skills and knowledge needed to join the technical labor force, as needed by manufacturers.

The Departments of Education and Commerce have developed a webinar series, “Skills on Purpose — Creating the Next Generation of Manufacturers”. A total of six programs were developed, and have been archived to serve as a resource that may be consulted by striving partnerships. They are available online at cte.ed.gov/initiatives/skills-on-purpose.

In 2012, the Departments of Education, Labor, and Health and Human Services committed to a joint approach to creating and implementing career pathway systems. The Workforce Innovation and Opportunity Act defined career pathways in 2014, and thirteen agencies have since adopted that definition. These agencies have created resources to assist policy makers and practitioners in developing programs to support the implementation of secondary to post-secondary career pathways in technical fields. These resources are available online and are applicable to training in advanced manufacturing, including:

- The Career Pathways Toolkit: A Guide for System Development (www.workforce3one.org/view/2001523732879857569/info).
- The Employability Skills Framework (cte.ed.gov/initiatives/employability-skills-framework).
- Strengthening Skills Training & Career Pathways Across the Transportation Industry (cte.ed.gov/initiatives/advancing-cte-in-state-and-local-career-pathways-system).

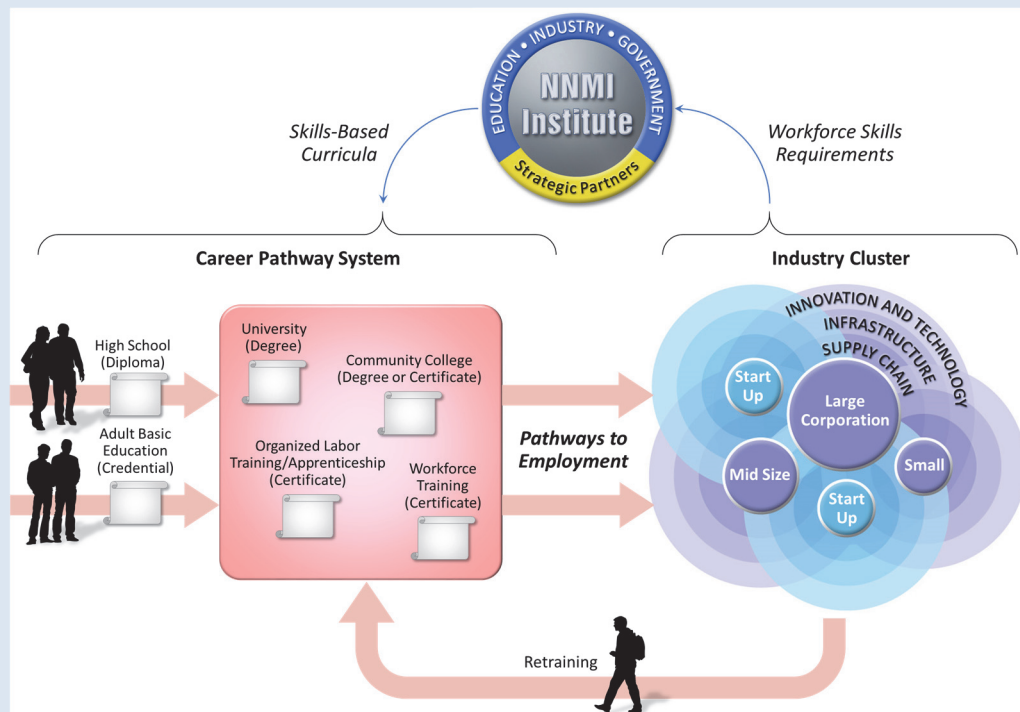


Figure 5. Supporting Public-Private Workforce Development Partnerships

Objective 3.2 Support, expand, and communicate relevant secondary and post-secondary pathways, including credentialing and certifications

Institutes are positioned to train the workforce at all levels, while also demonstrating to instructors how to develop effective workforce training programs.²⁵ These programs and initiatives support a coherent sequence of secondary to post-secondary courses as well as registered apprenticeships and cooperative (employer-educator) education programs to allow students to seamlessly transition through each level of study.

The NNMI Program may serve as a portal for providing institutes and stakeholders information and links to existing workforce development programs. In addition, the network may provide a common repository and venue for institutes to share their experiences and lessons learned in linking with existing national, state, local, and private industry-focused STEM education program and workforce development initiatives.

The network can help the institutes navigate federal workforce funding opportunities such as the Workforce Innovation and Opportunity Act (WIOA) of 2014.²⁶ WIOA is a public workforce investment system that presents an opportunity to improve job training and career options for job seekers and workers while meeting the needs of business. It works to meet the needs of unique regional, state, and local economies, and labor markets. WIOA aligns with and complements the President's vision for Job Driven Workforce Development and is reflected in federal investments for workforce training that combine strong employer engagement with high quality training to create career pathways for workers in high-growth occupations. For example, WIOA emphasizes working upfront with employers and determining local or regional hiring needs through greater use of labor market information in order to design responsive, training programs; offering work-based learning opportunities, including on-the-job training, paid internships, pre-apprenticeships, and registered apprenticeships; and promoting career pathways and sector strategies. The NNMI Program looks for opportunities such as those provided by WIOA as it develops workforce development plans.

Objective 3.3 Support the coordination of state and local education and training curricula with advanced manufacturing skill-set requirements

Institutes are well positioned to support a broad range of partners to define the technical job skills needed at all levels in the emerging technologies that they are developing. The institutes can:

- Work with national organizations, including professional organizations and trade groups, to support the development of needed worker credentials and testing where appropriate certifications and degrees are not already available.
- Support the development and distribution of appropriate academic curricula and educational materials to training providers.

²⁵ *National Network for Manufacturing Innovation: A Preliminary Design*, Executive Office of the President, National Science and Technology Council, Advanced Manufacturing National Program Office, January 2013, www.manufacturing.gov/docs/nnmi_prelim_design.pdf.

²⁶ Public Law 113 – 128 – Workforce Innovation and Opportunity Act, <https://www.gpo.gov/fdsys/pkg/PLAW-113publ128/content-detail.html>.

NNMI PROGRAM GOALS AND OBJECTIVES

- Provide internship and registered apprenticeship opportunities by working with their industry and academic members, as well as through regional partnerships and industrial cluster programs.

The network can serve as a clearinghouse for information about workforce support. It offers a means to coordinate the implementation of specialized skills programs within the network, in particular those that cut across the technologies of several institutes, such as taking steps to update North American Industry Classification System (NAICS) codes to reflect the growing variety of technical and manufacturing jobs.

Objective 3.4 Advanced-knowledge workers: researchers and engineers

The institutes' diverse range of private sector and academic partners makes them ideal for establishing internships and training opportunities that bring together leading practitioners in emerging technologies with science and engineering students seeking hands-on experience. As each set of students learn the skills needed to become valuable employment prospects, the internship programs will attract more academic and industrial applicants and produce more high quality hires. These students are expected to go on to become the next generation of senior engineers and research scientists.

Objective 3.5 Identify the competencies needed by the next generation of workers

As the institutes develop new technologies, materials, and processes, they will also need to begin identifying the new attributes required to perform the jobs these advances will create. These new competencies will need to be integrated into the educational pathways in K-12, community and technical colleges, and universities that are preparing our next generation of workers. These competencies will also need to be incorporated into efforts to increase the skills of each affected industry's incumbent workforce.

