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Report to Congressional Committees

May 2019

ADVANCED MANUFACTURING

Innovation Institutes Have Demonstrated Initial Accomplishments, but Challenges Remain in Measuring Performance and Ensuring Sustainability

GAO-19-409

GAO Highlights

Highlights of GAO-19-409, a report to congressional committees

May 2019

ADVANCED MANUFACTURING

Innovation Institutes Have Demonstrated Initial Accomplishments, but Challenges Remain in Measuring Performance and Ensuring Sustainability

Why GAO Did This Study

Manufacturing USA is a national network of manufacturing innovation institutes. Commerce, DOD, and DOE have together provided $1 billion to establish the network's institutes and to promote research, development, and commercialization of advanced manufacturing technologies.

The Revitalize American Manufacturing and Innovation Act of 2014 includes a provision for GAO to assess the Manufacturing USA program. This is GAO's second report in response to the provision. Among other objectives, this report (1) describes the status of the Manufacturing USA network; (2) evaluates actions taken by Commerce, DOD, and DOE to assess progress of the Manufacturing USA program; and (3) examines planning for institute sustainability beyond the initial 5 to 7 years of federal financial assistance.

GAO reviewed documentation and interviewed agency and Manufacturing USA institute officials, as well as a nongeneralizable sample of seven institute members from different-sized companies and academia.

What GAO Recommends

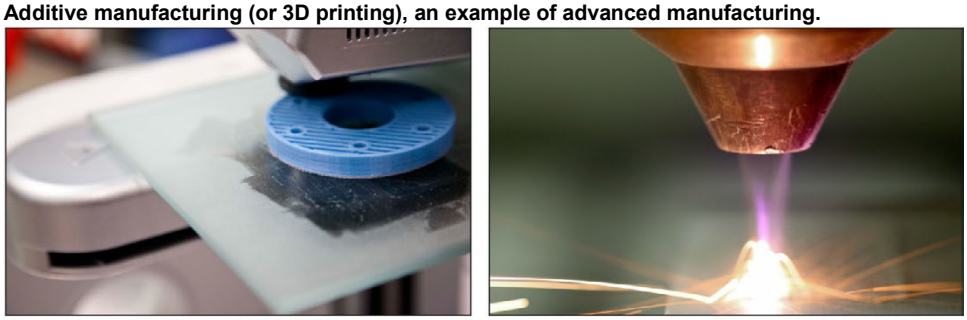
GAO is making five recommendations, including that Commerce work with DOD and DOE to develop performance goals with measurable targets and time frames, and the three agencies develop criteria to evaluate their institutes' sustainability. Commerce requested changes to the performance goals recommendations that would have altered their scope and intent. GAO maintains the recommendations are valid as stated. The three agencies generally agreed with the criteria development recommendations.

View GAO-19-409. For more information, contact John Neumann at (202) 512-6888 or neumannj@gao.gov.

What GAO Found

Since December 2016, the Manufacturing USA network has grown from 11 to 14 manufacturing innovation institutes that are implementing a wide array of activities aimed at developing manufacturing capabilities in promising new advanced technologies, as shown in the figure. As of March 2019, most institutes were operating under an initial 5- to 7-year period of federal financial assistance.

Additive manufacturing (or 3D printing), an example of advanced manufacturing.



Source: Department of Energy. | GAO-19-409

The Department of Commerce, through a national program office, along with the Departments of Defense (DOD) and Energy (DOE) have developed long-term goals for the Manufacturing USA program, such as increasing the competitiveness of U.S manufacturing, but have not developed measurable near-term goals with associated targets and time frames to assess progress over time. Prior GAO work has shown that systems of performance measures benefit from certain key practices, such as creating a hierarchy that breaks down broad, long-term goals and objectives into more specific, near-term performance goals with measurable targets and time frames. Commerce officials said that they are not in a position to set targets for the network-wide performance measures because they do not manage or fund individual institute activities. However, by developing and implementing network-wide performance goals with targets and time frames, Commerce would have better assurance that it could observe and report on progress toward Manufacturing USA long-term goals and objectives.

Commerce, DOD, and DOE have taken steps to support their institutes' sustainability planning for the years after the initial 5- to 7-year period of federal financial assistance. All 14 institutes have conducted various levels of sustainability planning and foresee generally negative impacts if baseline federal financial assistance ends, such as the need to focus more on short-term projects for industry use rather than projects that advance the manufacturing innovation ecosystem as a whole. However, as of February 2019, while the agencies had taken steps to support institute sustainability planning, they had not developed criteria to evaluate whether the institutes will be able to sustain their operations. Developing criteria for evaluating institutes' progress toward sustainability would provide Commerce, DOD, and DOE greater assurance that decisions about providing additional federal financial assistance for the institutes will be based on an analysis of the risks the institutes face in successfully carrying out the statutory purposes for the Manufacturing USA program.

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Abbreviations

AFFOA	Advanced Functional Fabrics of America Institute
AIM Photonics	American Institute for Manufacturing Integrated Photonics
America Makes	National Additive Manufacturing Innovation Institute
AMNPO	Advanced Manufacturing National Program Office
ARM	Advanced Robotics for Manufacturing Institute
BioFabUSA	Advanced Regenerative Manufacturing Institute
CESMII	Clean Energy Smart Manufacturing Innovation Institute
DOD	Department of Defense

Abbreviations Continued

DOE	Department of Energy
DOL	Department of Labor
IACMI	Institute for Advanced Composites Manufacturing Innovation
LIFT	Lightweight Innovations for Tomorrow
MRL	Manufacturing Readiness Level
MxD	The Digital Manufacturing Institute
NASA	National Aeronautics and Space Administration
NextFlex	America's Flexible Hybrid Electronics Manufacturing Institute
NIIMBL	The National Institute for Innovation in Manufacturing Biopharmaceuticals
NIST	National Institute of Standards and Technology
NSF	National Science Foundation
PCAST	President's Council of Advisors on Science and Technology
PowerAmerica	The Next Generation Power Electronics Manufacturing Innovation Institute
RAMI Act	Revitalize American Manufacturing and Innovation Act of 2014
RAPID	Rapid Advancement in Process Intensification Deployment Institute
REMADE	Reducing EMbodied-energy And Decreasing Emissions Institute
SEMATECH	U.S. Semiconductor Manufacturing Technology Consortium
TRL	Technology Readiness Level
USDA	U.S. Department of Agriculture

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Congressional Committees

Advanced technologies such as 3D printing and biopharmaceuticals[1] have become increasingly important to many aspects of the U.S. economy, including transportation, health care, and national security and defense. Throughout much of the 20th century, the United States was a global leader in innovation and manufacturing, and strategic private and public investment in research, development, and commercialization of advanced technologies played a crucial role in creating new U.S. industries and millions of jobs for American workers. However, the nation's manufacturing sector has experienced significant disruption over the last 2 decades.[2] According to a 2018 Congressional Research Service report, the United States' share of global manufacturing declined from 28 percent in 2002 to about 18 percent in 2016.[3] In addition, a recent expert study found that the United States has lost significant ability to manufacture the advanced technologies that were first innovated here and that represent the country's high-value innovation system.[4] The study warns that the ability to manufacture the next generation of these technologies is facing an imminent shift abroad, exacerbating the United States' trade deficit in advanced technology goods—which exceeded $100 billion in 2018, according to U.S. Census Bureau data[5]—and posing significant long-term economic risk to the United States' ability to generate economic growth through innovation leadership.[6]

[1]Biopharmaceuticals are medicines produced or extracted from biological sources, such as living cells.

[2]William B. Bonvillian and Peter L. Singer, *Advanced Manufacturing: The New American Innovation Policies* (Cambridge, MA: MIT Press, 2017), 1.

[3]The decline of U.S. share of global manufacturing to about 18 percent in 2016 includes a rise from 16.5 percent in 2011. Congressional Research Service, *U.S. Manufacturing in International Perspective* (Washington, D.C.: Feb. 21, 2018).

[4]Bonvillian and Singer, *Advanced Manufacturing*, 51, 55.

[5]According to 2018 data from the U.S. Census Bureau, the trade deficit in advanced technology products began in 2002 and grew to $120 billion by 2018.

[6]Bonvillian and Singer, *Advanced Manufacturing*, 51.

Beginning in June 2011, the President's Council of Advisors on Science and Technology (PCAST) issued a series of reports that recommended a number of steps to increase U.S. competitiveness in advanced manufacturing.[7] Among other things, PCAST recommended that the federal government establish a national network of manufacturing innovation institutes as public-private partnerships to create a manufacturing research infrastructure; according to PCAST, such a network could help bridge the gap between research and development activities and domestic production. At the request of the President, and using its existing statutory authority, the Department of Defense (DOD) established a pilot manufacturing innovation institute in 2012, which focused on additive manufacturing technology.[8] In January 2013, the National Science and Technology Council released a report proposing a preliminary design for the network.[9] Since that time, DOD and the Department of Energy (DOE) have established additional institutes using their existing statutory authorities.

In December 2014, the Revitalize American Manufacturing and Innovation Act of 2014 (RAMI Act) was enacted as part of the

[7]Executive Office of the President, President's Council of Advisors on Science and Technology, *Report to the President on Ensuring American Leadership in Advanced Manufacturing* (Washington, D.C.: June 2011). Also, see Executive Office of the President, President's Council of Advisors on Science and Technology, *Report to the President on Capturing Domestic Competitive Advantage in Advanced Manufacturing* (Washington, D.C.: July 2012); and Executive Office of the President, President's Council of Advisors on Science and Technology, *Report to the President: Accelerating U.S. Advanced Manufacturing* (Washington, D.C.: October 2014).

[8]DOD established the pilot institute with co-funding and participation from the Department of Energy and other agencies. Additive manufacturing (also called 3D printing) is a suite of technologies to fabricate metallic, plastic, ceramic, and electronic parts using a technique in which material is precisely placed layer-by-layer as directed from a digital file. For more information on 3D printing, see GAO, *3D Printing: Opportunities, Challenges, and Policy Implications of Additive Manufacturing*, GAO-15-505SP (Washington, D.C.: June 24, 2015).

[9]Executive Office of the President, National Science and Technology Council, Advanced Manufacturing National Program Office, *National Network for Manufacturing Innovation: A Preliminary Design* (Washington, D.C.: January 2013). The National Science and Technology Council was established by executive order on November 23, 1993. Exec. Order No. 12,881, 58 Fed. Reg. 62491 (Nov. 26, 1993). The principal functions of this cabinet-level council include coordinating the science and technology policy-making process and ensuring science and technology policy decisions and programs are consistent with the President's goals.

Consolidated and Further Continuing Appropriations Act, 2015.[10] Among other things, the RAMI Act requires the Secretary of Commerce to establish the Network for Manufacturing Innovation Program within the Department of Commerce's National Institute of Standards and Technology (NIST). As part of that program, the Secretary is to establish a network of centers for manufacturing innovation.[11] Now known as Manufacturing USA,[12] the network consists of manufacturing innovation institutes established by Commerce, DOD, and DOE.[13] Each institute has its own technological focus and is a public-private partnership between the sponsoring federal agency and a nonfederal entity (generally a nonprofit organization or university) in charge of the institute's operations. Each institute also consists of members, including private companies, nonprofit organizations, academic institutions, federal laboratories, and state and local governments. Under the RAMI Act, the purposes of the Manufacturing USA program include, among other things, stimulating U.S. leadership in advanced manufacturing research, innovation, and technology; accelerating development of an advanced manufacturing workforce; and leveraging nonfederal sources of support to promote a stable and sustainable business model without the need for long-term federal funding.[14]

The RAMI Act also requires the Secretary of Commerce to establish, within NIST, a national program office to oversee and carry out the program; this office is known as the Advanced Manufacturing National

[10]Pub. L. No. 113-235, Div. B, Title VII, § 703(2), 128 Stat. 2220, 2221 (2014) (codified at 15 U.S.C. § 278s).

[11]The act authorizes the Secretary of Commerce to award financial assistance to assist in planning, establishing, or supporting centers for manufacturing innovation.

[12]On September 12, 2016, then-Commerce Secretary Pritzker announced a new public brand name for the National Network for Manufacturing Innovation: Manufacturing USA. The official name of the program remains the National Network for Manufacturing Innovation. In this report, we use the name Manufacturing USA for the program.

[13]DOD and DOE established and manage their institutes under authority separate from the RAMI Act. For example, the DOD institutes are established under the DOD Manufacturing Technology Program codified at 10 U.S.C. §2521. DOD told us that its participation in the Manufacturing USA network is a collaborative partnership of choice in light of a common purpose.

[14]15 U.S.C. § 278s(a)(2). Under the design of the network as envisioned in the 2013 National Science and Technology Council report, an institute would become self-sustaining and fully independent of federal funds within 7 years of its launch.

Program Office (AMNPO).[15] The RAMI Act specifies a number of functions for the national program office, such as establishing procedures, processes, and criteria as may be necessary and appropriate to maximize cooperation and to coordinate the activities of the program with programs and activities of other federal departments and agencies whose missions contribute to or are affected by advanced manufacturing.[16] AMNPO also produces required reports on the Manufacturing USA program; the RAMI Act requires the Secretary of Commerce to report annually to Congress, until December 31, 2024, on certain elements of the program's performance, including an assessment of the program with respect to meeting its statutory purposes.[17]

The RAMI Act also contains a provision for GAO to, not less frequently than once every 2 years, submit to Congress an assessment of the operation of the Manufacturing USA program and to submit a final report not later than December 31, 2024.[18] The act provides that each assessment is to include a review of the management, coordination, and industry utility of the Manufacturing USA program and an assessment of the extent to which the Manufacturing USA program has furthered its statutory purposes, among other things. In our first report pursuant to the RAMI Act, issued in April 2017, we found that opportunities existed to strengthen interagency collaboration on the Manufacturing USA institutes, and we recommended that Commerce work with all relevant federal agencies to fully identify roles and responsibilities for how agencies that do not sponsor institutes (i.e., non-sponsoring agencies) could contribute

[15]AMNPO is an interagency team with participation from federal agencies involved in advanced manufacturing, such as DOD, the National Science Foundation, and the National Aeronautics and Space Administration. In addition to serving as the national office for the Manufacturing USA program, AMNPO also operates under the National Science and Technology Council on cross-agency initiatives related to advanced manufacturing.

[16]15 U.S.C. § 278s(f)(2). In this report, we refer to agencies that do not sponsor Manufacturing USA institutes but whose missions contribute to or are affected by advanced manufacturing as non-sponsoring agencies.

[17]15 U.S.C. § 278s(g)(2). In August 2018, AMNPO published its third annual report, which covered activities and accomplishments through fiscal year 2017. See also Executive Office of the President, National Science and Technology Council, Advanced Manufacturing National Program Office, *National Network for Manufacturing Innovation Program: Annual Report* (Washington, D.C.: February 2016), accessed March 2019, https://www.manufacturingusa.com/sites/prod/files/docs/resource/2015-NNMI-Annual-Report.pdf.

[18]15 U.S.C. § 278s(g)(3).

to the Manufacturing USA program.[19] Commerce agreed with our recommendation and provided information on steps that AMNPO planned to take to implement it. In our April 2017 report, we also found, among other things, that AMNPO, DOD, and DOE worked together to develop initial network-wide performance measures to track progress toward the Manufacturing USA program's statutory purposes, and that AMNPO planned to work with DOD and DOE to reach agreement on a revised set of measures.

This is our second report on the Manufacturing USA program. This report (1) describes the status of the Manufacturing USA network since our April 2017 report, (2) identifies lessons learned for the Manufacturing USA program from selected advanced manufacturing public-private partnerships, (3) evaluates the extent to which AMNPO has fully identified the roles and responsibilities of relevant non-sponsoring agencies, (4) evaluates what actions AMNPO and sponsoring agencies have taken to assess progress toward the statutory purposes of the Manufacturing USA program, and (5) examines planning for institute sustainability beyond the 5- to 7-year period of initial federal financial assistance.

To review the status of the Manufacturing USA network, the roles and responsibilities of relevant non-sponsoring agencies, actions taken by AMNPO and sponsoring agencies to assess progress toward the statutory purposes of the Manufacturing USA program, and planning for institute sustainability, we collected and analyzed information from AMNPO, sponsoring agencies, Manufacturing USA institutes, and selected non-sponsoring agencies. These efforts included the following:

- **AMNPO.** We obtained and analyzed Manufacturing USA program documentation, such as Manufacturing USA annual reports; documents detailing AMNPO, sponsoring agency, and non-sponsoring agency roles and responsibilities within the Manufacturing USA program; and the original and revised program charters. We also interviewed AMNPO officials to obtain information across our objectives.
- **Sponsoring agencies.** We obtained and reviewed guidance, policy, and institute documentation from the three federal agencies that sponsor institutes—Commerce, DOD, and DOE—including, for

[19]GAO, *Advanced Manufacturing: Commerce Could Strengthen Collaboration with Other Agencies on Innovation Institutes*, GAO-17-320 (Washington, D.C.: Apr. 6, 2017).

example, the cooperative agreements or other documents sponsoring agencies used to establish the institutes. We also interviewed sponsoring agency officials to obtain information on their interactions with non-sponsoring federal agencies, performance measures for their institutes and the Manufacturing USA program, and sustainability planning.

- **Manufacturing USA institutes.** We collected and analyzed documents and data from the institutes on institute composition, funding, and projects for all Manufacturing USA institutes and reviewed the sustainability plans from the 14 institutes. We asked the institute representatives a series of questions about their process for collecting data and determined that the data were sufficiently reliable for our purposes. Our review generally reflects the status of institutes' sustainability planning as of August through November 2018, which is when we collected the majority of the institute sustainability plans. We also asked institute representatives a structured set of questions related to their institutes' (1) status, (2) performance metrics, (3) coordination with non-sponsoring federal agencies, and (4) planning for sustainability beyond the 5- to 7-year period of initial federal funding.
- **Non-sponsoring agencies.** We interviewed officials from four federal agencies that do not currently sponsor institutes but that have missions that contribute to or are affected by advanced manufacturing: the Department of Labor (DOL), the National Aeronautics and Space Administration (NASA), the National Science Foundation (NSF), and the U.S. Department of Agriculture (USDA). We asked these officials about their involvement with the Manufacturing USA program and institutes, among other topics.