Implementation Principles

To address the above workforce development priorities, the institutes may choose approaches that:

- Are demand and data-driven.
- Lead to sustainable results.
- Leverage rather than supplant other private- and public-sector initiatives.
- Define strategic foci around specific opportunities (*see box below*).

Workforce as a Strategic Objective of All Institutes

Institutes and their partners each develop business and operational plans, informed by their sponsoring agencies' mission. Each institute develops its own creative programs, allowing workforce development approaches that serve the needs of its members. For information about current institute workforce programming, please see:

- americamakes.us/technology/growing-3d-workforce
- www.poweramericainstitute.com/#talent-and-workforce
- lift.technology/education-workforce-development
- dmdii.uilabs.org/workforce-development
- aimphotonics.com/education-and-workforce-development
- nextflex.us

Goal 4: Support business models that help institutes to become stable and sustainable

To best support a viable and lasting U.S. innovation ecosystem, each institute must develop a sustainable business model that delivers useful benefits to its members. An institute must receive sufficient support from its members and other sources to become independent of its initial federal support, which will also indicate the formation of a healthy ecosystem of customers and industrial, academic, and government partners focused on that institute's technology space. Viewing the institutes collectively, pursuit of this goal similarly serves to create a stable and sustainable network with broad national benefit.

Each institute works with their respective lead funding agency to establish and monitor sustainability. Funding from the lead funding agency supports a five- to seven-year establishment and initial operating phase for new institutes. During this period, institutes conduct pre-competitive applied research to advance the manufacturing processes and systems associated with their specific technology areas and work towards creating manufacturing innovation ecosystems.

The start-up phase includes activities such as:

- Recruiting members.
- Deciding how to share intellectual property.
- Developing technology roadmaps.
- Conducting advanced manufacturing research and development.
- Creating and demonstrating advanced manufacturing tools.
- Sharing pre-competitive knowledge among members.
- Developing curriculum and training programs for the workforce.

If participating in the institutes results in significant benefits for the members, they will be motivated to remain engaged and to continue their memberships, which will provide ongoing financial and other support needed to sustain the institutes. The NNMI Program will encourage institutes to implement business models with at least the following key attributes:

Identify Key Stakeholders

The institute business models should identify key stakeholders as potential members and partners. These stakeholders may include large, mid-size, and small industrial firms, academic institutions, federal government organizations, state and local governments, national laboratories, professional associations, and economic development organizations. The relationships between these stakeholders are illustrated in figure 6.

NNMI PROGRAM GOALS AND OBJECTIVES

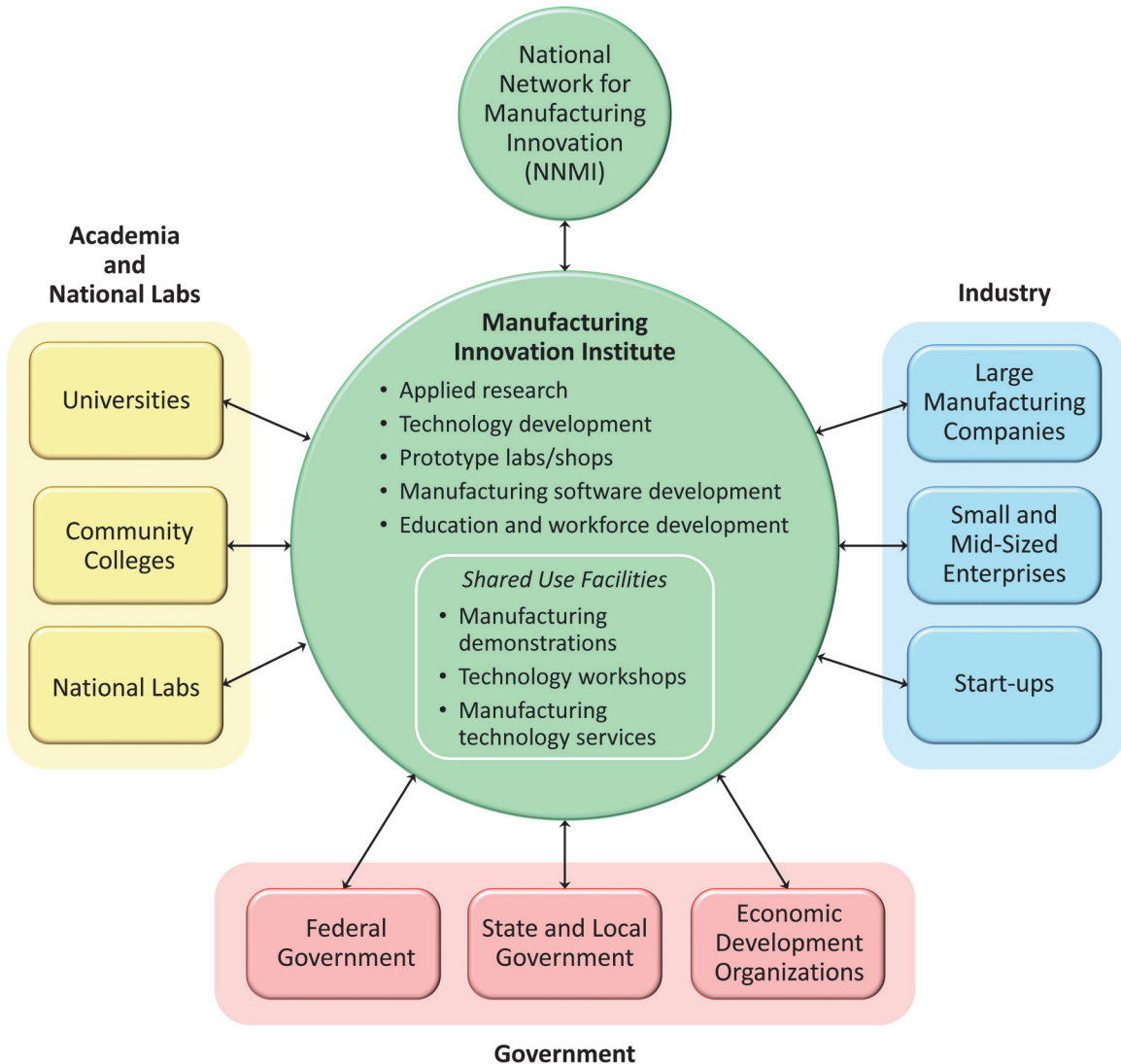


Figure 6. The Institute Ecosystem — Major Stakeholder Groups and their Interconnections

Define Value Propositions and the Value Cycle

The institute business models must include value propositions that define what each category of institute stakeholder needs from the institute and how the stakeholders can contribute to the institute’s mission in return. These exchanges of value between the institutes and their stakeholders define the value cycle by which the institutes create stable and sustainable ecosystems. Examples of key stakeholder value propositions include:

- Large manufacturers may seek access to new technologies and associated supply chains that can deliver these technologies reliably, securely, and affordably.
- Small manufacturers (also referred to as small and mid-sized enterprises, or SMEs) may seek large manufacturers that can serve as technology transition partners, technology and business development mentors, or as customers for their products and services. They also need access to technical and business expertise required to reduce the risk associated with scale-up and adoption

NNMI PROGRAM STRATEGIC PLAN

of new technologies. Small manufacturers also expect a low-threshold access to institute equipment and services that are expensive to establish in-house.

- Academic members, such as universities, may provide cutting-edge research and development capabilities, references to incubator services, mentoring and counseling services, and qualified personnel in return for real-world applications for their research.
- End user companies that procure parts or services from large and small manufacturers expect to influence the characteristics of what they procure by engaging in a collaborative proprietary exchange of needs versus capabilities.
- Community colleges and technical schools that are engaged in vocational training may seek industry partners to guide their curriculum development and delivery efforts.
- Federal, state, and local agencies involved in science and technology seek technology partnerships to develop technological solutions to support their mission objectives. Other government entities, including economic development agencies, seek opportunities to promote economic growth and workforce development.
- Federal laboratories seek business partners that can benefit from specialized equipment in their user facilities, multi-disciplinary analytical expertise, high performance computational capabilities, and subject matter expertise. These capabilities are often incorrectly assumed to be costly by potential industrial partners and are generally unadvertised.
- National associations need partners, such as these public-private partnerships or the network as a whole, to provide services to their individual members. Associations seek audiences for their tradeshow and users for their market analytical services. Associations also want to provide their member companies with access to facilities and specialized training.

Define the Core Functions of the Institute

The institute business models define the core functions of each institute. The models describe how the institutes deliver the services that their partners want and what resources are needed to support delivery of those services.

Require Member and Partner Contributions

The institute business models require different types of contributions from institute members to support core functions. Examples include tiered memberships; cash dues; free or discounted equipment, services, and materials for the institute; and sponsoring “fellowships” that loan personnel to the institute to perform core functions.

Record and Share Lessons Learned and Best Practices

Since each institute operates within unique technology areas with varying stakeholders, the operational procedures at each institute will differ. The NNMI Program can provide the greatest value in ensuring that best practices and hard lessons learned from unsuccessful efforts are both recorded and shared across the network. Sharing this type of information will help institutes reach sustainability more efficiently. Valuable information could include:

NNMI PROGRAM GOALS AND OBJECTIVES

- Membership agreements: information about clauses that have worked well and those that have caused prolonged disagreement or resistance to joining.
- Examples of the various types of membership tiers, associated dues, and the obligations and benefits of each.
- Intellectual property sharing arrangements.
- Business metrics, including common metrics that institutes are using, institute targets, and how institutes gather performance data.
- Facilities and services, including types of equipment and capabilities housed at each institute's hub and the services it provides to members and non-members.
- Member facility services and capabilities, if any.
- Ways institutes have acquired, upgraded, or replaced equipment.
- Physical security and cybersecurity practices.
- Information Technology (IT) systems: Examples of institutes' use of secure IT systems for web sites, project team support, knowledge storage and sharing, customer relationship management, metrics tracking, and status reporting.
- Outreach programs: Examples that have worked well for outreach efforts such as branding and social media, industry conferences, STEM, and workforce education and professional development.
- Co-sponsored initiatives: Examples that have worked well for co-sponsored projects, challenges, events, or other initiatives.
- Foreign participation: Models that work best to balance the needs of academic institutions and multinational companies with the overarching goal of increasing the competitiveness of U.S. manufacturing.

The network supports institute sustainability in a range of ways, including:

- Increasing the awareness of strategic partners associated with manufacturing.
- Sharing information across institutes about best practices for building their business models.
- Sharing information about a range of practical day-to-day operational lessons learned.

This page intentionally left blank.



Program Coordination and Assessment

NNMI Program Management: Structure and Responsibilities

Per the RAMI Act, the Secretary of Commerce has established the oversight and execution of the NNMI Program within the NIST.

In overseeing and carrying out the tasks assigned by the RAMI Act, the Advanced Manufacturing National Program Office (AMNPO)²⁷ will:

1. Oversee the planning, management, and coordination of the NNMI Program.
2. Enter into memoranda of understanding with federal departments and agencies contributing to or affected by advanced manufacturing in order to carry out the NNMI Program goals.
3. Establish the procedures, processes, and criteria needed to maximize cooperation and coordinate the activities of the NNMI Program with the activities of other federal departments and agencies whose missions contribute to or are affected by advanced manufacturing.
4. Establish a clearinghouse of public information related to the activities of the NNMI Program.
5. Act as the convener of the network.
6. Update, not less frequently than once every 3 years, a strategic plan to guide the NNMI Program.
7. Incorporate the Hollings Manufacturing Extension Partnership (MEP) into NNMI Program planning to ensure that the results of the NNMI Program reach small and mid-sized companies.

Under the NNMI Program, the Secretary is the convener of the network of institutes for manufacturing innovation, herein known as the network. The network includes the manufacturing innovation institutes already established by federal agencies prior to enactment of the RAMI Act.

Role of Advanced Manufacturing National Program Office

The interagency AMNPO was established in 2012 and is housed at the NIST. As recommended in the June 2011 PCAST *Report to the President on Ensuring American Leadership in Advanced Manufacturing*,²⁸ the AMNPO enables more effective collaboration in identifying and addressing challenges and opportunities that span technology areas and cut across agency missions.

The AMNPO helps to coordinate the efforts of all federal agencies involved in U.S. manufacturing, including the DOC, DoD, DOE, NASA, DoEd, USDA, NSF, FAA, and FDA. It does so by supporting the interagency coordination of advanced manufacturing programs, including the NNMI, providing a link to the growing number of private-sector partnerships between manufacturers, universities, state and local governments, and other manufacturing-related organizations. Currently collaborating agencies actively engaged in the NNMI Program include DOC (NIST), DoD, DOE, DoEd, NASA, NSF, and USDA.

²⁷ The Secretary of Commerce has charged the Advanced Manufacturing National Program Office at NIST with overseeing and carrying out the tasks assigned by the RAMI Act to the “National Office of the Network for Manufacturing Innovation Program” (also called the “National Program Office”).

²⁸ *Report to the President on Ensuring American Leadership in Advanced Manufacturing*, Executive Office of the President, President’s Council of Advisors on Science and Technology (PCAST), June 2011, www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-advanced-manufacturing-june2011.pdf.

NNMI PROGRAM STRATEGIC PLAN

The AMNPO reports to the Executive Office of the President and operates under the National Science and Technology Council (NSTC). The office also reports to the Secretary of Commerce in its role as the “the National Office of the Network for Manufacturing Innovation Program” (also referred to as the “National Program Office”), as described in the Revitalize American Manufacturing and Innovation Act of 2014. The AMNPO is staffed by representatives from federal agencies supporting U.S. manufacturing and by fellows from U.S. industry and academia.

Role of Subcommittee on Advanced Manufacturing

The Subcommittee on Advanced Manufacturing (SAM) was re-established on March 2, 2015, consistent with the requirements of Section 102 of the America COMPETES Reauthorization Act of 2010. It serves within the NSTC Committee on Technology as a forum for information sharing, collaboration, and consensus building among participating agencies regarding federal policy, programs, and budget guidance for advanced manufacturing. The SAM scope includes:

- Support for implementation of the AMP recommendations from the PCAST.
- Support for implementation of and updates to the National Strategic Plan for Advanced Manufacturing consistent with the requirements of Section 102 of the America COMPETES Reauthorization Act of 2010, as amended by the RAMI Act.
- Provision of guidance to the AMNPO or equivalent office as authorized by the RAMI Act.