In examining the actions AMNPO and sponsoring agencies have taken to assess progress toward the statutory purposes of the Manufacturing USA program, we compared AMNPO's performance measurement efforts against key practices for performance measurement we have identified in our past work.[20] We compared steps taken to support institutes'

[20]GAO, *Managing for Results: Practices for Effective Agency Strategic Reviews,* GAO-15-602 (Washington, D.C.: July 29, 2015).

sustainability planning against risk management protocols in the *Standards for Internal Control in the Federal Government*.[21]

Additionally, we conducted background interviews with representatives from three nonprofits focused on manufacturing and technology policy. We selected these organizations for interviews either based on recent, relevant reports they published on the Manufacturing USA network or on our awareness of the organization's familiarity with Manufacturing USA. We also interviewed a sample of seven institute members, including four large companies, two small companies, and one academic institution. We asked the members for their perspectives on various topics, including how their organizations benefited from Manufacturing USA institute membership, challenges in institute operations, and the institutes' sustainability planning. We selected institute members to provide a nongeneralizable sample of perspectives. Our selection is not representative of the full population of institute members but provides examples of the members' experiences with the institutes.

To identify lessons learned for the Manufacturing USA program from selected advanced manufacturing public-private partnerships, we conducted an initial literature review and analyzed reports and journal articles about advanced manufacturing initiatives and other public-private partnerships in the United States and internationally. We selected the U.S. Semiconductor Manufacturing Technology Consortium (SEMATECH) and Germany's Fraunhofer institutes as illustrative examples for this report due to the availability of information on these partnerships, their respective locations in the United States and abroad, their relevance to Manufacturing USA, and the frequency with which they were cited in our interviews with stakeholders.[22] We also conducted

[21]GAO, *Standards for Internal Control in the Federal Government*, GAO-14-704G (Washington, D.C.: Sept. 10, 2014). Internal controls comprise the plans, methods, polices, and procedures used to fulfill the mission, strategic plan, goals, and objectives of the agency.

[22]The SEMATECH and Fraunhofer models are discussed in PCAST's June 2011 report, which examined appropriate roles for the federal government in fostering innovation and recommended a number of steps to increase U.S. competitiveness in advanced manufacturing. While there are differences between the Fraunhofer and SEMATECH models and the Manufacturing USA program, such as the funding structure and the specific program purposes and goals, we believe Fraunhofer and SEMATECH can provide lessons learned in conducting applied research in advanced manufacturing that are applicable to the Manufacturing USA program because these models represent public-private partnerships for conducting applied research in advanced manufacturing.

interviews with current and former representatives from SEMATECH and Fraunhofer USA.

We conducted this performance audit from February 2018 through May 2019 in accordance with generally accepted auditing standards. Those standards require that we plan and perform the audit to obtain sufficient, appropriate evidence to provide a reasonable basis for our findings and conclusions based on our audit objectives. We believe that the evidence obtained provides a reasonable basis for our findings and conclusions based on our audit objectives.

Background

This section provides information on the Manufacturing USA network design, provisions of the RAMI Act, and the funding and membership of the Manufacturing USA institutes.

Manufacturing USA Network Design

According to the National Science and Technology Council's January 2013 report outlining the design of what would later become the Manufacturing USA network, the institutes would be designed to strengthen support for research and development that follows the beginning stages of innovation but precedes commercialization. As noted in our prior work, experts have said that middle-stage funding, investment, and support gaps occur for not only technology innovation but also manufacturing innovation.[23] The 2013 National Science and Technology Council report designed the Manufacturing USA institutes to address these gaps, alternately known as the "Valley of Death" and the "Missing Middle," which are represented by the middle section of the widely used Technology Readiness Level (TRL) scale.[24] According to the proposal, the institutes would therefore focus on TRL 4-7, shown in figure 1, which consist of component validation through system model or prototype demonstration. Figure 1 also shows the corresponding Manufacturing Readiness Level (MRL) scale on which the institutes would focus. The MRL scale is a measure of manufacturing maturity and is complementary to the TRL.

[23]GAO, *Nanomanufacturing: Emergence and Implications for U.S. Competitiveness, the Environment, and Human Health*, GAO-14-181SP (Washington, D.C.: Jan. 31, 2014).

[24]TRLs are a scale of nine levels used to measure a technology's progress, starting with paper studies of a basic concept and ending with a technology that has proven itself in actual usage on the product.

Figure 1: Technology Readiness Levels (TRL) and Manufacturing Readiness Levels (MRL)

	TRL 1:	Basic principles observed and reported	MRL 1:	Manufacturing feasibility assessed
	TRL 2:	Technology concept and/or application formulated	MRL 2:	Manufacturing concepts defined
	TRL 3:	Analytical and experimental critical function and/or characteristic proof of concept	MRL 3:	Manufacturing concepts developed
Manufacturing USA Target	TRL 4:	Component and/or breadboard validation in a laboratory environment	MRL 4:	Capability to produce the technology in a laboratory environment
Manufacturing USA Target	TRL 5:	Component or breadboard validation in a relevant environment	MRL 5:	Capability to produce prototype components in a production relevant environment
Manufacturing USA Target	TRL 6:	System/subsystem model or prototype demonstration in a relevant environment	MRL 6:	Capability to produce prototype system or subsystem in a production relevant environment
Manufacturing USA Target	TRL 7:	System prototype demonstration in an operational environment	MRL 7:	Capability to produce systems, subsystems, or components in a production-relevant environment
	TRL 8:	Actual system completed and qualified through test and demonstrated	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

Source: Executive Office of the President, National Science and Technology Council, Advanced Manufacturing National Program Office, *National Network for Manufacturing Innovation: A Preliminary Design* (Washington, D.C.: January 2013). | GAO-19-409

The National Science and Technology Council's preliminary design envisioned a network of public-private partnerships to be supported with a co-investment of federal obligations ranging from $70 million to $120 million for each institute and equal or greater amounts in nonfederal pledges (also known as cost-share). The amount of investment would depend on such factors as the magnitude of the opportunity and maturity of the technology and would be distributed across 5 to 7 years. According to the National Science and Technology Council's 2013 report, the total capitalization of an institute across this time period was envisioned to be $140 million to $240 million. The design also envisioned that an institute would become self-sustaining and fully independent of federal funds within 7 years of its launch through income-generating activities such as member fees, intellectual property licenses, contract research, and fee-for-service activities.

RAMI Act Provisions

Under the RAMI Act, the purposes of Manufacturing USA program are to:

- improve the competitiveness of U.S. manufacturing and to increase the production of goods manufactured predominantly within the United States;
- stimulate U.S. leadership in advanced manufacturing research, innovation, and technology;
- facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing manufacturing capabilities;
- facilitate access by manufacturing enterprises to capital-intensive infrastructure, including high-performance electronics and computing, and the supply chains that enable these technologies;
- accelerate the development of an advanced manufacturing workforce;
- facilitate peer exchange of and documentation of best practices in addressing advanced manufacturing challenges;
- leverage nonfederal sources of support to promote a stable and sustainable business model without the need for long-term federal funding; and
- create and preserve jobs.[25]

The RAMI Act requires the Secretary of Commerce, as part of the program, to establish a network of centers for manufacturing innovation, which we refer to as the Manufacturing USA network in this report. There are two types of centers (which we refer to as the Manufacturing USA institutes): those that receive financial assistance from Commerce under the RAMI Act and those that are part of the program but do not receive such funding from Commerce under the RAMI Act. Institutes that do not receive financial assistance from Commerce under the act are either (1) considered institutes by the act because they were formally recognized as manufacturing innovation centers under law or executive actions prior to the RAMI Act's enactment or (2) recognized by the Secretary of Commerce, at the institute's request, as an institute for manufacturing innovation for the purposes of participating in the network and are substantially similar to those established by Commerce under the act. There is one institute that receives financial assistance from Commerce under the RAMI Act—the National Institute for Innovation in

[25]15 U.S.C. § 278s(a)(2).

Manufacturing Biopharmaceuticals (NIIMBL). The RAMI Act also recognizes DOD's National Additive Manufacturing Innovation Institute (America Makes) as a manufacturing innovation center. The remaining institutes in the network were established by DOD and DOE and recognized as institutes by the Secretary of Commerce.[26]

AMNPO is the interagency office established to convene the network, support network functions, and issue RAMI Act-required reports on the Manufacturing USA program. As such, it is to implement the functions of the national program office, as identified under the act, including:

- overseeing the planning, management, and coordination of the program;
- entering into memorandums of understanding with federal departments and agencies whose missions contribute to or are affected by advanced manufacturing, to carry out the program's statutory purposes;
- developing, not later than 1 year after the date of enactment of the RAMI Act, and updating not less frequently than once every 3 years thereafter, a strategic plan to guide the program;
- establishing such procedures, processes, and criteria as may be necessary and appropriate to maximize cooperation and coordinate the activities of the program with programs and activities of other federal departments and agencies whose missions contribute to or are affected by advanced manufacturing;[27]
- establishing a clearinghouse of public information related to the activities of the program; and
- acting as a convener of the network.[28]

[26]Appendix I lists the 14 current Manufacturing USA institutes and provides background information about their missions and funding.

[27]However, the RAMI Act does not provide AMNPO with the authority to compel action by other federal agencies.

[28]15 U.S.C. § 278s(f)(2). A convener is a person who convenes or chairs a meeting, committee, etc., especially one who is specifically elected to do so.

Manufacturing USA Institutes' Funding and Membership

The Manufacturing USA institutes are established and managed through a cooperative agreement or a technology investment agreement between the federal sponsoring agency and nonfederal entity in charge of the institute's operations.[29] The agreements specify a total amount of federal financial assistance, along with a 1:1 minimum co-investment of matching funds. The federal investment provides the institutes with a baseline level of support—a set amount of federal financial assistance that institutes can use to sponsor projects as well as for general operations. According to the institutes' agreements and agency documentation, the planned federal baseline investments for the institutes range from about $55 million to $110 million over a period of 5 to 7 years. The planned co-investments range from about $70 million to $500 million over the same time period and include institute member dues, state support, and any federal support not part of the federal baseline investment, such as project-specific funding. Table 1 shows the planned federal baseline investment and co-investment for each institute over the life of its agreement.

Table 1: Planned Federal Baseline Investment and Co-Investment over the Life of the Institutes' Initial Agreements[a]

Dollars in millions

Institute	Planned federal baseline investment[b]	Planned co-investment[c]
America Makes – The National Additive Manufacturing Innovation Institute	56	85
MxD – The Digital Manufacturing Institute[d]	70	106
LIFT – Lightweight Innovations for Tomorrow	70	78
PowerAmerica – The Next Generation Power Electronics Manufacturing Innovation Institute	69	77
IACMI – Institute for Advanced Composites Manufacturing Innovation	70	95
AIM Photonics – American Institute for Manufacturing Integrated Photonics	110	503

[29]DOD entered into Technology Investment Agreements with the entities responsible for managing two institutes. Eleven federal agencies, including DOD and DOE, have statutory authority to use other transaction agreements. See also, GAO, *Federal Acquisitions: Use of 'Other Transaction' Agreements Limited and Mostly for Research and Development Activities*, GAO-16-209 (Washington, D.C.: Jan. 7, 2016).

Institute	Planned federal baseline investment[b]	Planned co-investment[c]
NextFlex – America's Flexible Hybrid Electronics Manufacturing Institute	75	96
AFFOA – Advanced Functional Fabrics of America Institute	75	272
CESMII – Clean Energy Smart Manufacturing Innovation Institute	70	171
BioFabUSA – Advanced Regenerative Manufacturing Institute	80	215
ARM – Advanced Robotics for Manufacturing Institute	80	174
NIIMBL – The National Institute for Innovation in Manufacturing Biopharmaceuticals	70	129
RAPID – Rapid Advancement in Process Intensification Deployment Institute	70	109
REMADE – Reducing EMbodied-energy And Decreasing Emissions Institute	70	70
Total	**1,035**	**2,180**

Source: GAO analysis of institute agreements and agency documentation. | GAO-19-409

[a]As of March 2019, all but two of the institutes were operating under their initial cooperative agreement or technology investment agreement. However, America Makes and MxD are operating under a second agreement.

[b]The amounts in table 1 are the federal funding commitments contained within the institutes' cooperative agreements or technology investment agreements. The Department of Defense has directed additional project funding amounts to its institutes that are outside of the institutes' agreements, and those amounts are not captured in this table.

[c]The institutes' cooperative agreements and technology investment agreements specify a minimum 1:1 co-investment of funds to match the federal baseline investment. These funds include member dues, state support, and any federal support outside of the federal baseline investment, such as project-specific funding.

[d]MxD was previously known as DMDII: The Digital Manufacturing and Design Innovation Institute. The institute was formally rebranded with its new name in February 2019.

The institutes provide members with a variety of benefits, such as access to shared facilities and equipment, access to intellectual property, and networking opportunities. Members can take advantage of these resources in a variety of ways, such as by collaborating with each other on cutting-edge research related to the technology focus area of the institute. Membership is open to all U.S. industrial organizations, academic institutions, nonprofit organizations, and government agencies that want to further technology and education in a certain focus area. Under some institutes' agreements, foreign members are allowed if the sponsoring agency approves such members and certain conditions are met, such as having a significant manufacturing footprint in the United States. Each institute has its own membership terms—including a range

of costs, rights and benefits, and required time commitment—as detailed in its formal membership agreement.

The 14 Institutes in the Network Are Operational and Have Undergone Some Changes, and Two Agencies Are Considering Establishing New Institutes

The Manufacturing USA network has continued to grow and develop since our April 2017 report described the network as of December 2016. Specifically, three new institutes have been established, bringing the total number of institutes operating and implementing activities in their technology areas to 14. The network has also developed task teams to work together on issues of mutual interest, and some institutes have undergone changes in management and membership structure. Additionally, DOE and USDA are considering establishing additional Manufacturing USA institutes.

Fourteen Institutes Are Operational and Implementing Activities in Their Technology Areas

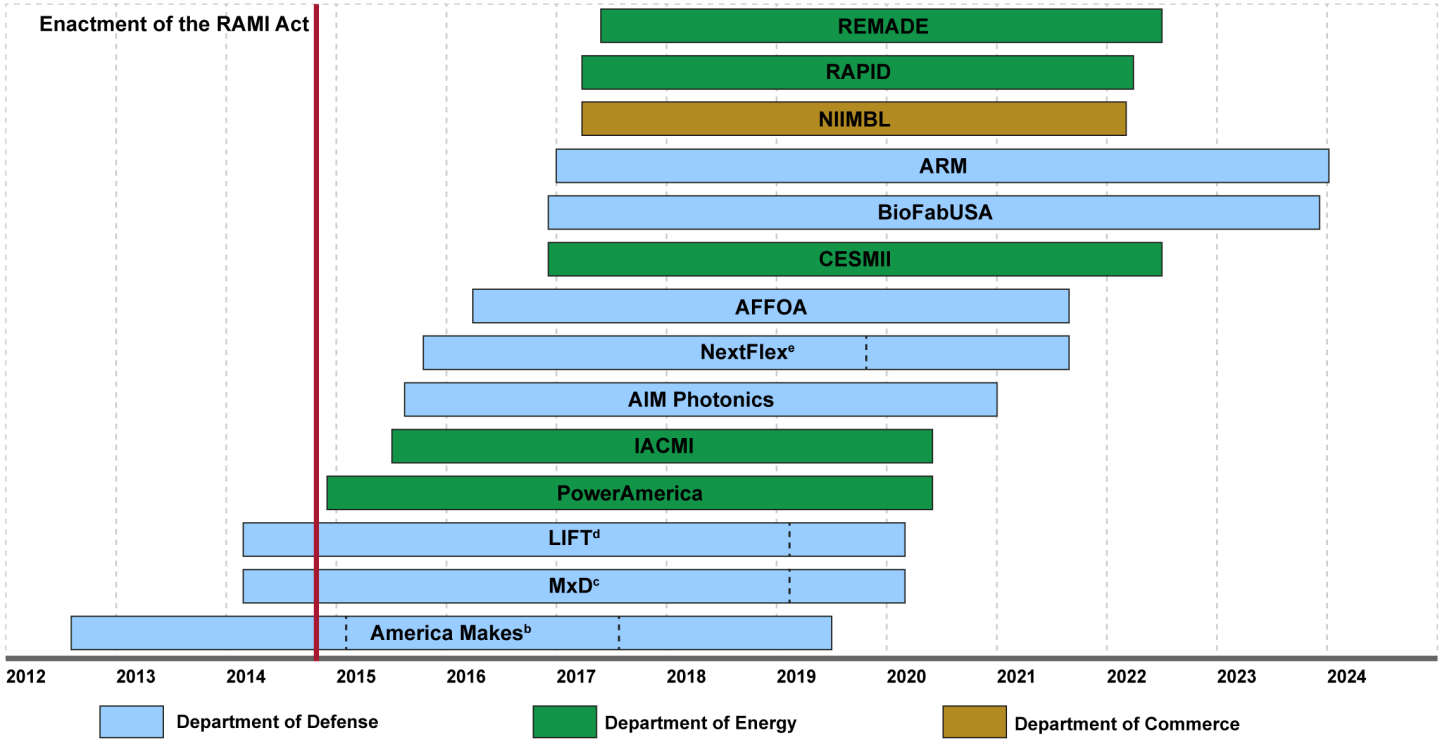
As of February 2019, 14 Manufacturing USA institutes were operational and implementing activities in their technology areas—an increase of three institutes since December 2016.[30] DOD established a new institute—the Advanced Robotics for Manufacturing (ARM) I nstitute—in January 2017. In addition, DOE established two new institutes in January 2017—the Rapid Advancement in Process Intensification Deployment Institute (RAPID) and the Reducing EMbodied-energy And Decreasing Emissions (REMADE) Institute.[31]

[30]December 2016 was the date through which we collected data for our April 2017 report on the Manufacturing USA program; see GAO-17-320. For the purposes of our analysis, we consider an institute to be established when the sponsoring federal agency signs an agreement, such as a cooperative agreement, with an award recipient to establish and manage the institute. Institute-sponsoring agencies may use a different definition of established.