The functions of the SAM include the following:

- Identify gaps in the Federal Government’s advanced manufacturing research and development portfolio and policies.
- Identify and evaluate policies and programs that support technology commercialization.
- Identify methods for improving the business climate.
- Identify and promote opportunities for public-private collaboration.
- Engage in three activities to support advanced manufacturing programs conducted by the Federal Government: 1) identification and integration of multi-agency technical requirements, 2) joint program planning and coordination, and 3) development of joint strategies or multi-agency joint solicitations.
- Provide periodic updates to the Committee on Technology and the Assistant to the President for Science and Technology on implementation of AMP recommendations and the National Strategic Plan for Advanced Manufacturing.

The SAM may seek advice from the PCAST to secure private-sector advice. The SAM may also interact with and receive *ad hoc* advice from various private-sector groups as consistent with the *Federal Advisory Committee Act of 1972*.

Role of the Executive Office of the President

Representatives from the Executive Office of the President (EOP) participate in NNMI activities to ensure that implementation of the NNMI Program is coordinated with and consistent with government-wide

PROGRAM COORDINATION AND ASSESSMENT

priorities. The primary points of interaction are the Office of Science and Technology Policy (OSTP), National Economic Council (NEC), and the Office of Management and Budget (OMB).

The OSTP is responsible for advising the EOP on matters relating to science and technology and supports coordination of interagency science and technology activities. Similarly, the NEC is responsible for advising the President on U.S. and global economic policy and coordinates policy-making for domestic and international economic issues. The OSTP administers the NSTC, and the OSTP and NEC representatives to the SAM serve as co-chairs of the subcommittee. This arrangement provides EOP-level input on and support for various NNMI activities.

The OMB is responsible for coordinating with the budget offices and programs of the agencies participating in the NNMI Program to establish and oversee their advanced manufacturing research and development budgets. Each year, OMB collects budget information regarding the total federal investment in advanced manufacturing research and development as well as information about agency investments within each program component area.

Related Interagency Activities

The NNMI Program leverages interagency efforts focused on advanced manufacturing, including an advanced manufacturing interagency working team, the NSTC and its subcommittees with overlapping interests, and other national initiatives. The AMNPO is responsible for outreach to non-federal stakeholders to ensure effective whole-of-government communications for advanced manufacturing and for the NNMI Program.

Program Assessment

Assessment and reporting in support of evidence based planning are integral elements of the strategic plan guiding the NNMI Program. Evaluation methods, performance measures, and associated metrics are important tools for assessing outcomes across the full range of NNMI Program expectations and activities, for refining future strategies, and communicating program impacts to stakeholders and the public at large.

Basis for Assessment

The evaluation strategy for the NNMI Program and its components is anchored by the following principles and best practices in impact assessment:

- Establish or leverage existing data infrastructures that can manage information needed to address the extent to which the NNMI Program is meeting its mission and purposes.
- Focus data collection on areas that can best provide rigorous and repeatable analysis.
- Leverage lessons learned from evaluation efforts underway within individual institutes, and from other similar programs and related interagency groups.
- Provide a trusted measure of the NNMI Program's performance that is broad enough to support process improvement analysis for the future design and activities of the institutes and the network.
- Leverage partnerships to improve data quality, e.g., linking of NNMI Program data to external data sources where appropriate and building a community of practice for evaluation.

These core principles enable sound evaluation and assessment methodologies while providing maximum flexibility for the institutes, federal agencies, and the AMNPO to assess the impacts and benefits of the NNMI Program.

NNMI PROGRAM STRATEGIC PLAN

NNMI Program evaluation will employ a diverse range of accepted methodologies and approaches across different impact time periods, which vary by technology area and industry, including:

- **Short Term:** Measures may include membership demographics, measures of partnering, research and development activity, and outputs such as publications, patents, prototypes, and process developments.
- **Middle Term:** Measures may include new products, licensing activity, additional capital, strategic alliance development, and company growth.
- **Long Term:** Measures may include return on investment, inter-industry diffusion, and broader manufacturing sector impacts.

Specific program metrics and methodologies for assessment will vary over time. For example, across institutes, assessment will depend on the technical challenges being addressed, the industries being served, and the maturity of the institute within its own performance life cycle. Consequently, assessment and reporting will reflect functions and activities at different stages of maturity within the NNMI Program and its components. In addition, the program metrics are complementary to but not a substitute for agency-specific or institute-specific performance guidelines or reviews.

The NNMI Program aims to utilize a diverse range of methodologies across the different impact time periods, as illustrated in figure 7. Specific examples of evaluation methods accepted as standard practices for assessing research programs²⁹ are described in table 3.

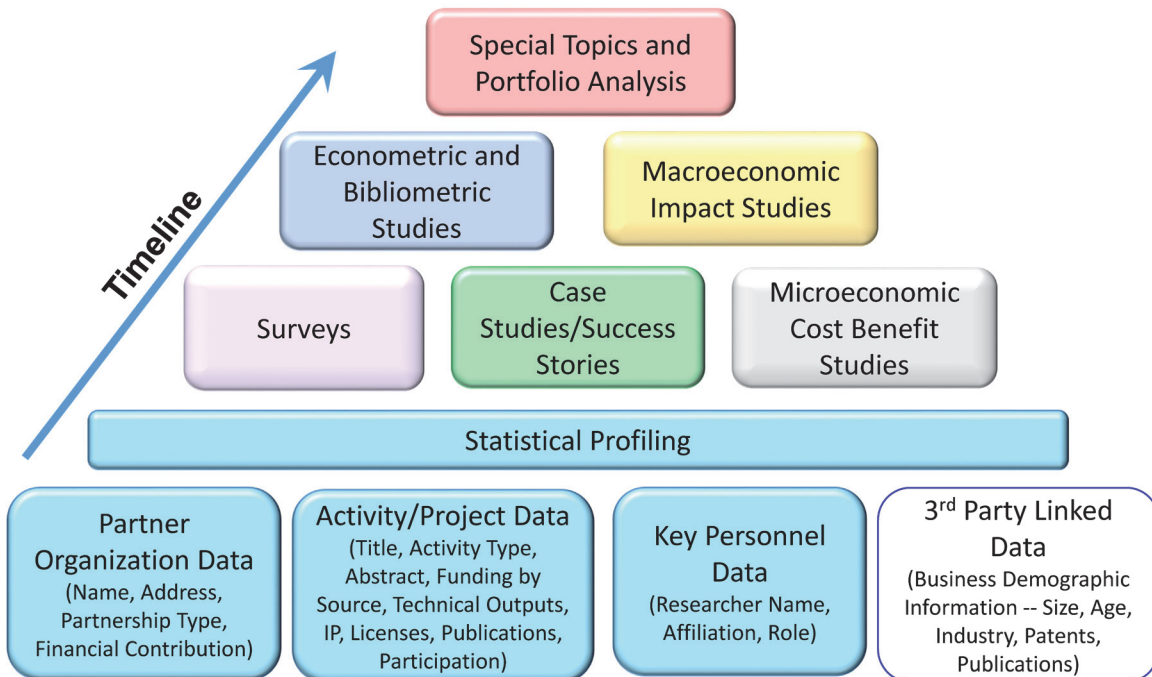


Figure 7. Illustration of Various Approaches for Performance Metrics at Different Stages of Timeline

²⁹ *A Toolkit for Evaluating Public R & D Investment: Models, Methods, and Findings from ATP's First Decade*, R. Ruegg and I. Feller, US Department of Commerce, Technology Administration, National Institute of Standards and Technology (2003).