[31]DOE considers RAPID to have been established in March 2017 and REMADE to have been established in May 2017. According to DOE, its financial assistance procedures allow DOE to issue conditional awards, which formally recognize the recipient and obligate DOE's appropriations, but the recipient is not authorized to spend the federal funds until full negotiations are completed. In the case of RAPID and REMADE, DOE told us that it opted to issue a conditional award for both institutes. DOE stated that once the conditions were lifted for RAPID on March 23, 2017, and REMADE and May 11, 2017, the recipients were authorized to spend federal funds to establish each institute, in partnership with DOE.

The initial federal financial assistance provided through the institutes' cooperative agreements or technology investment agreements with their sponsoring agencies will end at varying times, based on the period of performance agreed upon by the institutes and sponsoring agencies. Figure 2 shows the planned start and end dates identified in the institute agreements or by the sponsoring agencies for the institutes' initial federal financial assistance period.

Figure 2: Planned Start and End Dates for the Initial Federal Financial Assistance Period[a]



AFFOA – Advanced Functional Fabrics of America Institute
AIM Photonics – American Institute for Manufacturing Integrated Photonics
America Makes – The National Additive Manufacturing Innovation Institute
ARM – Advanced Robotics for Manufacturing Institute
BioFabUSA – Advanced Regenerative Manufacturing Institute
CESMII – Clean Energy Smart Manufacturing Innovation Institute
IACMI – Institute for Advanced Composites Manufacturing Innovation
LIFT – Lightweight Innovations for Tomorrow
MxD – The Digital Manufacturing Institute
NextFlex – America's Flexible Hybrid Electronics Manufacturing Institute
NIIMBL – The National Institute for Innovation in Manufacturing Biopharmaceuticals
PowerAmerica – The Next Generation Power Electronics Manufacturing Innovation Institute
RAPID – Rapid Advancement in Process Intensification Deployment Institute
REMADE – Reducting EMbodied-energy And Decreasing Emission Institute

Source: GAO analysis of institute agreements and agency information. | GAO-19-409

[a]The periods of performance for the institutes are identified in the institutes' cooperative agreements or technology investment agreements. However, agency officials stated that in some instances the agreements have not been formally modified to reflect when the sponsoring agency expects the

federal financial assistance period to end. We obtained additional documentation from sponsoring agencies to clarify the periods of performance for some institutes.

[b]According to the Department of Defense (DOD), the period of performance for America Makes' initial cooperative agreement was extended twice, from February 2015 to August 2017, and then again from August 2017 to June 2019. The extensions increased the period of performance to complete the work and write a final report. DOD does not anticipate providing additional baseline funding through the initial cooperative agreement.

[c]According to DOD, the period of performance for MxD's initial cooperative agreement was extended from February 2019 to February 2020. The extension increased the period of performance to complete the work and write a final report. DOD does not anticipate providing additional baseline funding through the initial cooperative agreement. MxD was previously known as DMDII: The Digital Manufacturing and Design Innovation Institute. The institute was formally rebranded with its new name in February 2019.

[d]According to DOD, the period of performance for LIFT's initial cooperative agreement was extended from February 2019 to February 2020. The extension increased the period of performance to complete the work and write a final report. DOD does not anticipate providing additional baseline funding through the initial cooperative agreement.

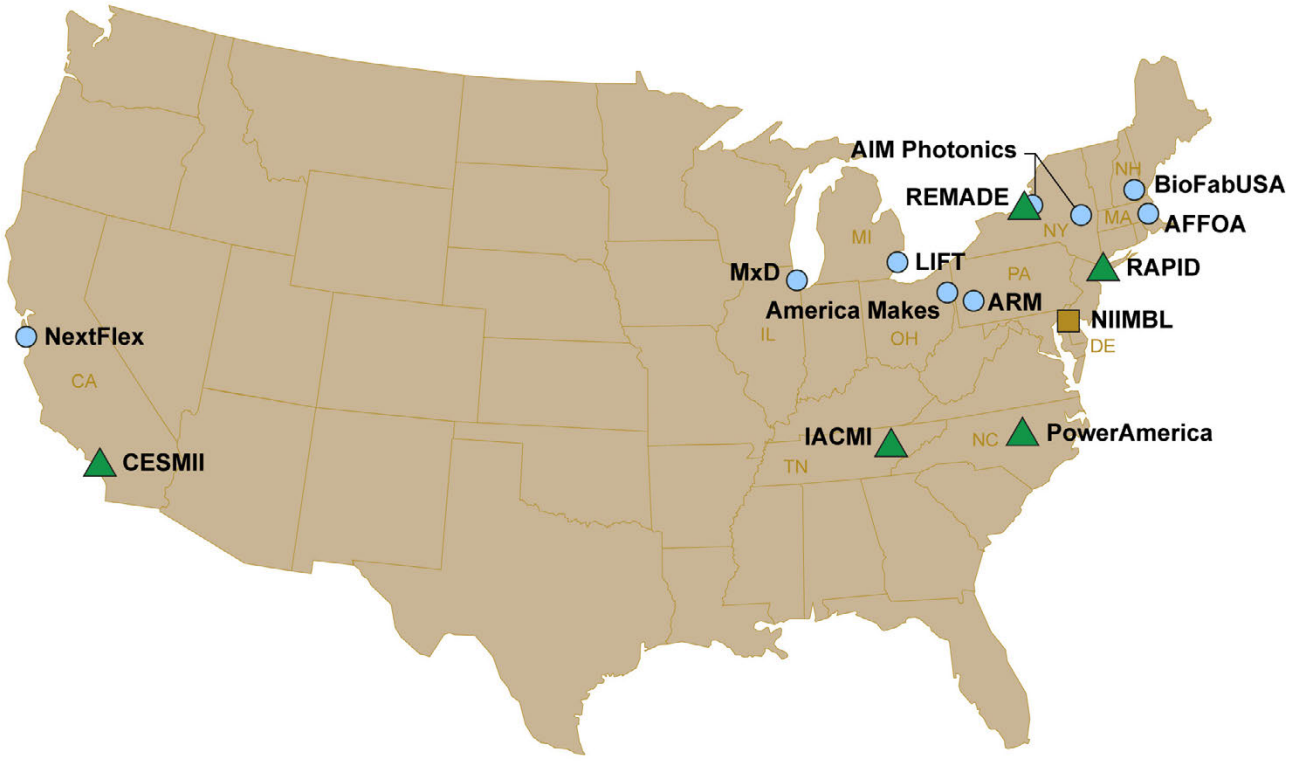
[e]According to DOD, the period of performance for NextFlex's initial cooperative agreement was extended from October 2019 to September 2021. The extension increased the period of performance to complete the work and write a final report. DOD does not anticipate providing additional baseline funding through the initial cooperative agreement.

The Manufacturing USA institutes are located across the country and focus on a variety of technical areas, including 3D printing, wide bandgap semiconductors, biopharmaceuticals, robotics, and advanced fibers. Figure 3 shows the location and a brief description of the institutes.

Interactive Graphic

Figure 3: Description and Location of the Manufacturing USA Institutes

Instructions: **Hover over each institute name on the map below to see more information.**
To print a version containing text, see Appendix I, page 56.



Department of Defense Department of Energy Department of Commerce

Sources: GAO analysis of information provided by the Advanced Manufacturing National Program Office; the Manufacturing USA institutes; and the departments of Commerce, Defense, and Energy; Map Resources (map). | GAO-19-409

Note: See Appendix I, page 52 for the text underlying this figure.

The Manufacturing USA institutes have implemented a wide array of activities aimed at developing manufacturing capabilities in promising new advanced technologies.[32] Institute activities include:

- conducting or funding pre-competitive applied research and development projects to reduce the cost, time, and technical uncertainty related to new manufacturing technologies;
- developing and implementing education, training, and workforce recruitment courses, materials, and programs;
- developing innovative methodologies and practices for supply chain integration;[33] and
- engaging with small, mid-sized, and larger-sized manufacturers.

In total, over 200,000 students have participated in institute education programs, and over 7,500 individuals have completed a workforce certificate, apprenticeship, or training program led by the institutes. Examples of institute education and workforce development programs described in the Manufacturing USA fiscal year 2017 annual report include:

- Lightweight Innovations for Tomorrow (LIFT), in collaboration with ASM International, developed new curricula on lightweight metals, materials, and manufacturing processes for the ASM Materials Science Summer Camps for Teachers. The camps were attended by over 200 master teachers in 22 states, who then trained 1,000 teachers to integrate the material into their classrooms.
- America's Flexible Hybrid Electronics Manufacturing Institute (NextFlex) created a program called FlexFactor designed to introduce high school students to flexible hybrid electronics and advanced

[32]Institute activities for fiscal year 2017 are described in the Manufacturing USA 2017 Annual Report, see Department of Commerce, National Institute of Standards and Technology, *Manufacturing USA Annual Report, FY 2017* (August 2018).

[33]The National Research Council's Committee on Supply Chain Integration has defined an integrated supply chain as an association of customers and suppliers who, using management techniques, work together to optimize their collective performance in the creation, distribution, and support of an end product. According to the committee, all supply chains are integrated to some extent. One objective of increasing integration is focusing and coordinating the relevant resources of each participant on the needs of the supply chain to optimize the overall performance of the chain. National Research Council, *Surviving Supply Chain Integration: Strategies for Small Manufacturers* (Washington, D.C.: 2000).

manufacturing through an in-class entrepreneurship project. Students who complete all requirements of the program earn college credit.

- America Makes partnered with General Electric's Center for Additive Technology Advancement, Robert Morris University, and the organization 3D Veterans to develop a 4-week additive manufacturing bootcamp for military veterans. Through the bootcamp, veterans learn how to use design tools and metal 3D printers to enter the additive manufacturing workforce. There are additive manufacturing jobs in a wide array of industries, ranging from healthcare to autos to food.

Institutes also support state-of-the-art facilities needed to enable development of promising technologies. For example, funding from the Next Generation Power Electronic Manufacturing Innovation Institute (PowerAmerica) enabled the installation of new equipment to enhance the ability to qualify and process silicon carbide devices at a foundry in Lubbock, Texas. This allowed multiple companies, including more than 10 members of PowerAmerica, to process silicon carbide devices at the facility.

Another example is an American Institute for Manufacturing Integrated Photonics (AIM Photonics) foundry improvement project that led to the development and installation of new inline controls and test equipment, significantly improving yield and enabling commercial applications for companies as well as allowing companies to share expensive silicon wafer space on multi-project wafer runs. Table 2 provides additional information on Manufacturing USA institute activities based on the network-wide performance measures reported in the Manufacturing USA annual reports.

PowerAmerica and Semiconductor Technology

PowerAmerica supports research for the development of advanced semiconductor components that can be used in electric power distribution, data centers, industrial motors, and power components in trains and electric vehicles. These semiconductors, called wide bandgap semiconductors, use silicon carbide and gallium nitrate and operate at higher voltages, frequencies, and temperatures than conventional semiconductors.

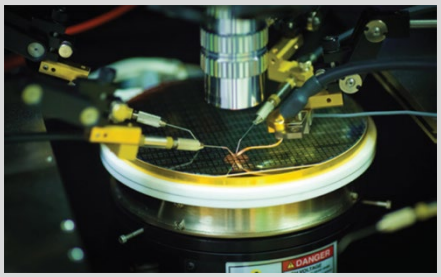


Photo of electrical probing of a silicon carbide device wafer.

Source: Department of Commerce, National Institute of Standards and Technology, *Manufacturing USA Annual Report, FY2017* (August 2018) (Text); Meg Chester, The Next Generation Power Electronics Manufacturing Innovation Institute (PowerAmerica) (Image). | GAO-19-409

Table 2: Aggregated Manufacturing USA Institute Performance Metrics for Fiscal Years 2016 and 2017

Institute metric category	Specific metric	Unit(s) of measure	Fiscal year 2016[a]	Fiscal year 2017[b]
Impact to U.S. Innovation Ecosystem	Number of partner organizations with institute membership agreement	Total number of memberships	830	1,291
Impact to U.S. Innovation Ecosystem	Diversity of Members	Number of large manufacturers (more than 500 employees)	187	295

AIM Photonics and Integrated Photonics

AIM Photonics supports research and development for integrated photonic circuit manufacturing technology. Researchers are finding ways to use photonics (the use of light for applications that traditionally function with electronics) in a wide range of applications, including telecommunications, laser-based radar, data communications, and remote sensing. Circuit technology that uses integrated photonics has better performance and reliability over electronic-integrated circuits, with significantly lower size, weight, and power consumption.

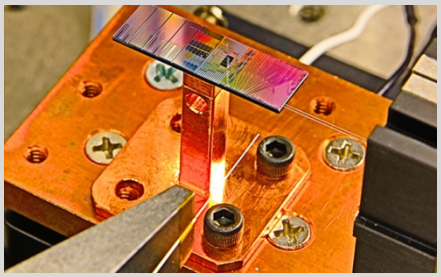


Photo of an AIM Photonic Imposer Chip designed by the Rochester Institute of Technology and AIM Photonics.

Source: Department of Commerce, National Institute of Standards and Technology, *Manufacturing USA Annual Report, FY 2017* (August 2018) (Text); Rochester Institute of Technology and American Institute for Manufacturing Integrated Photonics (AIM Photonics) (Image). | GAO-19-409

Institute metric category	Specific metric	Unit(s) of measure	Fiscal year 2016[a]	Fiscal year 2017[b]
		Number of small manufacturers (500 or fewer employees)	361	549
		Number of academic members (e.g., universities, community colleges)	177	297
		Number of other entities (e.g., members, government laboratories, not-for-profit organizations)	105	150
Financial Leverage	Total co-investment in each fiscal year	Amount of cost share expended in each fiscal year and any federal funding not part of the base federal funding, in millions of dollars	218.9[c]	177.8
Technology Advancement	Number and value of active research and development projects	Number of projects ongoing in each fiscal year (projects completed, started, and spanning each fiscal year)	191	273
		Total institute expenditures in the fiscal year, in millions of dollars	333.8	298.5
	Percentage of key project technical objectives met in each fiscal year	Percentage of key milestones met in each fiscal year	82 percent	79 percent

Institute metric category	Specific metric	Units(s) of measure	Fiscal year 2016[a]	Fiscal year 2017[b]
Development of an Advanced Manufacturing Workforce	Science, Technology, Engineering, and Mathematics activities	Number of students participating in institute projects or institute internship programs/training	23,560	185,425[d]
		Number of individuals in the workforce completing a certificate, apprenticeship, or training program led by the institutes	3,386	4,302
	Educator/trainer engagement	Number of teachers or trainers participating in institute-led training	1,023	1,299

Source: Department of Commerce, National Institute of Standards and Technology, Manufacturing USA Annual Report, FY 2017 (August 2018). | GAO-19-409

[a]According to Commerce officials, the performance metrics for fiscal year 2016 include data from eight institutes that were operational during that time period.

[b]According to Commerce officials, the performance metrics for fiscal year 2017 include data from 14 institutes that were operational during that time period.

[c]According to the Manufacturing USA annual report for fiscal year 2017, large investments in capital equipment and manufacturing facilities were enabled by a surge in nonfederal co-investment at one institute—American Institute for Manufacturing Integrated Photonics (AIM Photonics)—for fiscal year 2016. The report states that similar variations in expenditures in future years are expected, due to co-investments associated with capital-intensive equipment purchases.

[d]According to the Manufacturing USA annual report for fiscal year 2017, one institute's science, technology, engineering, and mathematics efforts are responsible for over 85 percent of the student participation. The report stated that the Lightweight Innovations for Tomorrow (LIFT) institute's education and workforce development initiatives have leveraged a novel online curriculum and resources to reach students across the country.

Institute membership has grown since our last report, and members that we interviewed provided their perspectives on how their organizations have benefited from institute membership. As shown in table 2, institute membership grew from 830 to 1,291 organizations from fiscal year 2016 through fiscal year 2017. Institutes reported that as of December 2018, there were a total of 1,826 institute members. Representatives from institute member organizations reported that they benefited from the networking and connections that they received from participating in Manufacturing USA. For example, representatives from a small wastewater treatment company told us that Manufacturing USA was an excellent networking and exposure vehicle for them. They stated that joining an institute helped them identify many more business opportunities, and they saw that there was potential to bring their innovative technology to a lot of new customers. Similarly, a representative from a large software company told us that their software gets used in many industries and schools, but they have had fewer

connections on the operations and manufacturing side. They believe that their software could be used for manufacturing, operations, and logistics and said that by joining an institute they hoped to discover places where the software could be of value and learn how they could improve the software for those applications.

The Manufacturing USA Network Developed Task Teams, and Some Institutes Have Undergone Changes in Management and Membership Structure

At a network level, since our last report, Manufacturing USA has developed several task teams, and some institutes have also undergone changes in management and membership structure. In summer 2018, institute leaders, AMNPO, and agencies participating in the Manufacturing USA program decided to form three task teams to address key challenges that were identified during discussions at the spring 2018 Manufacturing USA network meeting. According to AMNPO, the teams were formed to help the institute directors share best practices and develop strategies in the following three areas:

- **Ensuring success after institute/network startup.** The purpose of this task team is to define principles for long-term success of an institute and the network, from the perspective of institute directors.
- **Capturing institute and Manufacturing USA program value.** The purpose of this task team is to identify ways to capture the impacts of the Manufacturing USA program and the institutes in ways that will be meaningful to stakeholders.
- **Demonstrating effective public-private partnerships.** This task team's purpose is to communicate about the work of Manufacturing USA and its importance to the nation in ways that will resonate with key audiences and garner engagement with stakeholders, including the U.S. manufacturing community.

The task teams are in the early stages of their efforts. Each team has developed a set of working goals, but they have not developed a set of deliverables for the teams. AMNPO believes that the working goals are likely to evolve as the institute directors who lead the task teams and the participating agency representatives determine the tasks that will be most important to the program.

At an institute level, some institutes have undergone changes in management and membership structure since our last report. For example, several institutes have experienced leadership changes since January 2017.

- Seven institutes have installed new chief executive officers.