PROGRAM COORDINATION AND ASSESSMENT

Table 3. Overview of Various Evaluation Methods

Methods	Brief description	Example of use
Analytical or conceptual modeling of underlying theory	Investigating underlying concepts and developing models to advance understanding of some aspect of a program, project, or phenomenon.	To describe conceptually the paths through which cascading effects may occur.
Survey	Asking multiple parties a uniform set of questions about activities, plans, relationships, accomplishments, value, or other topics, which can be statistically analyzed.	To determine how many companies have licensed their newly developed technology to others.
Case study — Descriptive	In-depth investigation of a program or project, a technology, or a facility, describing and explaining how and why developments of interest have occurred.	To recount how a particular joint venture was formed, how its participants shared research tasks, and why the collaboration was successful or unsuccessful.
Case study — Economic estimation	Adding to descriptive case study quantification of economic effects, such as thorough cost-benefit analysis.	To estimate whether, and by how much, benefits of a project exceed its costs.
Econometric and statistical analysis	Using tools of statistics, mathematical economics, and econometrics to analyze functional relationships between economic and social phenomena, and to forecast economic effects.	To determine how public funding affects private funding of research.
Sociometric and social network analysis	Identifying and studying the structure of relationships by direct observation, survey, and statistical analysis of secondary databases to increase understanding of social organizational behavior and related economic outcomes.	To learn how projects can be structured to increase the diffusion of resulting knowledge.
Bibliometric — Count	Tracking the quantity of research outputs.	To find how many publications per research dollar a program generated.
Bibliometric — Citations	Assessing the frequency with which others cite publications or patents and noting who is doing the citing.	To learn the extent and pattern of dissemination of a project's publications and patents.
Bibliometric — Content analysis	Extracting content information from text using techniques such as co-word analysis, database tomography, and textual data mining, supplemented by visualization techniques.	To identify a project's contribution, and the timing of that contribution, to the evolution of a technology
Historical tracing	Tracing forward from research to a future outcome or backward from an outcome to precursor contributing developments.	To identify apparent linkages between a public research project and something of significance that happens later.
Expert judgment	Using informed judgments to make assessments.	To hypothesize the most likely first use of a new technology.

NNMI PROGRAM STRATEGIC PLAN

Assessing the Benefits from the Network and Institutes

Within the NNMI Program, all Institutes are aligned with a common set of activities in support of the NNMI Program’s goals. The outcomes from those activities help to establish metric categories applicable across the full network of institutes. Thus, these metric categories become one of many possible benchmarks for assessing institute impacts. Table 4 shows four common institute metric categories that encompass institute activities. As the institutes and participating government agencies gain experience, other valuable metrics will emerge and be incorporated. In addition to these common metric categories, specific metrics are expected to be used that are unique to the mission needs of the sponsoring federal agency or individual institute.

The institutes are central to the strategy of revitalizing U.S. manufacturing competitiveness and helping the United States rebuild its leadership in advanced manufacturing. The network supports the institutes and facilitates their success. The institutes are expected to demonstrate their effectiveness toward achieving their individual goals and objectives, supporting their sponsoring agency’s program and mission, and furthering the purposes of the NNMI Program. Metrics are useful for assessing contributions toward meeting national goals, as expressed in the RAMI Act. Additional inputs can be taken from recent advanced manufacturing policy reports.^{30, 31, 32}

Table 4. Common Institute Metric Categories

Goal	Competitiveness	Transitioning Technology	Workforce	Sustainability
Common Institute Metric Category	Impact to U.S. Innovation Ecosystem	Technology Advancement (development, transfer, commercialization, etc.)	Development of an Advanced Manufacturing Workforce	Financial Sustainability

Program Reporting

The RAMI Act³³ calls for periodic reporting on the NNMI Program through the following mechanisms:

1. *Annual Reports to Congress* — This reporting mechanism requires the Secretary of Commerce to submit an annual report to Congress describing the performance of the NNMI Program during the most recent 1-year period. This report includes descriptions of the progress being made by the

³⁰ *A National Strategic Plan for Advanced Manufacturing*, Executive Office of the President, President’s Council of Advisors on Science and Technology (PCAST), February 2012,

www.whitehouse.gov/sites/default/files/microsites/ostp/iam_advancedmanufacturing_strategicplan_2012.pdf.

³¹ *Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing*, Executive Office of the President, President’s Council of Advisors on Science and Technology (PCAST), July 2012,

www.whitehouse.gov/sites/default/files/microsites/ostp/pcast_amp_steering_committee_report_final_july_17_2012.pdf.

³² *Report to the President on Accelerating U.S. Advanced Manufacturing*, Executive Office of the President, The Advanced Manufacturing Partnership 2.0, President’s Council of Advisors on Science and Technology (PCAST), July 2012,

www.whitehouse.gov/sites/default/files/microsites/ostp/PCAST/amp20_report_final.pdf.

³³ Consolidated and Further Continuing Appropriations Act, 2015, Title VII — Revitalize American Manufacturing and Innovation Act of 2014, codified at 15 U.S.C. § 278s.

PROGRAM COORDINATION AND ASSESSMENT

individual institutes in the network and discussion of how the NNMI Program activities have furthered the program purposes described in the RAMI Act.

2. *Reporting and Auditing of Department of Commerce Institutes* — This mechanism requires each institute receiving federal funding under the RAMI Act's authority to submit an annual report to the Secretary of Commerce describing the finances and metrics-based performance of the institute with respect to its goals, plans, and accomplishments. The report is also required to address how the institute has furthered the purposes of the NNMI Program. The initial nine institutes were funded using other agency-specific authorities and are not subject to this requirement. Thus, each year, the AMNPO will prepare an NNMI Program Annual Report on behalf of the Secretary of Commerce for submission to Congress. This annual report will include: 1) an overview of public and private investment committed under the NNMI Program; 2) an assessment of the participation in and contributions to the network by the institutes; and 3) a metrics-based performance assessment of the NNMI Program with respect to the program goals.

The RAMI Act also calls for the NNMI Strategic Plan to be updated triennially. This first NNMI Strategic Plan outlines the NNMI Program's vision, goals, and management, and describes the types of network and institute activities in support of the goals. Future plans will refine the NNMI Program, the goals, and performance metrics based on lessons learned.

In refining and updating the strategic plan for the NNMI Program, the Secretary will solicit recommendations and advice from a wide range of stakeholders on an ongoing basis, including the institutes, federal agencies funding the institutes, industry, small and mid-sized enterprises, research universities, community colleges, and other relevant organizations and institutions.

Upon each update of the NNMI Program Strategic Plan, the Secretary of Commerce will transmit the plan to the Committee on Commerce, Science, and Transportation of the Senate and the Committee on Science, Space, and Technology of the House of Representatives.

Upon request, the Department of Commerce, the federal agencies participating in the NNMI Program, and the institutes will provide requested data to the Government Accountability Office for its assessment of the NNMI Program.

This page intentionally left blank.



Appendix A. Current Network-Level Functions of the NNMI Program

A multi-agency Network Governance Team was tasked in May 2015 by the Subcommittee on Advanced Manufacturing (SAM) National Network for Manufacturing Innovation (NNMI) Leaders to begin development of the network’s governance system. The task included identifying network functions, along with the associated organizational roles and responsibilities. The team created a draft, network-level functions document describing high level (Level 1) and more detailed (Level 2) functions, which has been vetted by the network’s key stakeholders and is currently under review. Table 5 lists the current draft Level 1 and Level 2 network functions under study.

The SAM NNMI Leaders and their staffs are working with the institutes and the AMNPO to prioritize activities within these functions to act on as part of a 2016 “Game Plan” supporting the NNMI Program’s vision and goals.

Table 5. Current Network Functions

Level 1 Functions	Level 2 Functions (Sub-Functions or Tasks)
Establish the network.	Establish memoranda of understanding between the AMNPO and affected federal departments and agencies.
	Develop and deploy essential network operational protocols, policies, and procedures.
	Develop and deploy the initial version of the network strategic plan.
Facilitate value-added, intra-network collaboration.	Establish forums for robust network collaboration, information exchange, and knowledge management.
	Facilitate the organization and sharing of lessons learned and best practices across the network.
	Identify all-institute challenges, issues, and problems; study how institutes address them in their policies and procedures, and document comparative options, examples, and rationales.
	Provide situational awareness to individual institutes regarding key contextual landscape issues.
	Facilitate the management of technology interfaces to improve network efficiency and generate leveraged funding.
	Resolve disputes not otherwise addressed through other network functions.

NNMI PROGRAM STRATEGIC PLAN

Table 5. Current Network Functions (Continued)

Level 1 Functions	Level 2 Functions (Sub-Functions or Tasks)
Foster robust communication between the network and external stakeholders.	Develop, deploy, and update a network brand and public messaging strategy.
	Establish a framework and facilitate effective, two-way flow of collective information across the network boundary.
	Promote U.S. advanced manufacturing to government stakeholders (Executive/Interagency, Legislative).
	Promote and advocate U.S. advanced manufacturing to non-member industrial and academic stakeholders.
	Promote and advocate U.S. advanced manufacturing to the media, public, and others.
	Manage White House, Congressional, and Interagency communications interfaces as they relate to the network.
Sustain, strengthen, and grow the network.	Update the NNMI Program Strategic Plan.
	Maintain and execute an effective network resourcing strategy.
	Find and achieve economies of scale in common infrastructure for the benefit of individual institutes.
	Establish, maintain or amend, and execute network membership policies.
	Provide network-level support and guidance for newly established institutes.
	Identify and help to establish long-term NNMI Program non-financial support mechanisms.
	Assess and report on NNMI Program performance.
	Adjust governance system and functions over time as needed.



Appendix B. Federal Agencies Participating in the NNMI Program

The interagency Advanced Manufacturing National Program Office (AMNPO) helps to coordinate the efforts of all federal agencies involved in advanced manufacturing. First recommended by the Advanced Manufacturing Partnership (AMP), a steering committee under the President's Council of Advisors on Science and Technology (PCAST) comprised of national leaders from industry and academia, the office was established in 2012 by the Secretary of Commerce and the Director of the National Economic Council. The AMNPO provides both a key convening body for requesting and accepting multi-sector input as well as a platform for communication, collaboration, and coordination among the federal agencies participating in the National Network for Manufacturing Innovation (NNMI) Program.

The following agencies and offices participate in the NNMI Program:

National Economic Council

The National Economic Council (NEC) was established in 1993 to advise the President on U.S. and global economic policy. It resides within the Office of Policy Development and is part of the Executive Office of the President. The NEC has four principal functions: to coordinate policy-making for domestic and international economic issues, to coordinate economic policy advice for the President, to ensure that policy decisions and programs are consistent with the President's economic goals, and to monitor implementation of the President's economic policy agenda. More information is available at www.whitehouse.gov/administration/eop/nec.

Office of Science and Technology Policy

The Office of Science and Technology Policy (OSTP) was established by the National Science and Technology Policy, Organization, and Priorities Act of 1976. OSTP's responsibilities include advising the President in policy formulation and budget development on questions in which science and technology are important elements; articulating the President's science and technology policy and programs; and fostering strong partnerships among federal, state, and local governments, and the scientific communities in industry and academia. The Director of OSTP also serves as Assistant to the President for Science and Technology and manages the National Science and Technology Council (NSTC). More information is available at www.ostp.gov.

National Science and Technology Council

The National Science and Technology Council is the principal means by which the Executive Branch coordinates science and technology policy across the federal research and development enterprise. A primary objective of the NSTC is establishing clear national goals for federal science and technology investments. The NSTC prepares research and development strategies that are coordinated across federal agencies to form investment packages aimed at accomplishing multiple national goals. The work of the NSTC is organized under committees that oversee subcommittees and working groups focused on different aspects of science and technology. More information is available at:

www.whitehouse.gov/administration/eop/ostp/nstc.

NNMI PROGRAM STRATEGIC PLAN

Subcommittee on Advanced Manufacturing

The NSTC Subcommittee on Advanced Manufacturing (SAM) serves as a forum for information-sharing, coordination, and consensus-building among participating agencies regarding federal policy, programs, and budget guidance for advanced manufacturing. Originally chartered in 2012, the Subcommittee seeks to identify: gaps in the federal advanced manufacturing research and development portfolio and policies, programs and policies that support technology commercialization, methods of improving business climate, and opportunities for public-private collaboration. Regarding advanced manufacturing programs conducted by the Federal Government, the Subcommittee engages in the identification and integration of multi-agency technical requirements, joint program planning and coordination, and development of joint strategies or multi-agency joint solicitations.

Advanced Manufacturing National Program Office

Hosted by the Department of Commerce at the National Institute of Standards and Technology (NIST), the AMNPO is an interagency team with participation from federal agencies involved in advanced manufacturing. Principal participant agencies currently include the Departments of Commerce, Defense, Education, and Energy, the National Aeronautics and Space Administration, and the National Science Foundation. Established in 2012, the AMNPO reports to the Executive Office of the President and operates under the NSTC on cross-agency initiatives. The office reports to the Secretary of Commerce in its role as the “the National Office of the Network for Manufacturing Innovation Program,” also referred to as the “National Program Office,” as described by the Revitalize American Manufacturing and Innovation Act of 2014. More information is available at www.manufacturing.gov.

Department of Commerce

As part of its mission to support innovation, manufacturing, exports, and foreign direct investment, the Department of Commerce supports the work of the NNMI Program by establishing industry-led manufacturing innovation institutes. The Department hosts the AMNPO, an interagency team with participation from federal agencies that oversees the planning, management, and coordination of the NNMI Program.

Innovation results from initial advances that lead to additional technology and process improvements, with resulting benefits accruing to industry, the economy, and society as a whole. Innovation in advanced manufacturing begins with the generation of new ideas that are refined and matured through applied research, development, and invention. Manufacturers then scale those ideas for mass production in order to generate process improvements and make new products. The experience and knowledge gained through manufacturing then leads to new ideas that start the cycle again. The Department has central responsibility for supporting and expanding each part of this cycle and has the relationships with businesses necessary to identify the workforce skills needed to support new and growing industries.

The Department increases regional and national capacity for innovative manufacturing through partnerships with state and local governments, academic institutions, and the private sector. Through the Department’s convening power, regional economic development programs, and statistical and economic analysis, it empowers industry-driven solutions to the shortage of high demand skills. Finally, the Department supports research and development leading to transformative changes in technology and promotes intellectual property policy that supports and protects innovation. By supporting public-private partnerships, such as the NNMI, the Department helps to accelerate technology development and

APPENDIX B. FEDERAL AGENCIES PARTICIPATING IN THE NNMI PROGRAM

commercialization, and strengthen the nation's position in the global competition for new products, new markets, and new jobs.