- Ten institutes have made other changes to their executive leadership team, including positions such as Chief Technology Officer, Chief Financial Officer, and Director of Education and Workforce.

Some institutes have also adjusted their membership structures to, for example, change the required contributions or benefits associated with different levels of institute membership. For example,

- One institute created two additional tiers to accommodate the needs of community colleges and small (1-3 employees) organizations.
- One institute created more levels for industry members. The changes created a lower-commitment pathway for companies to join and increase their commitment to the institute as their level of engagement increases.

Agencies Are Considering Establishing Two New Institutes

As of February 2019, two agencies—DOE and USDA—were considering or were in the process of establishing new Manufacturing USA institutes, which will continue to grow the Manufacturing USA network. Specifically, DOE was in the process of establishing its sixth institute. On February 6, 2019, DOE announced that the new institute would focus on cybersecurity in manufacturing to understand the evolving cybersecurity threats to greater energy efficiency in manufacturing industries, develop new cybersecurity technologies and methods, and share information and expertise to the broader community of U.S. manufacturers.[34]

USDA was also considering establishing an institute, which would be focused on biomanufacturing and renewable performance materials from forest and agricultural feedstock. These materials have several applications, including in electronics, bioplastic, and new fibers. USDA's interest in this technology area is to leverage the U.S. Forest Service's and the National Institute of Food and Agriculture's leadership in research and development related to understanding biomanufacturing and the nano-scale structure of wood. According to USDA officials, whether the agency establishes such an institute is contingent upon whether it receives appropriations for the institute. According to one USDA official,

[34]The national strategic plan for advanced manufacturing notes that strengthening cybersecurity in manufacturing is a national priority and that the Cyber Hub for Manufacturing within DOD's Digital Manufacturing Innovation Institute will address manufacturing-related cybersecurity vulnerabilities and conduct outreach to support adoption of best practices. See National Science and Technology Council, Committee on Technology, Subcommittee on Advanced Manufacturing, *Strategy for American Leadership in Advanced Manufacturing* (Washington, D.C.: October 2018).

the department is considering including funds for a Manufacturing USA institute in future National Institute of Food and Agriculture budget requests.

Officials with selected non-sponsoring agencies that we interviewed described multiple reasons that influenced their decision whether to sponsor an institute. For example, NASA officials told us that their budgets generally would not allow for a $70 million commitment over 5 years. Additionally, NSF officials told us that their agency mission is not compatible with sponsoring an institute. According to agency officials, NSF focuses on basic research (TRL 1-3), while the institutes focus on bridging basic research into production (TRL 4-7). NSF officials also stated that sponsoring a new institute would require a very substantial funding commitment that is not within NSF's capability given budget constraints. In addition, DOL officials stated that while DOL does not have resources to sponsor an institute, it engages with existing institutes by providing technical assistance and subject matter expertise on workforce matters.

Selected Public-Private Partnerships Provide Lessons Learned on Establishing Criteria for Funding Decisions and Leveraging Global Business Relationships

Selected advanced manufacturing public-private partnerships, such as Germany's Fraunhofer institutes and the U.S. semiconductor manufacturing consortium SEMATECH, provide two key lessons learned for the Manufacturing USA program.[35] These public-private partnership examples show that establishing criteria for funding decisions can provide a basis to link performance to government funding. Further, the Fraunhofer institute and SEMATECH examples show that leveraging global business relationships and finding opportunities for collaboration with global partners can help public-private partnerships make progress toward their goals.

Lesson Learned: Establishing Criteria for Funding Decisions Can Link Government Funding with Performance Toward Goals

The public-private partnership models we reviewed demonstrate that establishing criteria for funding decisions can link government funding with performance toward goals. For example, in the Fraunhofer institute network, which is comprised of applied research institutes specializing in a particular subject matter, each institute's funding is a mix of support from private-sector contracts for research and national and state government sources. Two-thirds of an institute's budget comes from

Fraunhofer institutes

Germany began establishing the Fraunhofer institutes, a network of applied research facilities with expert research staff, in 1949 as part of its efforts to rebuild its research infrastructure after World War II. Today, each Fraunhofer institute specializes in a particular subject matter (e.g., transportation and infrastructure systems, silicon technology, factory automation).

According to Fraunhofer's 2017 annual report, the Fraunhofer institutes conduct applied research that is intended to drive economic development and benefit society. Private companies and local governments can contract with Fraunhofer institutes for specific, short-term applied research projects. In addition, the network of Fraunhofer institutes helps lead broad initiatives, such as Industrie 4.0, a national strategic initiative from the German government to drive digital manufacturing forward by increasing digitization and the interconnection of products, value chains, and business models.

Source: GAO analysis of documents and interviews related to the Fraunhofer institutes. | GAO-19-409

[35]We believe that as public-private partnerships for conducting applied research in advanced manufacturing, Fraunhofer and SEMATECH can provide lessons learned that are applicable to the Manufacturing USA program, though there are some differences between the programs. For example, in contrast to the Manufacturing USA model, Fraunhofer institutes do not have a limit on how long they can receive government baseline funding, and institutes are not expected to be self-sustaining. Moreover, Fraunhofer's research projects generally support incremental results with near-term commercial impact while Manufacturing USA institutes often support research projects to advance the manufacturing innovation ecosystem in their technology area. SEMATECH's circumstances and ability to improve U.S. manufacturing competitiveness also differ somewhat from that of Manufacturing USA. SEMATECH was able to work with existing companies and equipment suppliers to improve manufacturing capabilities to the point where they could compete with Japanese competitors. Manufacturing USA institutes, on the other hand, are often working in innovative and leading edge technology areas where the market segments and companies may not exist yet, and so the pathway to improving U.S. competitiveness may not be as straightforward as in the SEMATECH case.

contracts with the public and private sectors for technical projects, while one-third of an institute's budget comes from government base funding.[36]

Although government funding for Fraunhofer institutes is long-term and stable, institutes are evaluated against financial viability criteria to receive continued funding. Specifically, the Fraunhofer institutes measure their performance by the amount of revenue generated by contracts with the private and public sectors. Focusing on the amount of contract revenue serves a dual purpose. A Fraunhofer director told us that, on a practical level, higher contract revenue provides the institute with the funding needed to remain financially viable. If an institute has a deficit over multiple years, it can be closed. Further, contract revenue also acts as an indicator of the public and private sector utilization of that institute. Industry contract revenue in particular signals that private companies are employing the institute to address their technical challenges, which helps to justify continued government base funding for the public-private partnership. Moreover, the formula Fraunhofer uses to allocate base funding to institutes incentivizes industry contract revenue such that institutes that raise more external funding receive more base funding.[37]

[36]According to one expert we interviewed for a prior report, the time frames over which public support for the Fraunhofer institutes is provided—5 or even 20 years—helps to support technology development. See, GAO, *Science and Technology: Considerations for Maintaining U.S. Competitiveness in Quantum Computing, Synthetic Biology, and Other Potentially Transformational Research Areas*, GAO-18-656 (Washington, D.C.: Sept. 26, 2018).

[37]National Academy of Sciences, National Research Council Board on Science, Technology, and Economic Policy, *21st Century Manufacturing: The Role of the Manufacturing Extension Partnership Program of the National Institute of Standards and Technology* (Washington, D.C.: 2013).

SEMATECH

During the early 1980s, the U.S. semiconductor industry lost a significant portion of its market share for semiconductors to Japan. In response to this loss, SEMATECH was formed to conduct research and development (R&D) on advanced semiconductor manufacturing. SEMATECH was established in 1987 by 14 U.S.-based companies representing 80 percent of the United States' capacity for semiconductor manufacturing. In 1987, Congress also authorized the Department of Defense to make grants to SEMATECH to defray up to half of the consortium's R&D expenses. In a September 1992 report, we stated that Congress provided funding to SEMATECH with the intention that the consortium be industry-led, as member companies were in the best position to assess weaknesses in U.S. semiconductor manufacturing, establish R&D priorities, and manage a program to develop advanced manufacturing technology.

By 1994, U.S. semiconductor manufacturers achieved technological parity with their Japanese competitors, which contributed to the revival of the U.S. semiconductor manufacturing industry.

Source: GAO analysis of documents related to SEMATECH and prior GAO reports. | GAO-19-409

In the case of SEMATECH, an industry-led consortium for semiconductor manufacturing, our prior reporting highlighted the importance of criteria for linking government funding with performance toward goals. SEMATECH received federal financial assistance through fiscal year 1996, with the goal of strengthening U.S. competitiveness in semiconductor manufacturing.[38] In a September 1992 report examining lessons learned from SEMATECH, we reported that Congress had recommended continuing to provide funding to SEMATCH but that criteria for terminating federal support for the consortium had not been established. In our report, we stated that Congress may wish to consider linking the decision of whether to continue funding SEMATECH to assessments of SEMATECH's performance, such as assessing whether U.S. semiconductor manufacturers had reached parity with their Japanese competitors, among other criteria.[39] While our report did not identify which criteria should be used, it described several additional alternatives, such as assessing whether:

- research and development projects potentially had a high return on investment;
- continued federal funding was likely to substantially benefit the U.S. economy by retaining or increasing manufacturer jobs; and
- industry received sufficient benefits from the consortium as evidenced by the decision-making of its largest members to continue or end participation.

According to former SEMATECH officials, SEMATECH's governing board chose to stop seeking federal financial assistance once SEMATECH demonstrated a reversal of market share trends for the U.S. semiconductor industry. This decision reflected the application of one of the criteria we identified in our September 1992 report.[40]

[38]The National Defense Authorization Act for Fiscal Years 1988 and 1989, enacted in December 1987, provided that the Secretary of Defense make grants to SEMATECH to defray its R&D expenses. Pub. L. No. 100-180, Div. A, § 272(a), 101 Stat. 1019, 1068 (1987) (codified as amended at 15 U.S.C. § 4602(a)). It was anticipated that the federal government would provide $100 million per year to SEMATECH over a 5-year period through fiscal year 1992. SEMATECH received federal financial assistance through 1996, at which point its leadership chose not to solicit continued federal support.

[39]GAO, *Federal Research: Lessons Learned From SEMATECH,* GAO/RCED-92-283 (Washington, D.C.: Sept. 28, 1992).

[40]GAO/RCED-92-283.

Lesson Learned: Leveraging Global Business Relationships Can Help Public-Private Partnerships Make Progress toward Their Goals

The public-private partnership models we reviewed show that leveraging global business relationships and finding opportunities for collaboration with global partners can help public-private partnerships make progress toward their goals. For example, the Fraunhofer network includes international institutes, which, similar to a multi-national company, provide opportunities to reach new clients, bring in additional revenue, and leverage international expertise from the local partner. For instance, Fraunhofer USA, a nonprofit network of research institutes dedicated to the advancement of applied research, was founded in 1994 to conduct applied research and development for customers in the United States from industry, state governments, and the federal government. According to the Fraunhofer USA website, international exchange and collaboration by Fraunhofer in applied research and education contributes to the economic development of industrial society and enhances transatlantic research cooperation. An official from Fraunhofer USA said that Fraunhofer's international presence helps to bolster its reputation as a research institution, even if it does not provide a direct benefit to the German economy through traditional means, such as jobs.

SEMATECH's work with global partners also demonstrated the importance of leveraging global business relationships and finding opportunities for collaboration with global partners. Specifically, after its board chose to stop seeking federal financial assistance, SEMATECH expanded its membership to include international companies. According to former SEMATECH officials we interviewed, SEMATECH decided to open its membership for several reasons: (1) semiconductors were becoming more of a global industry; (2) many of SEMATECH's members were gaining a presence overseas; and (3) providing solutions to next-generation manufacturing challenges required global consensus and alignment. The former SEMATECH officials acknowledged that there was concern that incorporating international membership into SEMATECH would enable other countries to compete against the United States by affording access to technological innovations and intellectual property.[41]

[41]Similarly, AMNPO officials told us they believed that after federal funding ended and SEMATECH began accepting international members, SEMATECH focused on industry success rather than U.S. competitiveness. DOD also noted that the Fraunhofer institutes have different intellectual property models compared to DOD's Manufacturing USA institutes and that SEMATECH started its global business model only after its initial objectives were met, U.S. firms had become competitive, and the technology had matured. According to DOD, additional analysis is needed to determine the appropriate scope of international participation in DOD's Manufacturing USA institutes.

However, they said SEMATECH's international leadership ensured that U.S. industry was on the forefront of next-generation technologies because the consortium had immediate access to new technologies produced by other countries and that SEMATECH was able to direct the research agenda for the next generation of product development, all while preserving the U.S. market share recovery of the early 1990s. The officials added that, as a result, SEMATECH's work with trusted global partners facilitated the development of international standards and accelerated the development and acceptance of new equipment, materials, and manufacturing processes.

AMNPO and Federal Agencies Have Taken Some Steps but Have Not Fully Identified the Roles and Responsibilities of Relevant Non-Sponsoring Agencies

AMNPO has taken some steps to implement our prior recommendation—to work with other federal agencies to identify how non-sponsoring agencies could contribute to the Manufacturing USA program—but has not fully identified the roles and responsibilities of relevant non-sponsoring agencies. In our April 2017 report, we found that opportunities existed to strengthen interagency collaboration on the Manufacturing USA institutes. We stated that our work has shown that collaborative mechanisms, such as the Manufacturing USA program's governance system, benefit from certain key features, including the clarity of roles and responsibilities and ensuring that the relevant participants are included in the collaborative effort. We recommended that the Secretary of Commerce direct the NIST Director to work with all non-sponsoring agencies whose missions contribute to or are affected by advanced manufacturing to revise the Manufacturing USA governance system document to ensure the roles and responsibilities for how these agencies could contribute to the Manufacturing USA program are fully identified.[42] Commerce agreed with our recommendation, and AMNPO planned several actions in response. Specifically, AMNPO planned to:

- renew outreach to DOL and other non-sponsoring agencies to provide information on the Manufacturing USA program and invite them to participate;
- invite DOL to participate in and present at the spring 2017 Manufacturing USA network meeting; and
- work with interested agencies to expand the Manufacturing USA network governance system document to include activities, roles, and responsibilities of non-sponsoring agencies.

[42]GAO-17-320.

According to information AMNPO provided on the implementation of these actions, outreach and informational briefings were held with DOL, the Department of Homeland Security, and the Department of Health and Human Services in spring 2017. Following these meetings, DOL and the Department of Health and Human Services named representatives to begin participating in Manufacturing USA interagency meetings.[43] DOL participated in Manufacturing USA network meetings in spring and summer 2017, where representatives presented on DOL programs and participated in the education and workforce sessions. Subsequently, according to AMNPO, DOL has continued to participate in the Manufacturing USA Education and Workforce Development team meetings. DOL also hosted a Manufacturing USA interagency working group meeting in October 2017, which was attended by several high-level DOL officials, and officials with DOL's Employment and Training Administration provided a presentation on the workforce development system and DOL activities.

Some institute representatives and agency officials described enhanced participation in the Manufacturing USA program by non-sponsoring agencies, particularly DOL, compared to what we found in our prior report. For example, some institute representatives said that they have interacted with DOL and the Department of Education on workforce development issues, and that DOL has presented information during quarterly workforce meetings. Similarly, DOL officials said that DOL participates in network meetings and serves as resource for the institutes. Specifically, officials stated that DOL has proactively shared informational resources, websites, and other information developed by DOL's Bureau of Labor Statistics, which received positive feedback from institute representatives. Other non-sponsoring agency officials also described ways in which they are engaged with the Manufacturing USA institutes, such as:

- NSF officials said that NSF assigns a liaison to each institute and, through information posted on the NSF website, has encouraged the submission of proposals and awarded grants to support basic research related to the institutes' technology areas.

[43]According to the documents AMNPO provided on these efforts, the Department of Health and Human Services specifically named representatives from the Food and Drug Administration, the Biomedical Advanced Research and Development Authority, and the National Cancer Institute.

- NASA officials said that NASA has assigned liaisons to 11 of the 14 institutes and that they participate on institute committees and advisory boards, depending on how closely an institute's technology area is aligned with NASA's mission. NASA officials also said that NASA technical experts helped one institute develop standards for its technology area.

With regard to AMNPO's planned action to expand the Manufacturing USA network governance system document, AMNPO officials stated that an interagency team of representatives participated in six working sessions to discuss, revise, and finalize the Manufacturing USA governance document, which was originally created in 2015.[44] This team consisted of representatives from Commerce, DOD, DOE, Education, DOL, Health and Human Services, NASA, NSF, and USDA. The governance document identifies different network functions and associated sub-functions or tasks. For example, one function identified in the governance document is "to sustain, strengthen, and grow the network," and this function includes such sub-functions as identifying and helping to establish long-term nonfinancial support mechanisms for the Manufacturing USA program. For each sub-function, the governance document identifies a role for AMNPO, sponsoring agencies, institutes, and other stakeholders as being accountable, responsible, consulted, or informed. According to AMNPO, as a result of the interagency working team's discussions, the participating agencies agreed to revise the governance document in the following ways:

- **Removed an "Establish the Network" function and associated sub-functions.** According to the updated Manufacturing USA Network Charter, the function to establish the network has been completed, so this function was removed from the governance document.[45] The other three functions identified in the governance document remained the same, and no new functions or sub-functions were added.

[44]In addition to sponsoring and non-sponsoring agencies, the governance system defines roles and responsibilities for Executive Office of the President entities, including the National Economic Council, Office of Management and Budget, and Office of Science and Technology Policy. The functions identified in the governance system generally align with those identified in the December 2016 network charter.

[45]Department of Commerce, National Institute of Standards and Technology, *NIST Advanced Manufacturing Series 600-4: Network Charter Manufacturing USA Program* (September 2018).

- **Added a new stakeholder category for specific agency programs.** The revised governance document includes a new column to recognize the different roles and responsibilities for non-sponsoring agencies' programs. For example, this column defines how interactions occur between Manufacturing USA and Commerce's Manufacturing Extension Partnership program, which has specific engagement with Manufacturing USA apart from Commerce's role as a sponsoring agency.
- **Revised non-sponsoring agencies' roles for implementing network functions and sub-functions.** Revisions to non-sponsoring agencies' roles identified in the governance document included elevating or lowering those agencies' prior roles. For example, non-sponsoring agencies are now consulted (i.e., two-way communication) on "Updating the Network Strategic Plan," whereas before they were only informed (i.e., one-way communication). The governance document assigned non-sponsoring agencies the role of being consulted or informed on about half of the sub-functions for which they were previously not assigned a role.