National Institute of Standards and Technology

The Department's National Institute of Standards and Technology (NIST) is the only research laboratory in the U.S. government specifically focused on enhancing industrial competitiveness, including a robust research portfolio concentrated on the technical challenges associated with advanced manufacturing. In addition, the NIST Manufacturing Extension Partnership (MEP) is a critical resource to engage small and mid-size manufacturers to develop new products, expand into global markets, and adopt new technologies, such as those in development at the institutes.

Department of Defense

The Department considers the Defense Industrial Base to be a part of its force structure. It is as essential to national security as its people in uniform and DoD civilians. For nearly 60 years, the DoD Manufacturing Technology (ManTech) Program, overseen by the Office of the Deputy Assistant Secretary of Defense for Manufacturing and Industrial Base Policy, has been the Defense Department's investment mechanism for staying at the forefront of defense-essential manufacturing capability and is a key component of maintaining a healthy and resilient Defense Industrial Base. ManTech focuses on enabling the affordable and timely development, production, and sustainment of defense systems, thereby enhancing the nation's technological edge in a dynamic, diverse, and evolving threat environment. The growing family of DoD-led manufacturing innovation institutes has become a key component of the Department's strategy to fully develop and enable the full-scale production of critical technologies across the Defense Industrial Base.

The DoD has established five institutes and has one more planned for Fiscal Year 2016. The five established institutes are: America Makes, the National Additive Manufacturing Innovation Institute; the Digital Manufacturing and Design Innovation Institute (DMDII); Lightweight Innovations For Tomorrow (LIFT), at the time called the Lightweight and Modern Metals Manufacturing Innovation Institute; the American Institute for Manufacturing integrated Photonics - AIM Photonics; and NextFlex | America's Flexible Hybrid Electronics Manufacturing Institute. The DoD plans to award a cooperative agreement for Revolutionary Fibers and Textiles in Fiscal Year 2016.

Department of Education

The Department of Education supports education at all levels with across-the-board relevance to the knowledge and skill needs of the economy. Particular programs and initiatives focus on Science, Technology, Engineering, and Mathematics (STEM) fields, which are especially important in building the technically skilled workforce needed by the advanced manufacturing industry. Most significantly, the Department administers funds that support career and technical education programs in local education agencies and community colleges across the nation. Further, the Department conducts leadership and technical assistance activities to promote quality career and technical education programs that are well articulated between secondary and post-secondary levels, and lead to successful careers. A particular focus for leadership and assistance programs is on advanced manufacturing. The Department is supporting federal efforts to revive this sector through its support for the technical skills agenda.

NNMI PROGRAM STRATEGIC PLAN

The Department has been active in helping develop NNMI from its formation, and collaborates with other federal agencies, in particular those that focus on the knowledge and skill needs of the economy and efforts related to student success.

Department of Energy

The Department of Energy (DOE) mission is to ensure America's security and prosperity by addressing its energy, environmental, and nuclear challenges through transformative science and technology solutions. This includes catalyzing the timely, material and efficient transformation of the nation's energy system and securing U.S. leadership in clean energy technologies, as well as, maintaining a vibrant U.S. effort in science and engineering as a cornerstone of our economic prosperity. To accomplish these goals, the DOE has established the Clean Energy Manufacturing Initiative (CEMI) as a cross-cutting initiative within the department to strengthen U.S. clean energy manufacturing competitiveness and to increase U.S. manufacturing competitiveness across the board by boosting energy productivity and leveraging low-cost domestic energy resources and feedstocks. Clean energy manufacturing involves the minimization of the energy and environmental impacts of the production, use, and disposal of manufactured goods, which range from fundamental commodities such as metals and chemicals to sophisticated final-use products such as automobiles and wind turbine blades. The manufacturing sector, a subset of the industrial sector, consumes 25 exajoules (24 quads) of primary energy annually in the United States — about 79% of total industrial energy use. The DOE partners with private and public stakeholders to support the research, development, and deployment of innovative technologies that can improve U.S. competitiveness, save energy, and ensure global leadership in advanced manufacturing and clean energy technologies.

The DOE uses manufacturing innovation institutes to develop energy efficiency and renewable energy technologies to support the CEMI. To date, the DOE has awarded two institutes. The first, PowerAmerica, is focused on wide bandgap semiconductor technologies for next generation power electronics. The second, the Institute for Advanced Composites Manufacturing Innovation, is focused on composite technologies for vehicles, wind turbine blades, and compressed gas storage tanks. A third institute, Smart Manufacturing: Advanced Sensors, Controls, Platforms and Modelling for Manufacturing, has been issued as an open competitive solicitation at the time of this report.

National Aeronautics and Space Administration

The National Aeronautics and Space Administration (NASA) depends on manufacturing innovation to enhance its technical and scientific capabilities in aeronautics and space exploration. NASA will support the NNMI Program through funded research and development to help stimulate its mission-related capacity for innovation and economic growth within the government, at universities, and at industrial companies.

NASA's Space Technology Mission Directorate (STMD) serves as the Agency's principal organization supporting the NNMI Program. STMD rapidly develops, demonstrates, and infuses revolutionary, high-payoff technologies through transparent, collaborative partnerships, expanding the boundaries of the aerospace enterprise. By investing in bold, broadly applicable, disruptive technology that industry cannot tackle today, STMD seeks to mature the technology required for NASA's future missions in science and exploration while proving the capabilities and lowering the cost for other government agencies and commercial space activities. These collective efforts give NASA the ability to do first-of-a-kind missions and longer-term advancements in research and technology — those beyond what industry will take on

APPENDIX B. FEDERAL AGENCIES PARTICIPATING IN THE NNMI PROGRAM

and those focused on national advancement in aeronautics and space that also align with NASA's role in the NNMI Program.

NASA will leverage the NNMI Program to support advanced manufacturing technology research and development as a critical means of addressing improved affordability, enhanced performance, and improved safety and reliability for NASA's aerospace research and development efforts. NASA investments span low, mid, and high technology readiness levels (TRLs) through multiple NASA programs including the Small Business Innovation Research (SBIR) Program, Small Business Technology Transfer (STTR), Game Changing Development, Technology Demonstration Missions, and other grant opportunities.

Advanced manufacturing research and development at NASA is focused in several areas: cutting-edge materials, additive manufacturing (3D printing), polymer matrix composites, metals processing/joining, robotics, computational physics-based modeling, non-destructive evaluation, and other highly specialized areas. This research and development is conducted through a combination of in-house activities at NASA centers, competitively funded research with universities and industry, and collaborations with other agencies, universities, and industry. The rapid infusion of advanced manufacturing technologies into mission applications is a major emphasis of NASA's technology investment plan.

NASA is expanding its efforts to engage industry and academia on advanced manufacturing topics central to the nation's space mission through its National Center of Advanced Manufacturing, with a particular focus to develop "technology testbeds" within its research facilities and manufacturing technologies that reduce the weight of materials during space flight.

NASA has participated in the NNMI Program since its inception and is committed to partnering with other participating agencies to identify key technical challenges in advanced manufacturing research and development, focus resources to address these challenges, and accelerate the development of advanced manufacturing breakthroughs and their translation into commercial products.