However, while the steps AMNPO has taken to implement our April 2017 recommendation have helped increase the involvement of non-sponsoring agencies in the Manufacturing USA program and better identified how they can contribute to the program, the roles of non-sponsoring agencies have not yet been fully identified. For example, AMNPO officials told us agencies involved in interagency meetings to revise the governance document agreed to provide the network with information or expertise related to their activities, but the network governance document still does not specify responsibility for this function. In our prior report, we noted that some non-sponsoring agencies may be implementing programs or other activities that could contribute to the Manufacturing USA program.[46]

During our interviews with institute representatives for this report, we found an example of a potentially relevant program that not all institutes were aware of: Commerce's Regional Innovation Strategies program, which is implemented by Commerce's Economic Development Administration. This program supports the creation of centers for innovation and entrepreneurship that increase the rate at which innovations, ideas, intellectual property, and research are translated into products, services, viable companies, and jobs. Under the program, the

[46]GAO-17-320.

Economic Development Administration awards grants to build regional capacity to translate innovations into jobs through proof-of-concept and commercialization assistance to innovators and entrepreneurs. Such activities could be complementary to the efforts of individual Manufacturing USA institutes and their members, and one institute representative we interviewed knew about the program because the institute's chief executive officer (CEO) had experience with it from a prior position. However, other institutes that we interviewed did not mention the program.

Additionally, some institute representatives said that while they have some interaction with certain non-sponsoring agencies participating in the interagency task team, they thought that enhanced coordination could be helpful. For example, representatives from one institute expressed interest in greater coordination with DOL on access to employment data. Another institute representative (not DOD-sponsored) said they wanted more interaction with DOD, which could be a customer of the institute's technological innovations. Additionally, representatives from one institute also told us that their technology area may be relevant to an agency such as USDA, among others. Although USDA is a part of the interagency team, a USDA official told us that USDA has not been directly involved with any of the institutes. Some institute representatives also said that they would like to have more interaction with certain non-sponsoring agencies not included on the interagency team. For example, representatives from some institutes said that they would like more information from, or coordination with, agencies such as the departments of Homeland Security, State, Transportation, and Veterans Affairs; in particular, representatives from one institute stated that they would like more engagement with the Department of Transportation because their institute's technology area has potential applications in infrastructure.

We continue to believe that AMNPO should work with relevant non-sponsoring agencies in an interagency collaborative effort to ensure the roles and responsibilities for how those agencies could agree to contribute to the Manufacturing USA program are fully identified. As we noted in our April 2017 report, we recognize that AMNPO cannot prescribe functions for other federal agencies or compel agency participation in the Manufacturing USA network.[47] Nonetheless, without ensuring that non-sponsoring agencies' roles and responsibilities have

[47]GAO-17-320.

been fully identified, as we recommended in our April 2017 report, AMNPO may still be missing opportunities to leverage potential contributions of non-sponsoring agencies, consistent with key practices for interagency collaboration and effective implementation of AMNPO's coordination functions under the RAMI Act.[48]

AMNPO and Sponsoring Agencies Developed Long-Term Goals, but Have Not Developed Measurable Near-Term Goals to Assess Progress of the Manufacturing USA Program

AMNPO and sponsoring agencies have developed long-term goals and objectives based on the statutory purposes of the Manufacturing USA program and have also developed initial performance measures for the network. However, AMNPO and sponsoring agencies have not developed near-term network-wide performance goals with measurable targets and time frames that would demonstrate the progress over time of the Manufacturing USA program.

AMNPO and Sponsoring Agencies Developed Long-Term Goals and Initial Performance Measures

AMNPO and sponsoring agencies have developed long-term goals and objectives for the Manufacturing USA program. As we described in our April 2017 report, AMNPO and sponsoring agencies developed program goals for Manufacturing USA in the program's first strategic plan. These four broad, long-term program goals are based on the statutory purposes of the RAMI Act. The strategic plan does not identify a time frame for achieving the long-term goals but describes them as goals that can be measured by, for example, broader manufacturing sector impacts.[49]

[48]The RAMI Act requires AMNPO to, among other things, establish such procedures, processes, and criteria as may be necessary and appropriate to maximize cooperation and coordinate the activities of the Manufacturing USA program with the programs and activities of other federal departments and agencies whose missions contribute to or are affected by advanced manufacturing. 15 U.S.C. § 278s(f)(2)(D).

[49]An external consultant's assessment of the program defined long-term outcomes as occurring after the 5th year of the institutes' start, after the institutes have begun executing research and development activities. Deloitte Touche Tohmatsu Limited, *Manufacturing USA: A Third-Party Evaluation of Program Design and Progress* (January 2017).

Three of the four program goals are further divided into objectives in the Manufacturing USA strategic plan, as shown in Table 3.

Table 3: Relationship between Manufacturing USA Statutory Purposes, Program Goals, and Objectives

Program statutory purpose	Manufacturing USA program goal	Strategic plan objective
• To improve the competitiveness of U.S. manufacturing and increase production of goods manufactured predominantly within the United States • To stimulate U.S. leadership in advanced manufacturing research, innovation, and technology	Goal 1: Increase the competitiveness of U.S. manufacturing.	• Objective 1.1: Support the increased production of goods manufactured predominantly within the United States. • Objective 1.2: Foster the leadership of the United States in advanced manufacturing research, innovation, and technology.
• To facilitate transition of innovative technologies into scalable, cost-effective, and high-performing manufacturing capabilities • To facilitate access by manufacturing enterprises to capital-intensive infrastructure • To facilitate peer exchange of and documentation of best practices in addressing advanced manufacturing challenges	Goal 2: Facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing capabilities.	• Objective 2.1: Enable access by U.S. manufacturers to proven manufacturing capabilities and capital-intensive infrastructure. • Objective 2.2: Facilitate sharing and documentation of best practices for addressing advanced manufacturing challenges. • Objective 2.3: Foster the development of standards and services that support U.S. advanced manufacturing.
• To accelerate development of an advanced manufacturing workforce • To create and preserve jobs	Goal 3: Accelerate the development of an advanced manufacturing workforce.	• Objective 3.1: Nurture future workers for Science, Technology, Engineering, Mathematics-related work. • Objective 3.2: Support, expand, and communicate relevant secondary and post-secondary pathways, including credentialing and certifications. • Objective 3.3: Support the coordination of state and local education and training curricula with advanced manufacturing skill-set requirements. • Objective 3.4: Advanced-knowledge workers: researchers and engineers. • Objective 3.5: Identify the competencies needed by the next generation of workers.
• To leverage nonfederal sources of support to promote a stable and sustainable business model without the need for long-term federal funding	Goal 4: Support business models that help institutes to become stable and sustainable.	• None listed

Source: GAO analysis of information provided by the Department of Commerce Advanced Manufacturing National Program Office. | GAO-19-409

In addition, AMNPO and sponsoring agencies developed a set of initial performance measures, which they have linked to the long-term program goals, as shown in table 4. Each category of measures corresponds with two to three of the Manufacturing USA program goals.

Table 4: Relationship between Manufacturing USA Initial Performance Measures and Program Goals

Initial Performance Measures	Corresponding Manufacturing USA Program Goals
Impact to U.S. Innovation Ecosystem • Total number of memberships • Number of large manufacturer members (more than 500 employees) • Number of small manufacturer members (500 or fewer employees) • Number of academic members (e.g., universities, community colleges) • Number of other entities (e.g., members, government laboratories, not-for-profit organizations)	• 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 4: Support business models that help institutes to become stable and sustainable.
Financial Leverage • Amount of cost share expended in each fiscal year and any federal funding not part of the base federal funding	• Goal 2: Facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing capabilities. • Goal 4: Support business models that help institutes to become stable and sustainable.
Technology Advancement • Number of projects ongoing in each fiscal year (projects completed, started, and spanning each fiscal year) • Total institute expenditures in each fiscal year • Percentage of key milestones met in the fiscal year	• 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.
Development of an Advanced Manufacturing Workforce • Number of students participating in institute projects or institute internship programs/training • Number of individuals in the workforce completing a certificate, apprenticeship, or training program led by the institutes • Number of teachers or trainers participating in institute-led training	• Goal 1: Increase the competitiveness of U.S. manufacturing. • Goal 3: Accelerate the development of an advanced manufacturing workforce.

Source: GAO analysis of information provided by the Department of Commerce Advanced Manufacturing National Program Office. | GAO-19-409

In our April 2017 report, we noted that AMNPO officials said they planned to develop a set of revised performance measures that incorporate the results of an external consultant's assessment of the Manufacturing USA program.[50] When we asked about those plans, AMNPO officials said that

[50]Deloitte Touche Tohmatsu Limited, *Manufacturing USA.*

they had discussions with sponsoring agencies and institutes to consider appropriate metrics to capture the performance of the program, including a session at the spring 2018 Manufacturing USA network meeting dedicated to performance measures. Following that meeting, in summer 2018, institute leaders, AMNPO, and the agencies participating in the Manufacturing USA program formed a performance measure task team composed of institute directors and representatives from sponsoring agencies. As of February 2019, the task team had not yet developed revised measures, and AMNPO continued to report on the initial network-wide performance measures in its fiscal year 2017 annual report. AMNPO officials said they anticipate that a set of revised network-wide measures will be included in the fiscal year 2018 annual report for Manufacturing USA.

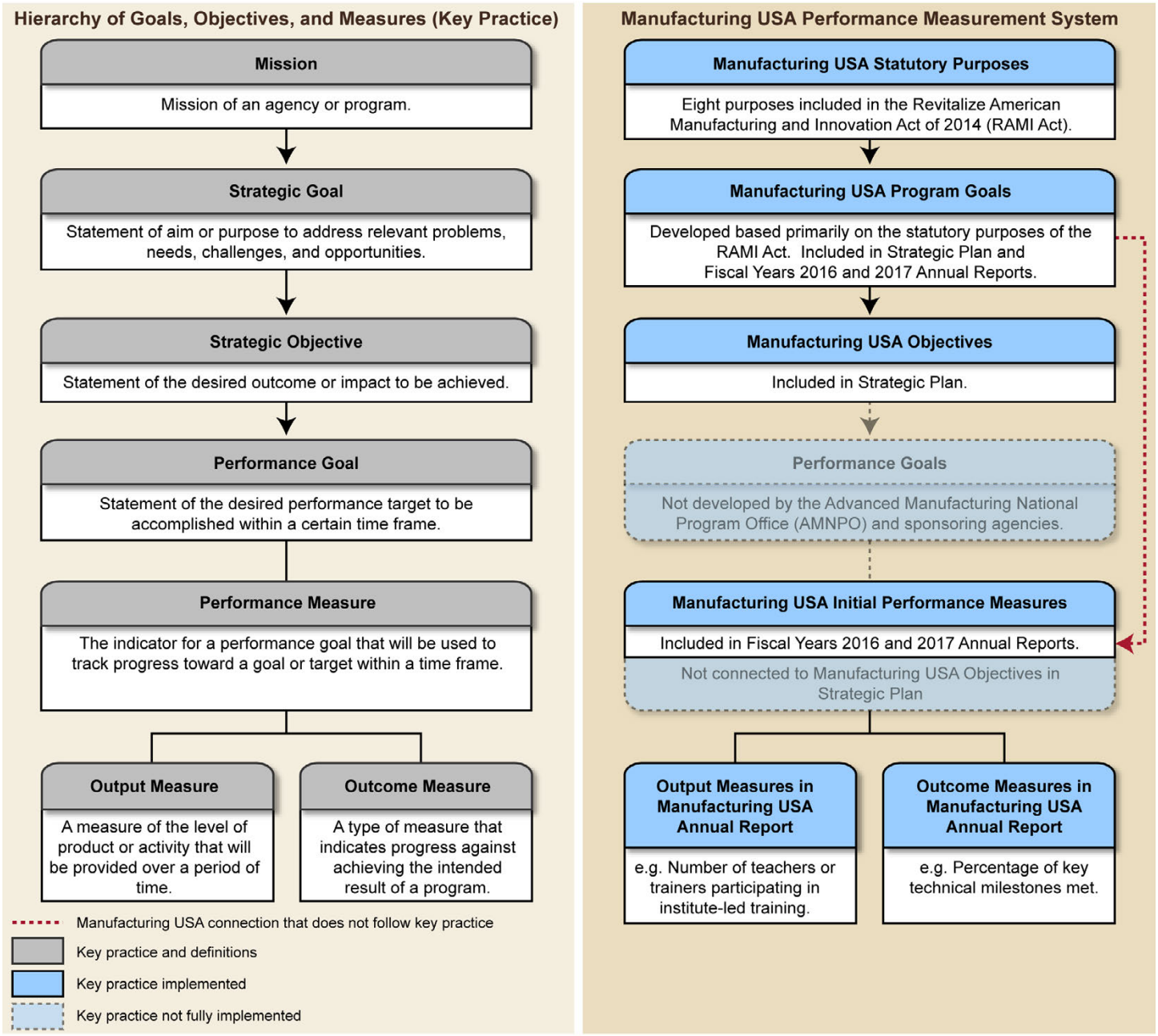
AMNPO and Sponsoring Agencies Have Not Developed Measurable Near-Term Performance Goals to Assess the Progress of the Manufacturing USA Program

AMNPO and sponsoring agencies have not developed near-term network-wide performance goals with measurable targets and time frames to assess the Manufacturing USA program's progress toward achieving the RAMI Act's statutory program purposes. Our work has shown that systems of performance measures benefit from certain key practices, such as creating a hierarchy that breaks down broad, long-term goals and objectives into more specific, near-term performance goals with measurable targets and time frames.[51]

Figure 4 shows the key practice hierarchy of fully connected strategic goals and objectives, including performance goals with measurable targets and time frames, compared with the extent to which these connections have been established for the Manufacturing USA program as a whole.

[51]GAO-15-602.

Figure 4: Key Practice Implementation in the Manufacturing USA Performance Measurement System



Source: GAO analysis of Office of Management and Budget guidance and AMNPO information. I GAO-19-409

As shown in figure 4, AMNPO and sponsoring agencies have not developed performance goals with associated targets and time frames

that connect the initial network-wide performance measures to Manufacturing USA's strategic objectives. Although AMNPO reports the percentage of key project technical objectives the Manufacturing USA institutes collectively met in each fiscal year, it does not include a performance goal with a target the network as a whole is working toward or a time frame in which it aims to meet that target. Additional network-wide targets could relate to the total number of workers completing certificate or apprenticeship programs collectively led by the institutes. The only stated target in the Manufacturing USA annual reports is for the performance measure on nonfederal cost share.[52] By developing and implementing network-wide performance goals with targets and time frames, Commerce would have better assurance that AMNPO could observe and report on progress toward Manufacturing USA long-term goals and objectives.

Further, AMNPO and the sponsoring agencies have not specifically connected the objectives described in the Manufacturing USA strategic plan with the initial program performance measures. Instead, AMNPO and sponsoring agencies have connected the near-term performance measures directly to the long-term program goals, bypassing the objectives and performance goals that would demonstrate progress over time.

AMNPO officials said that AMNPO and sponsoring agencies developed the Manufacturing USA initial network-wide performance measures without targets to let the institutes and agencies innovate as they run their programs, and that, because AMNPO does not manage or fund individual institute activities, they are not in a position to set targets for the network-wide performance measures. However, as the national program office for the Manufacturing USA program, the RAMI Act identifies coordination-related functions that would support AMNPO efforts to work with the sponsoring agencies to collaboratively develop targets and time frames for those measures.[53] Moreover, the RAMI Act requires Commerce to

[52]According to the fiscal year 2017 Manufacturing USA report, the target for this performance measure is for institutes to contribute an amount of nonfederal cost share that at least matches the amount of financial assistance provided by the sponsoring federal agencies. AMNPO officials said that this target is intended to leverage the federal financial assistance agencies provide with a level of nonfederal contributions that will start the institutes with the size, scale, and technology sector acceptance needed to provide long-term impact to U.S. manufacturing.

[53]See 15 U.S.C. § 278s(f)(2).

annually submit a report including, among other things, an assessment of the Manufacturing USA program with respect to meeting the statutory purposes.[54] By ensuring that the Manufacturing USA network-wide performance measures are directly aligned with the Manufacturing USA strategic program goals and objectives and the statutory purposes of the RAMI Act, Commerce would be better able to observe and report on progress made toward achieving the statutory purposes of the Manufacturing USA program.

Institutes Are Conducting Sustainability Planning and Foresee Potential Operational Impacts, but Sponsoring Agencies Have Not Developed Criteria to Assess Sustainability

All 14 Manufacturing USA institutes have conducted sustainability planning and foresee impacts to their institutes if baseline federal support ends; however, while sponsoring agencies have taken steps to support sustainability planning, they have not developed criteria to evaluate whether institutes will be able to sustain their operations beyond the initial 5- to 7-year period of federal financial assistance. Institutes' planning for how to sustain their operations beyond the initial period of federal financial assistance are at different stages, and their sustainability plans vary in their level of detail and focus on different revenue-generating activities. Institute representatives said that they foresee impacts to their operations if they do not receive additional baseline federal support beyond the initial period of federal financial assistance. However, as of February 2019, while the sponsoring agencies had taken steps to support institute sustainability, they had not developed criteria to evaluate whether institutes will be able to sustain their operations.

Institutes Have Conducted Sustainability Planning with Varying Levels of Detail and with a Focus on Different Revenue-Generating Activities

We found that the institutes have produced sustainability plans with varying levels of detail and with a focus on different revenue-generating activities.

Varying Levels of Detail in Sustainability Plans

The institutes' sustainability plans that we reviewed ranged from preliminary outlines to detailed strategies to sustain and expand nonfederal sources of revenue after the initial period of federal baseline financial assistance. For example, we found that, as of late 2018, about

[54]15 U.S.C. § 278s(g)(2)(B)(iv).

two-thirds of the institutes had developed sustainability plans at a high level of detail, including overarching strategic goals and multiple, revenue-generating activities to achieve those goals by the end of the initial federal financial assistance period. Other institutes provided sustainability plans in a draft stage. One of the draft plans included milestones to finalize the plan before the initial federal financial assistance period ends, such as forming a committee to identify models for financial sustainability and developing a final draft of the plan that includes criteria, goals, and milestones to track progress. Still other institutes' sustainability plans focused on providing status updates toward achieving revenue-generating objectives, such as developing and testing prototypes for commercialization and standing up new education and workforce development training programs.

While the level of detail ranged across institutes' sustainability plans, we identified several common elements, including:

- a timeline to reevaluate, and if necessary revise, the plan at regular intervals (13 institutes);
- plans to sustain or expand nonfederal sources of revenue beyond the initial period of federal baseline financial assistance (11 institutes);
- projected future expenses and revenues, including projected expenses and revenues related to nonfederal sources of funding (seven institutes);
- identification of a working group or committee dedicated to sustainability (six institutes); and
- financial or other targets for the years beyond the initial period of federal baseline financial assistance, such as target annual membership revenues (five institutes).

Additionally, we found three institutes' plans also provided possible metrics to track progress toward becoming sustainable. These metrics include the number of affiliated university faculty and staff available to support grant proposal writing, revenue generated from membership dues, and the number of medium- and large-size companies within the institutes' membership.

Funding and Revenue Generation

We also found that Manufacturing USA institutes' sustainability planning includes a variety of long-term, revenue-generating activities beyond the initial period of federal baseline financial assistance. For instance, some institutes plan to use existing or planned facilities to enable members to conduct research, test new technology and new manufacturing

processes, organize industry gatherings, and host education and workforce trainings, among other things. One institute developed a digital collaborative infrastructure—comprised of a member capability database and product development management application—to provide members with centralized access to relevant research, standards, and project management services, among other things. Several institutes' sustainability plans include technology transition and commercialization consulting to help members identify manufacturing applications for innovative technologies. As part of their consulting services, some institutes' sustainability plans discuss producing proprietary manufacturing and business solutions, which members can then license for a fee. Additionally, some institutes' sustainability planning includes the development of fee-based workforce training curricula and skills certifications.

In addition to institutes' various strategies for generating revenue from members, institutes' sustainability planning also anticipates some mixture of continued revenue from public and private contracts competed for on an individual project basis, including with the federal government. The plans generally do not specify the proportion of project funding anticipated to make up future income, but one institute's sustainability plan anticipates 33 percent of its total future income to come from federal grants and contracts. Another institute's sustainability plan anticipates increasing state-funded project revenue from 36 percent to nearly 40 percent, and privately funded revenue from 5 percent to nearly 25 percent of total income.

Institute Representatives Foresee Operational Impacts without Additional Federal Support

Institute representatives said that they foresee generally negative, but also some positive, impacts to institute operations if federal baseline support ends after the institutes' initial agreements with their sponsoring agencies. Some institute representatives told us that the 5- to 7-year time frame of institutes' initial agreements with their sponsoring agencies does not align with the technology cycle and startup times in their industries and pointed to a number of potential negative operational impacts if federal financial assistance for their operations ends after their initial agreements. For example, some institute representatives stated that their institutes would have to focus more on short-term research projects for private industry use rather than projects that advance the manufacturing innovation ecosystem as a whole. Representatives from one institute stated federal financial assistance has enabled the institute to have cutting edge capabilities, but that it will be difficult, if not impossible, to maintain that technological advantage without federal baseline financial

assistance. Some institute representatives also noted that without federal baseline support there may be a potential decrease in education and workforce training.

Additionally, representatives from some institutes stated that they may need to take on additional international companies as members, which could divert their institutes' focus away from increasing U.S. competitiveness. Representatives from one institute also noted that there was a risk that international members could take the institute's knowledge outside of the United States. Another institute's representatives told us that ending federal baseline support could negatively influence industry perception and create doubt among industry members about the sustainability of the institutes. In the most serious example of potential negative impacts, a representative from one institute said that the institute may need to cease operations without continued federal baseline support.

Although institute representatives described the potential difficulties they may face in sustaining their current operations without additional baseline support from the federal government, institute representatives did not say that they would need indefinite federal funding. Some institute representatives were unsure of how much additional funding the institutes would need. Other institute representatives provided estimates of the length of time that baseline support for operations would be necessary, including estimates of an additional 5 years, as well as an estimate of a total of 7 to 9 years of baseline support.[55]

Agency officials echoed some of the concerns that institute representatives expressed. Commerce officials said that one of the challenges its institute faces in terms of sustainability is a technical development cycle of 10 to 12 years or more to deploy an innovation. DOD officials said that many institute members may only stay involved with the Manufacturing USA institutes if the federal government stays involved. Regarding the extent of global participation in the network, DOD officials also said that caution is appropriate in order to protect the national security benefits of the DOD-sponsored institutes.

[55]We spoke with a representative from a manufacturing policy organization who was involved in shaping the original model for the manufacturing innovation institutes, and he noted that the 5-year time frame for sustainability was somewhat arbitrary and could have adverse consequences because institutes are focused on sustainability as opposed to more important metrics, such as advancing TRLs and MRLs.

However, some institute representatives cited positive impacts to institute operations due to restrictions that would be loosened at the end of the initial cooperative and technology investment agreements with their sponsoring agencies. Specifically, institute representatives told us that not working under a financial assistance agreement with a federal agency would allow them to alleviate delays caused by government review and, after their agreements end, they will conduct more outreach to international companies. Many institute representatives told us they currently have international and multi-national companies as members, but institutes usually require the companies to have a manufacturing footprint within the United States. Notwithstanding the concerns about international members described above, some institute representatives said that having additional international members involved in the institutes could help U.S. companies potentially sell their products overseas, and it could more quickly drive the adoption of new technology by U.S. manufacturers. The institute representatives' views on international members were consistent with information on the benefits of global business relationships provided by representatives from Fraunhofer and SEMATECH.

Sponsoring Agencies Have Taken Steps to Support Institute Sustainability Planning but Have Not Developed Criteria to Evaluate Whether Institutes Will Be Able to Sustain Their Operations

Commerce, DOD, and DOE have taken steps to support the sustainability planning of the institutes they sponsor but, as of February 2019, had not developed criteria to evaluate whether institutes will be able to sustain their operations beyond the initial period of federal baseline financial assistance. Specifically,

- **Commerce:** Commerce officials said that they provide formal and informal input on sustainability to the Commerce-funded institute in two areas: (1) the institute's sustainability plan and (2) strategic planning with NIST program management and technical teams. The cooperative agreement for the institute outlines the minimum elements that are to be included in its sustainability plan, such as the specifying actions to be taken by the institute to sustain the project after federal financial assistance ends and providing key milestones for planning and implementation phases of the sustainability plan. However, Commerce has not developed criteria to evaluate whether the institute will be able to sustain its operations beyond its initial cooperative agreement without additional federal financial assistance. For example, the cooperative agreement for the institute does not specify how, if at all, Commerce will evaluate the sufficiency of the sustainability plan.

Commerce officials stated that the definition of sustainability that it communicates to its institute is that the institute would continue to operate beyond its period of federal financial assistance, maintaining alignment with the purposes established for the network by the RAMI Act, including a focus on U.S. competitiveness. The Commerce officials said that the institute's progress toward sustainability could be measured through total membership growth, membership retention, and the mix of members, among other things. However, Commerce has not established criteria to evaluate whether the institute is making sufficient progress with these measures to become sustainable. Commerce officials stated that they do not feel that they should establish benchmarks at this time for measures to ensure sustainability, because Commerce does not want to stifle options by establishing an expected path to sustainability.

- **DOD:** DOD officials said that they formally discuss sustainability with the DOD-sponsored institutes and also frequently discuss it internally with the DOD institute program managers. DOD officials said that, based on their own and their institutes' concerns about sustainability, they believe that the institutes need a long-term commitment from the federal government and continued strategic investment from DOD. DOD officials further stated that DOD believes that it needs to preserve its strategic influence with the institutes and the manufacturing ecosystems they have created to ensure that the priorities, participants, and funding sources of these public-private partnerships remain consistent with national security and departmental priorities. Accordingly, DOD is developing a long-term partnership model for the DOD-sponsored institutes based on a three-pronged approach: (1) a predictable level of annual support to institutes based on satisfactory performance; (2) technical, business, and workforce development project funding that will be competed among the eight DOD-sponsored institutes; and (3) DOD-driven project funding based on the institutes' unique manufacturing capabilities. As of February 2019, DOD was in the process of developing this partnership model and had commissioned a workshop led by the National Academies of Sciences, Engineering, and Medicine to provide findings, options, and recommendations for DOD to consider in developing its long-term role with existing and potential

future DOD-sponsored institutes.[56] However, since DOD is still developing is long-term partnership model, it has not yet developed criteria to evaluate whether or to what extent to provide institutes with additional baseline support after initial agreements end.

- **DOE:** DOE's cooperative agreements with the institutes it sponsors provide that the institutes develop a formal sustainability plan, and DOE officials told us that they review the plans periodically with the institutes. In terms of defining sustainability, DOE officials stated that, after the institutes' cooperative agreements end, they expect the institutes to function at a level that is supportive of U.S. manufacturing needs for technology development, education, and workforce development. DOE officials further stated that institute management and operations will be privately funded, and research and development may be funded via merit-based competitions. The DOE officials also said that institutes must think about what value they can offer members to attract sufficient membership at certain dues levels so the institute will be sustainable without relying on federal research awards for funding. The officials acknowledged that the DOE-sponsored institutes tend to rely heavily on project-based financial assistance from the federal government in their sustainability planning. However, according to the officials, DOE has not set criteria for where membership levels or other measures should be in order to ensure sustainability because DOE does not have plans to provide non-competitively awarded financial assistance to its institutes beyond the end of their current 5-year cooperative agreements.

Commerce, DOD, and DOE officials expressed different views about their agencies' plans to provide additional support to their institutes. Commerce's cooperative agreement for its institute is for a period of 5 years. The RAMI Act prohibits Commerce from providing any financial assistance to its institute beyond 7 years.[57] Commerce officials told us that they have not yet made any decisions regarding whether to provide additional financial assistance to its institute for the 2 years beyond its initial 5-year cooperative agreement. Alternatively, DOD officials told us that they are exploring the option of providing financial assistance to the

[56]In April 2019, the National Academies released a report on DOD's long-term participation with its institutes which contained a number of recommendations for DOD, including that DOD conduct a formal review of each institute to support decisions on renewing, re-competing, or canceling current agreements. See National Academies of Sciences, Engineering, and Medicine, *Strategic Long-Term Participation by DOD in Its Manufacturing USA Institutes* (Washington, D.C.: 2019).

[57]15 U.S.C. § 278s(d)(5)(A).

DOD-sponsored institutes beyond their initial agreements and that DOD has estimated the additional appropriations needed for this purpose. Because DOD and DOE institutes were not established and funded under the RAMI Act, their institutes are not subject to the 7-year funding limit under the RAMI Act. As stated above, DOE officials said DOE does not have plans to provide non-competitively awarded financial assistance to its institutes beyond the end of their current 5-year cooperative agreements.[58] Officials stated that per DOE policy, the period of performance for a financial assistance award should not be longer than 5 years. However, officials stated that the technology areas of the institutes will remain important areas for DOE after federal financial assistance for the institutes end. DOE officials further stated that DOE expects to run competitive solicitations for which institutes or their members could compete.

Federal internal control standards direct management to identify, analyze, and respond to risks related to achieving the defined objectives.[59] Because none of the three sponsoring agencies have developed criteria for evaluating whether their institutes are likely to be able to sustain operations beyond their initial agreements, the agencies have not fully analyzed the institutes' sustainability or the risks the institutes face. The examples of Fraunhofer and SEMATECH demonstrate that establishing criteria for decisions about federal financial assistance can link such assistance with performance toward goals. By developing such criteria, Commerce, DOD, and DOE would have greater assurance that decisions about whether or to what extent to provide additional support to their institutes are based on an analysis of the risks the institutes face in successfully carrying out the statutory purposes under the RAMI Act.

Conclusions

In an effort to revitalize the U.S. manufacturing sector and increase U.S. competitiveness in advanced manufacturing, Congress enacted the RAMI Act. AMNPO, Commerce, DOD, and DOE have developed long-term goals and an initial set of network-wide performance measures to report the progress of the Manufacturing USA program. However, they have not developed network-wide performance goals with measurable targets and

[58]The President's Budgets for fiscal years 2018 and 2019 also called for eliminating financial assistance for the DOE-sponsored institutes prior to the end of their initial cooperative agreements.

[59]GAO-14-704G.

time frames, a key performance measurement practice that can help agencies plan for and demonstrate near-term progress towards achieving longer-term goals. By developing such goals with targets and time frames, Commerce would have better assurance that it could demonstrate progress toward Manufacturing USA long-term goals and objectives. Additionally, AMNPO and the sponsoring agencies have not directly aligned the program goals and objectives described in the Manufacturing USA strategic plan with the initial program performance measures, which would demonstrate progress over time. By ensuring that the Manufacturing USA network-wide performance measures are directly aligned with the Manufacturing USA strategic program goals and objectives and the statutory purposes of the RAMI Act, Commerce would have better assurance in AMNPO's ability to observe and report on progress made toward achieving the statutory purposes of the Manufacturing USA program.

Similarly, Commerce, DOD, and DOE have taken steps to support their institutes' sustainability planning but have not developed criteria to evaluate whether institutes are on track to sustain their operations beyond the initial period of federal financial assistance. By developing criteria for evaluating whether their institutes are likely to be able to sustain their operations without additional federal financial assistance beyond their initial agreements, the sponsoring agencies would have greater assurance that any future decisions about whether or to what extent to provide additional support to their institutes are based on an analysis of the risk the institutes face in successfully carrying out the statutory purposes under the RAMI Act.

Recommendations for Executive Action

We are making a total of five recommendations, including three to Commerce, one to DOD, and one to DOE.

- The Secretary of Commerce should direct the NIST Director to work with other sponsoring federal agencies to develop and implement network-wide performance goals for the Manufacturing USA program with measurable targets and time frames. (Recommendation 1)
- The Secretary of Commerce should direct the NIST Director to work with other sponsoring federal agencies to ensure that the Manufacturing USA network-wide performance measures are directly aligned with the network-wide performance goals, the Manufacturing USA strategic objectives and program goals, and the statutory purposes of the RAMI Act. (Recommendation 2)

- The Secretary of Commerce should direct the NIST Director to develop criteria to evaluate whether the Commerce-sponsored institute can sustain its operations without additional federal financial assistance after its initial agreement. If an analysis based on such criteria indicates that additional federal financial assistance is needed to help the institute sustain its operations, then the Secretary of Commerce should consider a legislative proposal to amend relevant provisions of the RAMI Act. (Recommendation 3)
- The Secretary of Defense should direct the Director of DOD's Manufacturing USA institutes to develop criteria to evaluate whether DOD-sponsored institutes can sustain their operations without additional federal financial assistance after their initial agreements. (Recommendation 4)
- The Secretary of Energy should direct the Director of DOE's Manufacturing USA institutes to develop criteria to evaluate whether DOE-sponsored institutes can sustain their operations without additional federal financial assistance after their initial agreements. (Recommendation 5)

Agency Comments and Our Evaluation

We provided a draft of this report for review and comment to USDA, Commerce, DOD, DOE, DOL, NASA, and NSF. Commerce, DOD, and DOE generally agreed with our recommendations to those agencies to develop criteria to evaluate whether their institutes can sustain their operations without additional federal financial assistance after their initial agreements. Commerce stated that it would concur with our recommendations that it work with the other sponsoring federal agencies to develop network-wide performance goals with measureable targets and time frames and ensure alignment of the network-wide performance measures with the Manufacturing USA program goals if we made modifications to those recommendations. We do not agree with Commerce's proposed modifications as they would fundamentally change the intent and scope of the recommendations. In addition, Commerce and NSF provided technical comments, which we incorporated as appropriate. Officials from USDA, DOL, and NASA stated via email that they had no comments on the report.

Commerce, DOD, and DOE provided written comments that are reproduced in appendixes II, III, and IV, respectively. In expressing concurrence with the recommendations to develop criteria to evaluate institute sustainability, the agencies provided the following comments:

- Commerce generally agreed with our recommendation, but provided an alternative version to recommend the Secretary of Commerce consider developing, rather than develop, a legislative proposal to amend relevant provisions of the RAMI Act pending results of an analysis of the Commerce-sponsored institute's sustainability. We incorporated this suggested revision.

- DOD stated that it partially concurred with our recommendation, but that developing criteria to evaluate whether DOD-sponsored institutes could sustain their operations without additional federal financial assistance did not address all of the factors that DOD should consider as it defines its long-term strategic engagement with its institutes. DOD stated that additional criteria should include whether institutes are protecting critical technologies, transferring advanced manufacturing technologies to the industrial base, and supporting advanced manufacturing education and workforce activities. DOD further stated that its approach with its institutes would be focused on outcomes and progress toward a viable business model that can demonstrate, via performance metrics, that each institute is operating efficiently and effectively and is addressing risk factors. We view DOD's approach of including a variety of criteria as being consistent with the intent of our recommendation. The RAMI Act does not provide a definition of sustainability, but states that one of the purposes of the program is to leverage non-federal sources of support to promote a stable and sustainable business model without the need for long-term federal funding. Further, DOD, which has sponsored its institutes using its own existing authority separate from the RAMI Act, could consider a variety of criteria in evaluating institute sustainability. We did not modify our recommendation to include mention of specific criteria so as to not constrain the flexibility DOD has to consider a range of potential criteria.

- DOE stated that it agreed with our recommendation and that it would work collaboratively with the directors of the DOE-sponsored institutes to update institutes' sustainability plans and develop criteria and metrics to assess institutes' progress toward sustainability. DOE further stated that it would track metrics, as appropriate, after their development.