National Science Foundation

The National Science Foundation (NSF) supports fundamental advanced manufacturing research, education and workforce training in its Directorates for Engineering, Computer and Information Science and Engineering, Mathematical and Physical Sciences, and Education and Human Resources. It also promotes advanced manufacturing innovation through a variety of translational research programs, including the SBIR, STTR, and Grant Opportunities for Academic Liaison with Industry (GOALI) Programs, and by partnering with industry, states, and other agencies. In Fiscal Year 2015, the NSF and NIST jointly established and funded MForesight: Alliance for Manufacturing Foresight, a think-and-do tank that harnesses the expertise of the broad U.S.-based manufacturing community to forecast future advanced manufacturing technologies.

The NSF advanced manufacturing investment is primarily through its Cyber-enabled Materials, Manufacturing and Smart Systems (CEMMSS) priority area. An estimated \$231.46 million was invested in CEMMSS in Fiscal Year 2015, with an estimated \$164.73 million of that in advanced manufacturing. These programs support fundamental research leading to transformative advances in manufacturing that address size scales from nanometers to kilometers, including process modeling, advanced sensing and control techniques, smart manufacturing using sustainable materials, chemical reactor design and control,

NNMI PROGRAM STRATEGIC PLAN

and manufacturing processes and enabling technology to support the biopharmaceutical, biotechnology, and bioenergy industries, with emphases on efficiency, economy, and minimal environmental impact. Advanced manufacturing is also supported through the Engineering Research Centers (ERC), Industry/University Cooperative Research Centers (I/UCRC), and Advanced Technological Education (ATE) programs. With an emphasis on two-year colleges, the ATE program focuses on the education of technicians for the high-technology fields that drive our nation's economy.

All NSF programs welcome the submission of proposals to collaborate with manufacturing innovation institutes in cutting-edge research and educational projects. Projects that are currently funded by NSF are also encouraged to request funding supplements to perform collaborative research and/or educational projects with institutes. It is expected that the incorporation of the resources, expertise, and experience of the institutes' members will increase the competitiveness of such proposals in merit review.

Small Business Administration

The U.S. Small Business Administration (SBA) was created in 1953 as an independent agency of the federal government to aid, counsel, assist and protect the interests of small business concerns, to preserve free competitive enterprise, and to maintain and strengthen the overall economy of our nation. We recognize that small business is critical to our economic recovery and strength, to building America's future, and to helping the United States compete in today's global marketplace. Although SBA has grown and evolved in the years since it was established in 1953, the bottom line mission remains the same. The SBA helps Americans start, build, and grow businesses. Through an extensive network of field offices and partnerships with public and private organizations, SBA delivers its services to people throughout the United States, Puerto Rico, the U.S. Virgin Islands and Guam.

U.S. Department of Agriculture

Worldwide, the bioenergy and bio-products industries are emerging as new and rapidly growing sectors; given the high productivity of the U.S. agricultural industry, bio-based product manufacturing is a significant opportunity for the United States to support growth of a bio-economy. Expansion of the bio-economy has the potential to sustainably harvest and utilize 1 billion tons of new biomass in the United States without affecting existing farm and forestry product markets, growing the current market five-fold over the next 15 years and adding \$500 billion to the annual bio-economy.

The agricultural sector is essential for ensuring sustainable, reliable, and accessible production of bioenergy and bio-based products that: 1) replace the use of petroleum and other strategic materials that would otherwise need to be imported, 2) create higher-value revenue streams for producers in rural and agricultural communities, 3) improve the nutrition and well-being of animals and humans; and 4) provide ecosystem services such as ensuring clean air and water, biodiversity, and nutrient cycling to the environment and society.

The U.S. Department of Agriculture recognizes the role that manufacturing plays in maximizing the benefits of a sustainable, rural economy. Areas of interest include bio-manufacturing and bio-products development to: 1) establish processes and chemical platforms leading to high-value intermediate and end-use products, 2) support commercialization of products developed from basic and applied research, 3) build domestic capability for ongoing bio-manufacturing and bio-products development, and 4) educate and train needed workforce. The growth of the bio-economy also depends upon understanding and

APPENDIX B. FEDERAL AGENCIES PARTICIPATING IN THE NNMI PROGRAM

addressing the entire supply chain of the bio-economy, rural America's role in the bio-economy, and the role of research and development.

In addition, nanocellulose materials have enormous promise to bring about fundamental changes in and significant benefit from our nation's use of renewable resources. When derived from trees, these cellulose nanomaterials: 1) are renewable and sustainable; 2) are produced in trees via photosynthesis from solar energy, atmospheric carbon dioxide, and water; 3) store carbon; and 4) depend upon how long cellulose-based products remain in service, are carbon negative or carbon neutral. Cellulosic nanocrystals, for example, are predicted to have strength properties comparable to Kevlar, have piezoelectric properties comparable to quartz, and can be manipulated to produce photonic structures. Current global research directions in cellulose nanomaterials indicate that this material could be used for a variety of new and improved product applications, including lighter and stronger paper and paperboard products; lighter and stronger building materials; wood products with improved durability; barrier coatings; body armor; automobile and airplane composite panels; electronics; biomedical applications; and replacement of petrochemicals in plastics and composites.



Appendix C. Abbreviations

AIM Photonics	American Institute for Manufacturing Integrated Photonics
AMNPO	Advanced Manufacturing National Program Office
AMP	Advanced Manufacturing Partnership
ATE	Advanced Technological Education (NSF)
CEMI	Clean Energy Manufacturing Initiative (DOE)
CEMMSS	Cyber-enabled Materials, Manufacturing and Smart Systems (NSF)
DMDII	Digital Manufacturing and Design Innovation Institute
DOC	Department of Commerce
DoD	Department of Defense
DOE	Department of Energy
DOEd	Department of Education
EDA	Economic Development Administration (DOC)
EOP	Executive Office of the President
ERC	Engineering Research Center (NSF)
FAA	Federal Aviation Administration
FDA	Food and Drug Administration
GAO	Government Accountability Office
GOALI	Grant Opportunities for Academic Liaison with Industry (NSF)
I/UCRC	Industry/University Cooperative Research Centers (NSF)
IACMI	Institute for Advanced Composites Manufacturing Innovation
IT	Information Technology
LIFT	Lightweight Innovations for Tomorrow
ManTech	Manufacturing Technology (DoD)
MEP	Manufacturing Extension Partnership (DOC/NIST)
MOU	Memorandum of Understanding
MRL	Manufacturing Readiness Level
NAICS	North American Industry Classification System
NASA	National Aeronautics and Space Administration
NEC	National Economic Council (EOP)
NIST	National Institute of Standards and Technology (DOC)
NNMI	National Network for Manufacturing Innovation
NSF	National Science Foundation
NSTC	National Science and Technology Council
OMB	Office of Management and Budget (EOP)
OSTP	Office of Science and Technology Policy (EOP)
PCAST	President's Council of Advisors on Science and Technology
RAMI	Revitalize American Manufacturing and Innovation
SAM	Subcommittee on Advanced Manufacturing (NSTC)
SBIR	Small Business Innovation Research
SME	Small and Mid-Sized Enterprise
STEM	Science, Technology, Engineering, and Mathematics
STMD	Space Technology Mission Directorate
STTR	Small Business Technology Transfer Research Program
TRL	Technology Readiness Level
USDA	United States Department of Agriculture
WIOA	Workforce Innovation and Opportunities Act

Advanced Manufacturing National Program Office

www.manufacturing.gov