Commerce also provided comments related to the Manufacturing USA network-wide performance measurement recommendations. With regard to our first recommendation to work with other sponsoring federal

agencies to develop and implement Manufacturing USA network-wide performance goals with measureable targets and time frames, Commerce stated that it agreed with our recommendation if we modified the recommendation to apply only to institutes funded under RAMI Act authority. Commerce stated that it lacks legal authority to compel action by other federal agencies or provide oversight of institutes funded by other agencies and established under authorities other than the RAMI Act and therefore expected resistance from other sponsoring agencies in establishing network-wide performance goals, targets, and time frames. Commerce also stated that as it has no management authority over institutes sponsored by other agencies, any performance goals, targets, and time frames that are aligned to the purposes of the RAMI Act would potentially distort activities in institutes funded under other authorities to support other agencies' missions. Commerce stated that it would support modification of our recommendation to call for developing program-level performance goals for the Manufacturing USA network with measurable targets and time frames for institutes funded under RAMI Act authority within the Manufacturing USA network and that such goals should be implemented when there are at least two such institutes in operation.

We recognize that Commerce has no management authority over other agencies' programs or the institutes that they sponsor, nor authority to compel action by other agencies. We believe our report sufficiently characterizes the development of network-wide performance goals, targets, and time frames as a collaborative effort between AMNPO and sponsoring agencies that is in keeping with AMNPO's network-wide coordination functions under the RAMI Act. Further, our recommendation does not ask Commerce to compel action by other agencies or impose goals upon other agencies' institutes but to collaborate with sponsoring agencies to agree upon network-wide performance goals, targets, and time frames. As noted in the report, AMNPO and sponsoring agencies have already collaborated to establish a set of initial performance measures.

Additionally, we note that DOE stated in its written comments that it would work with Commerce and DOD to implement this recommendation. Finally, Commerce's suggested modifications to our recommendation are inconsistent with the purpose of the recommendation as it pertains to the network-wide program assessment the Secretary of Commerce is charged with reporting on under the RAMI Act. Therefore, we did not modify our recommendation. We continue to believe that by working with other sponsoring federal agencies to develop and implement network-wide performance goals with targets and time frames, Commerce would

be better able to observe and report on progress toward Manufacturing USA long-term goals and objectives.

With regard to our second recommendation on aligning network-wide performance measures with the network-wide performance goals, Manufacturing USA strategic objectives and program goals, and purposes of the RAMI Act, Commerce stated that it agreed with our recommendation if we modified the recommendation to apply only to institutes funded under RAMI Act authority. Commerce stated that as described in its comments to our first recommendation, it does not support the creation of network-wide performance goals based on the purposes of the RAMI Act and therefore cannot support aligning network-wide performance measures with performance goals based on the RAMI Act. Commerce also noted that, unlike institutes funded under RAMI Act authority, NIST has no management authority over institutes funded by other agencies and established under other authorities. Commerce stated that it would support a modification of our recommendation for the NIST Director to work with the institutes funded under RAMI Act authority to develop program-level performance measures aligned with program-level performance goals, the Manufacturing USA strategic objectives and program goals, and the statutory purposes of the RAMI Act. Commerce also stated that the program-level performance measures should be implemented when there is a sufficient cohort of RAMI Act-authorized institutes in operation so that they can be reported in aggregate.

As with our first recommendation, we believe our report sufficiently characterizes the effort to align the network-wide performance measures with the network-wide performance goals and Manufacturing USA program goals as a collaborative effort between Commerce and sponsoring agencies that is in keeping with AMNPO's coordination functions under the RAMI Act. Our recommendation does not ask Commerce to compel actions by other agencies but to collaborate with sponsoring agencies as it has done with the initial set of near-term performance measures. Also, as with the first recommendation, Commerce's suggested modifications are inconsistent with the purpose of our second recommendation as it pertains to the network-wide program assessment the Secretary of Commerce is charged with reporting on under the RAMI Act. Therefore, we did not modify our recommendation. We continue to believe that by working with other sponsoring federal agencies to ensure that the Manufacturing USA network-wide performance measures are directly aligned with the Manufacturing USA strategic program goals and objectives and the statutory purposes of the RAMI Act, Commerce would be better able to observe and report on

progress made toward achieving the statutory purposes of the Manufacturing USA program.

We are sending copies of this report to the appropriate congressional committees; the Secretaries of Agriculture, Commerce, Defense, Energy, and Labor; the Director of NSF; the Administrator of NASA; and other interested parties. In addition, the report will be available at no charge on the GAO website at http://www.gao.gov.

If you or your staff have any questions about this report, please contact me at (202) 512-6888 or neumannj@gao.gov. Contact points for our Offices of Congressional Relations and Public Affairs may be found on the last page of this report. GAO staff who made key contributions to this report are listed in appendix V.

John Neumann
Managing Director, Science, Technology Assessment, and Analytics

List of Committees

The Honorable Jerry Moran
Chairman
The Honorable Jeanne Shaheen
Ranking Member
Subcommittee on Commerce, Justice, Science, and Related Agencies
Committee on Appropriations
United States Senate

The Honorable Richard Shelby
Chairman
The Honorable Richard Durbin
Ranking Member
Subcommittee on Defense
Committee on Appropriations
United States Senate

The Honorable Lamar Alexander
Chairman
The Honorable Dianne Feinstein
Ranking Member
Subcommittee on Energy and Water Development
Committee on Appropriations
United States Senate

The Honorable Roger Wicker
Chairman
The Honorable Maria Cantwell
Ranking Member
Committee on Commerce, Science, and Transportation
United States Senate

The Honorable José Serrano
Chairman
The Honorable Robert Aderholt
Ranking Member
Subcommittee on Commerce, Justice, Science, and Related Agencies
Committee on Appropriations
House of Representatives

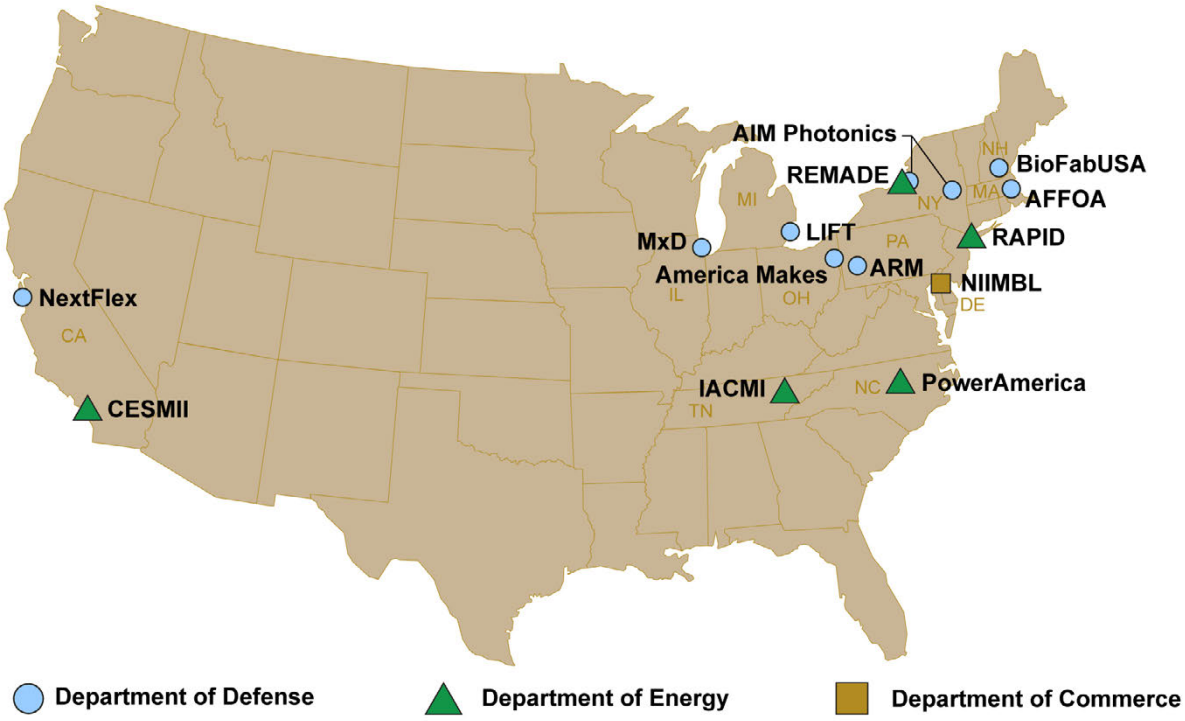
The Honorable Pete Visclosky
Chairman
The Honorable Ken Calvert
Ranking Member
Subcommittee on Defense
Committee on Appropriations
House of Representatives

The Honorable Marcy Kaptur
Chairwoman
The Honorable Mike Simpson
Ranking Member
Subcommittee on Energy and Water Development, and Related Agencies
Committee on Appropriations
House of Representatives

The Honorable Eddie Bernice Johnson
Chairwoman
The Honorable Frank Lucas
Ranking Member
Committee on Science, Space, and Technology
House of Representatives

Appendix I: Description and Location of the Manufacturing USA Institutes (Corresponds to fig. 3)

This appendix provides details on Manufacturing USA institutes, including rollover information, depicted in figure 3.



Sources: Department of Commerce, National Institute of Standards and Technology, *Manufacturing USA Annual Report, FY 2017* (August 2018); Map Resources (map). | GAO-19-409

Table 5: Description and Location of the Manufacturing USA Institutes

Institute	Headquarters	Description
AFFOA – Advanced Functional Fabrics of America Institute	Cambridge, Massachusetts	**Lead funding agency:** DOD **Technology focus area:** Advanced fibers and textiles **Mission:** To enable a domestic manufacturing-based revolution by transforming traditional fibers, yarns, and fabrics into highly sophisticated, integrated, and networked devices and systems. **Consortium organizer:** Massachusetts Institute of Technology **Initial federal financial assistance period:** March 2016 to September 2021 **Planned federal financial assistance:** $75M **Planned nonfederal funding:** $272M **Number of members** (as of December 2018): 118

Institute	Headquarters	Description
AIM Photonics – American Institute for Manufacturing Integrated Photonics	Rochester and Albany, New York	**Lead funding agency:** DOD **Technology focus area:** Integrated photonics **Mission:** AIM Photonics seeks to advance integrated photonic circuit manufacturing technology development while simultaneously providing access to state-of-the-art fabrication, packaging, and testing capabilities for small-to-medium enterprises, academia, and the government; create an adaptive integrated photonic circuit workforce capable of meeting industry needs and thus further increasing domestic competitiveness; and meet participating commercial, defense, and civilian agency needs in this burgeoning technology area. **Consortium organizer:** Research Foundation for the State University of New York **Initial federal financial assistance period:** July 2015 to January 2021 **Planned federal financial assistance:** $110M **Planned nonfederal funding:** $503M **Number of members** (as of December 2018): 99
America Makes – The National Additive Manufacturing Innovation Institute	Youngstown, Ohio	**Lead funding agency:** DOD **Technology focus area:** Additive manufacturing **Mission:** Develop and grow a comprehensive and globally competitive U.S. additive manufacturing and 3D printing infrastructure comprised of world-class domestic sources of equipment and support; a robust domestic supply chain of high-quality materials and services; and a highly skilled workforce capable of executing and exploiting the capabilities and advantages of additive manufacturing and 3D printing. **Consortium organizer:** National Center for Defense Manufacturing and Machining **Initial federal financial assistance period:** August 2012 to August 2019 **Planned federal financial assistance:** $56M **Planned nonfederal funding:** $85M **Number of members** (as of December 2018): 225

Institute	Headquarters	Description
ARM – Advanced Robotics for Manufacturing Institute	Pittsburgh, Pennsylvania	**Lead funding agency:** DOD **Technology focus area:** Advanced robotics **Mission:** ARM accelerates robotics innovation to drive U.S.-based growth in manufacturing while developing domestic robotics expertise to create high-value careers. By lowering economic, technical, and operational barriers, ARM ensures that enterprises of all sizes can adopt robotic solutions while preparing the American workforce to work collaboratively with robots. **Consortium organizer:** Carnegie Mellon University **Initial federal financial assistance period:** January 2017 to January 2024 **Planned federal financial assistance:** $80M **Planned nonfederal funding:** $174M **Number of members** (as of December 2018): 179
BioFabUSA – Advanced Regenerative Manufacturing Institute	Manchester, New Hampshire	**Lead funding agency:** DOD **Technology focus area:** Regenerative manufacturing **Mission:** BioFabUSA seeks to make the large-scale manufacturing of engineered tissues and tissue-related technologies practical and prepare the required workforce to meet the needs of the wounded warfighter and others in need of this technology across the United States. **Consortium organizer:** Advanced Regenerative Manufacturing Institute **Initial federal financial assistance period:** December 2016 to December 2023 **Planned federal financial assistance:** $80M **Planned nonfederal funding:** $215M **Number of members** (as of December 2018): 110
CESMII – Clean Energy Smart Manufacturing Innovation Institute	Los Angeles, California	**Lead funding agency:** DOE **Technology focus area:** Smart sensors and digital process control **Mission:** Radically accelerate the development and adoption of advanced sensors, controls, platforms, and models to enable Smart Manufacturing to become the driving, sustainable engine that delivers real-time business improvements in U.S. manufacturing. **Consortium organizer:** University of California, Los Angeles **Initial federal financial assistance period:** December 2016 to June 2022 **Planned federal financial assistance:** $70M **Planned nonfederal funding:** $171M **Number of members** (as of December 2018): 102

Institute	Headquarters	Description
IACMI – Institute for Advanced Composites Manufacturing Innovation	Knoxville, Tennessee	**Lead funding agency:** DOE **Technology focus area:** Advanced composites **Mission:** To accelerate innovative research and development in the advanced composites field. **Consortium organizer:** Collaborative Composite Solutions Corporation **Initial federal financial assistance period:** June 2015 to May 2020 **Planned federal financial assistance:** $70M **Planned nonfederal funding:** $95M **Number of members** (as of December 2018): 156
LIFT – Lightweight Innovations for Tomorrow	Detroit, Michigan	**Lead funding agency:** DOD **Technology focus area:** Lightweight metals **Mission:** To develop advanced lightweight materials manufacturing technologies and implement educational programs to train a workforce confident in deploying those technologies in defense and commercial applications. **Consortium organizer:** American Lightweight Materials Manufacturing Innovation Institute **Initial federal financial assistance period:** February 2014 to February 2020 **Planned federal financial assistance:** $70M **Planned nonfederal funding:** $78M **Number of members** (as of December 2018): 113
MxD – The Digital Manufacturing Institute	Chicago, Illinois	**Lead funding agency:** DOD **Technology focus area:** Digital manufacturing and design **Mission:** The Digital Manufacturing Institute provides the government and U.S. manufacturers with the digital tools needed to transform American manufacturing. **Consortium organizer:** UI Labs **Initial federal financial assistance period:** February 2014 to February 2020 **Planned federal financial assistance:** $70M **Planned nonfederal funding:** $106M **Number of members** (as of December 2018): 324

Institute	Headquarters	Description
NextFlex – America's Flexible Hybrid Electronics Manufacturing Institute	San Jose, California	**Lead funding agency:** DOD **Technology focus area:** Flexible hybrid electronics **Mission:** To pioneer Flexible Hybrid Electronics manufacturing to serve our nation's warfighters and the U.S. economy. **Consortium organizer:** FlexTech Alliance Inc. **Initial federal financial assistance period:** August 2015 to September 2021 **Planned federal financial assistance:** $75M **Planned nonfederal funding:** $96M **Number of members** (as of December 2018): 89
NIIMBL – The National Institute for Innovation in Manufacturing Biopharmaceuticals	Newark, Delaware	**Lead funding agency:** Commerce **Technology focus area:** Biopharmaceutical manufacturing **Mission:** To accelerate biopharmaceutical manufacturing innovation, to support the development of standards that enable more efficient and rapid manufacturing capabilities, and to educate and train a world-leading biopharmaceutical manufacturing workforce, fundamentally advancing U.S. competitiveness in this industry. **Consortium organizer:** University of Delaware **Initial federal financial assistance period:** March 2017 to February 2022 **Planned federal financial assistance:** $70M **Planned nonfederal funding:** $129M **Number of members** (as of December 2018): 113
PowerAmerica – The Next Generation Power Electronics Manufacturing Innovation Institute	Raleigh, North Carolina	**Lead funding agency:** DOE **Technology focus area:** Wide bandgap semiconductors **Mission:** The PowerAmerica institute at North Carolina State University seeks to save energy and create U.S. manufacturing jobs by accelerating the development and large-scale adoption of wide bandgap semiconductor technology in power electronic systems. **Consortium organizer:** North Carolina State University Initial federal financial assistance period: December 2014 to May 2020 **Planned federal financial assistance:** $69M **Planned nonfederal funding:** $77M **Number of members** (as of December 2018): 46

Institute	Headquarters	Description
RAPID – Rapid Advancement in Process Intensification Deployment Institute	New York, New York	**Lead funding agency:** DOE **Technology focus area:** Modular chemical process intensification **Mission:** Advance Modular Chemical Process Intensification technologies to reduce energy consumption, improve process efficiencies, and lower investment and operating requirements. **Consortium organizer:** American Institute of Chemical Engineers **Initial federal financial assistance period:** March 2017 to March 2022 **Planned federal financial assistance:** $70M **Planned nonfederal funding:** $109M **Number of members** (as of December 2018): 75
REMADE – Reducing EMbodied-energy And Decreasing Emissions Institute	Rochester, New York	**Lead funding agency:** DOE **Technology focus area:** Sustainable manufacturing **Mission:** Enable the early stage applied research and development of key industrial platform technologies that could dramatically reduce the embodied energy and carbon emissions associated with industrial-scale materials production and processing. **Consortium organizer:** Sustainable Manufacturing Innovation Alliance **Initial federal financial assistance period:** May 2017 to June 2022 **Planned federal financial assistance:** $70M **Planned nonfederal funding:** $70M **Number of members** (as of December 2018): 77

Source: GAO analysis of information provided by the Advanced Manufacturing National Program Office, the Manufacturing USA institutes, and the departments of Commerce, Defense, and the Energy. | GAO-19-409

Appendix II: Comments from the Department of Commerce

UNITED STATES DEPARTMENT OF COMMERCE
The Secretary of Commerce
Washington, D.C. 20230

April 22, 2019

Mr. John Neumann
Director, Natural Resources and Environment
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Neumann:

Thank you for the opportunity to review and comment on the Government Accountability Office's (GAO) draft report titled *Advanced Manufacturing: Innovation Institutes Have Demonstrated Initial Accomplishments, but Challenges Remain in Measuring Performance and Ensuring Sustainability* (GAO-19-409).

On behalf of the Department of Commerce, I have enclosed our comments on the draft report. The attached response states that the National Institute of Standards and Technology (NIST) concurs with the recommendations pending suggested modifications. In the formal comments, NIST provides our rationale for the modifications to the recommendations and a description of the actions we can take in response to the recommendations. We will provide more details on how and when the Department will address the recommendations in the action plan that is required 180 days after issuance of the final GAO report.

If you have any questions, please contact MaryAnn Mausser, Department of Commerce Audit Liaison, at (202) 482-8120.

Sincerely,

Wilbur Ross

Wilbur Ross

Enclosure

Department of Commerce's Comments on
GAO Draft Report titled *Advanced Manufacturing: Innovation Institutes Have Demonstrated Initial Accomplishments, but Challenges Remain in Measuring Performance and Ensuring Sustainability*
(GAO-19-409)

The Department of Commerce (DOC) has reviewed the draft report and we offer the following comments for the Government Accountability Office's (GAO) consideration.

General Comments
The Department of Commerce appreciates the thorough analysis done by the GAO staff in its most recent study of the Manufacturing USA program.

The draft report has five recommendations. DOC would like to provide clarifying comments on the first three of these, which relate to the Secretary of Commerce and the National Institute of Standards and Technology (NIST). Additionally, DOC will provide factual and editorial feedback in the Technical Response Memorandum.

Comments on Recommendations
GAO made three recommendations to DOC in the report.

- **Recommendation 1:** The Secretary of Commerce should direct the NIST Director to work with other sponsoring federal agencies to develop and implement network-wide performance goals for the Manufacturing USA network with measurable targets and time frames.

  Commerce Response: The DOC agrees with this recommendation if modified as described below to apply only to institutes funded under the Revitalize American Manufacturing and Innovation Act of 2014 (RAMI) authority.

  DOC notes that the annual reporting currently performed meets – and exceeds – the requirements defined by RAMI. Institutes sponsored by other Federal agencies are required to only report on their participation and contributions to the network, yet voluntarily report on a dozen key metrics. The institute sponsored by DOC/NIST in the upcoming annual report will include detailed RAMI reporting as this is the first full year of institute operations.

  Because DOC lacks the legal authority to compel action by other Federal agencies or to provide oversight of institutes funded by other agencies and created under authorities other than RAMI, DOC anticipates principled resistance from other funding agencies in any attempt to develop network-wide, RAMI-derived performance goals, targets, and time frames. While RAMI sets a framework for managing institutes receiving DOC funding, currently only one has received funding, while an additional 13 institutes funded by other agencies have been recognized as Manufacturing USA institutes by DOC. This situation presents significant opportunities for cooperation and beneficial coordination of activities, but it does not permit DOC to create performance goals, targets, and timeframes for the other 13 institutes or their funding agencies.

As the DOC has no management authority over institutes sponsored by other agencies, any performance goals, targets, and time frames that are aligned to the RAMI purposes would potentially distort activities in institutes that are funded under alternate authorities to support the funding agencies' programmatic missions. Legal constraints aside, DOC believes it is a bad management practice to ask institutes to respond to performance goals issued by different bodies; thus, DOC anticipates significant resistance from other funding agencies in this area.

DOC would support modification of the recommendation to indicate that "the Secretary of Commerce should direct the NIST Director to develop program-level performance goals for the Manufacturing USA network with measurable targets and time frames for institutes funded under RAMI authority within the Manufacturing USA network.
These program-level performance goals should be implemented when there is a sufficient cohort of RAMI-authorized institutes in operation – at least two – so that associated performance measures can be reported in aggregate."

- **Recommendation 2:** The Secretary of Commerce should direct the NIST Director to work with other sponsoring federal agencies to ensure that the Manufacturing USA network-wide performance measures are directly aligned with the network-wide performance goals, the Manufacturing USA strategic objectives and program goals, and the statutory purposes of the RAMI Act.

  Commerce Response: The DOC agrees with this recommendation if modified as described below to apply only to institutes funded under the Revitalize American Manufacturing and Innovation Act of 2014 (RAMI) authority.

  As described in Recommendation 1, DOC does not support the creation of network-wide performance goals based on the purposes of the RAMI Act. DOC therefore cannot support aligning network-wide performance measures with performance goals based on RAMI.

  The DOC also notes that unlike institutes funded under RAMI authority, NIST has no management authority over institutes funded by other agencies and established under other (non-RAMI) authorities. DOC therefore has no authority to require other agencies to provide DOC with access to performance metrics for institutes funded by other agencies.

  The DOC believes that alignment of performance measurements with performance goals for institutes supported under RAMI authority is appropriate because, unlike institutes funded under other agencies' authorities in support of their missions, the NIST-supported institutes are funded with the intent of supporting the RAMI purposes. Therefore, the development and implementation of RAMI-derived performance goals and measures for this subset of institutes would be meaningful.

  However, until there is a sufficient cohort of RAMI-authorized institutes in operation so that multi-institute performance measures tied to performance goals can be reported in aggregate, DOC cannot support the specific reporting of any of these measures for the single

Commerce-sponsored institute, as doing so would expose that institute to an unfair level of scrutiny with potential impacts on its competitiveness and sustainability.

DOC would support a modification of this recommendation stating that "the Secretary of Commerce should direct the NIST Director to work with the institute(s) funded under RAMI authority to develop program-level performance measures aligned with the program-level performance goals, the Manufacturing USA strategic objectives and program goals, and the statutory purposes of the RAMI Act. These program-level performance measures should be implemented when there is a sufficient cohort of RAMI-authorized institutes in operation so that they can be reported in aggregate."

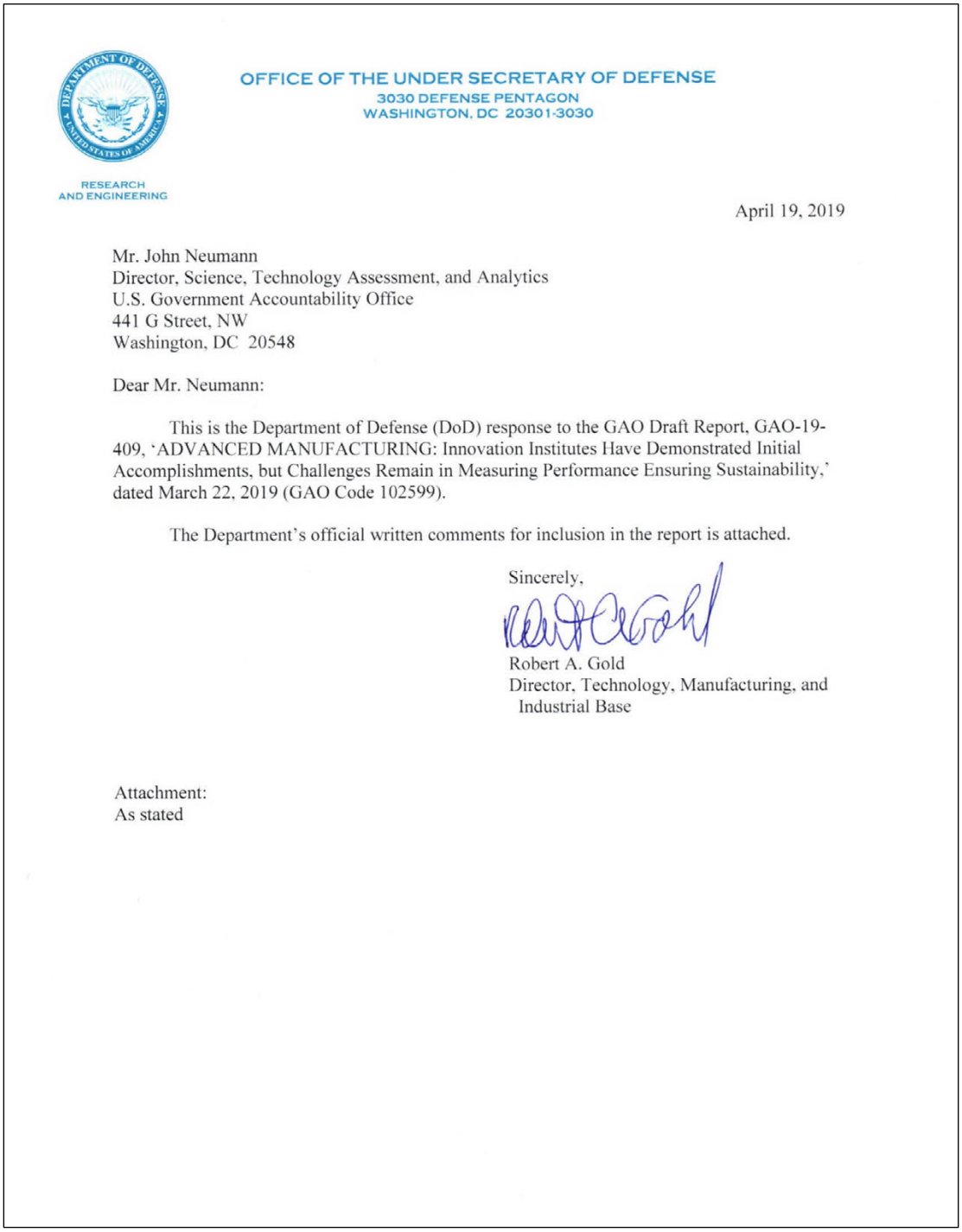
- **Recommendation 3:** The Secretary of Commerce should direct the NIST Director to develop criteria to evaluate whether the Commerce-sponsored institute can sustain its operations without additional federal financial assistance after its initial agreement. If an analysis based on such criteria indicates that additional federal financial assistance is needed to help the institutes sustain their operations, then the Secretary of Commerce should develop a legislative proposal to amend relevant provisions of the RAMI Act.

  Commerce Response: The DOC agrees with this recommendation if modified to reflect that there is a range of possible sustainability futures as described below.

  As the National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL) matures into a fully operational, steady-state enterprise, its sustainability plan will evolve to include additional granularity. It is the intention of the DOC/NIST program management team to continue work with NIIMBL to support the development of the more mature sustainability plan by the Strategic Advisory Committee, and to evaluate the sufficiency of that plan for achieving sustainability by the end of the period of Federal funding. In general, evaluation criteria will consider operating costs of the institute at steady state and the likelihood of sustaining those operations through the efforts outlined in the sustainability plan. DOC will continue quarterly reviews of NIIMBL's sustainability and strategic planning. DOC anticipates that evaluation criteria with appropriate granularity can be developed that are consistent with the level of detail in NIIMBL's sustainability plan and will be revised as needed as the plan undergoes additional iterations throughout the Federal funding period.

  DOC would support a modification of this recommendation stating that "the Secretary of Commerce should direct the NIST Director to develop criteria to evaluate whether the Commerce-sponsored institute can sustain its operations without additional Federal financial assistance after its initial agreement. If an analysis based on such criteria indicates that additional Federal financial assistance is needed to help the institutes sustain its operations, then the Secretary of Commerce should consider a legislative proposal to amend relevant provisions of the RAMI Act."

Appendix III: Comments from the Department of Defense



OFFICE OF THE UNDER SECRETARY OF DEFENSE
3030 DEFENSE PENTAGON
WASHINGTON, DC 20301-3030

RESEARCH
AND ENGINEERING

April 19, 2019

Mr. John Neumann
Director, Science, Technology Assessment, and Analytics
U.S. Government Accountability Office
441 G Street, NW
Washington, DC 20548

Dear Mr. Neumann:

This is the Department of Defense (DoD) response to the GAO Draft Report, GAO-19-409, 'ADVANCED MANUFACTURING: Innovation Institutes Have Demonstrated Initial Accomplishments, but Challenges Remain in Measuring Performance Ensuring Sustainability,' dated March 22, 2019 (GAO Code 102599).

The Department's official written comments for inclusion in the report is attached.

Sincerely,

Robert A. Gold
Director, Technology, Manufacturing, and Industrial Base

Attachment:
As stated

GAO DRAFT REPORT DATED MARCH 22, 2019

GAO-19-409 (GAO CODE 102599)

"ADVANCED MANUFACTURING: Innovation Institutes Have Demonstrated Initial Accomplishments, but Challenges Remain in Measuring Performance Ensuring Sustainability"

DEPARTMENT OF DEFENSE COMMENTS

TO THE GAO RECOMMENDATION

RECOMMENDATION 4: The GAO recommends that the Secretary of Defense should direct the Director of DoD Manufacturing USA Institutes to develop criteria to evaluate whether DoD-sponsored institutes can sustain their operations without additional federal financial assistance after their initial agreements. (Recommendation 4)

DoD RESPONSE: The DoD partially concurs with recommendation 4. The GAO's recommendation that Secretary of Defense should direct the Director of DoD Manufacturing USA Institutes to develop criteria to evaluate whether DoD-sponsored institutes can sustain their operations without additional federal financial assistance after their initial agreements does not address all of the factors DoD should consider when deciding on continuing strategic engagements with the institutes as a federal partner. The ability to sustain operations is one of several criteria that should be considered by the DoD to maintain long-term strategic engagements with the DoD-sponsored manufacturing innovation institutes (MIIs). Other criteria includes protecting critical technologies, transferring advanced manufacturing to the industrial base, and supporting education and workforce activities aligned with advanced manufacturing.

Based upon regular interaction with the DoD-sponsored institutes, the Office of the Secretary of Defense (OSD) Manufacturing Technology (ManTech) program office believes that the DoD-sponsored institutes can achieve sustainability without DoD funding. However, DoD also needs to consider the ramifications of DoD technology transfer and loss of benefit to the US industrial base since these ecosystems would likely rapidly migrate offshore without U.S. federal funding and the associated IP protection requirements. Manufacturing technology and capability are important elements of the DoD's modernization priorities. The nation's manufacturing industrial base underpins the defense industrial base's ability to securely deliver capability advances to the warfighter in the quantities required, at the time needed, and with cost efficiency.

The DoD has significant influence on the DoD-sponsored manufacturing innovation institutes' (MIIs') direction through technology roadmaps, government subject matter experts, and DoD project investments. Although the original vision for the MIIs was for the institutes to become totally self-sustaining after the initial startup period, as this program has evolved the DoD has concluded that: (1) there is value in maintaining the public-private partnership model; (2) the ecosystems created in the technology areas provide value to the DoD; (3) strategic engagement between the MIIs and the DoD will accelerate innovation; (4) work done by the MIIs impacts national security and economic security; (5) the DoD's involvement as a partner in the MIIs provides a higher rate of return by making investing in MIIs and MII-focused technology areas more appealing to industry; and (6) if the DoD is only a passive participant in the MIIs there

would be significant risk that adversary nations, such as China, will attempt to partner with the MIIs to create value for their country instead of the United States.

The eight DoD MIIs were founded because innovation in the technology areas selected could provide benefit to DoD acquisition and sustainment that would also benefit commercial customers. The MIIs are public-private partnerships chartered to address critical manufacturing risks, boost manufacturing innovation for the DoD, encourage re-development of U.S. manufacturing capabilities, and provide an integrated whole-of-sector approach in each of the MIIs' eight technology-focused areas. To date, the DoD has invested over $600M to establish MIIs for additive manufacturing; lightweight and modern metals; digital manufacturing, design, and cybersecurity; integrated photonics; flexible hybrid electronics; revolutionary fibers and textiles; regenerative tissue manufacturing; and advanced robotics. This DoD funding has engendered more than $1.6B in additional state, industry, and academic cost-share contributions; demonstrating a substantial return on investment for the DoD.

The participation of mutually self-interested industry and academic partners in the MIIs creates an ecosystem with benefits to the U.S. manufacturing and industrial base. The ecosystems sustained by the MIIs enable technology investments beyond the risk of any one company or government entity. At the same time, they facilitate data and knowledge sharing that is not typically possible across the public and private sectors – while at the same time protecting intellectual property. The MIIs attract non-traditional DoD partners that expand the innovation pipeline and open opportunities to rapidly facilitate partnerships between small businesses and other communities (e.g., government labs and large companies). By making specialized equipment and expertise available, they allow innovative and agile small businesses access to prototype at a reduced cost. The MIIs complement technology development with much needed co-investment in education and workforce development training programs accessible to both the public and private sectors. All of these benefits underpin a healthy, resilient, and agile technological and industrial base.

For the reasons explained above, the DoD has not yet decided to end its funding of, or involvement as a partner with, the MIIs. Therefore, the GAO's recommendation does not account for all factors necessary for such a decision. An approach that is consistent with the DoD's intended course of action with the MIIs must be focused more on outcomes and progress toward a viable business model that can demonstrate, via performance metrics, that each institute is operating efficiently and effectively and is addressing risk factors. To this end, Director of the DoD Manufacturing USA Institutes will develop criteria to evaluate whether each DoD-sponsored institute is effectively executing its mission, providing value to the Department, and transitioning advanced manufacturing to U.S. manufacturers while demonstrating progress toward business sustainability (diversified revenue, controlled costs, etc.).

Appendix IV: Comments from the Department of Energy

Department of Energy
Washington, DC 20585

April 30, 2019

Mr. John Neumann
Managing Director
Science, Technology Assessment, and Analytics
U.S. Government Accountability Office
441 G Street, N.W.
Washington, D.C. 20548

Dear Mr. Neumann:

The Department of Energy (DOE) has reviewed the U.S. Government Accountability Office (GAO) draft report titled, "*Advanced Manufacturing: Innovation Institutes Have Demonstrated Initial Accomplishments, but Challenges Remain in Measuring Performance and Ensuring Sustainability* (GAO-19-409)." DOE appreciates GAO's assessment of the DOE manufacturing institutes as part of the larger Manufacturing USA Network. The particular emphasis on financial sustainability is important as two of the sponsored institutes move into each institute's final budget period.

The draft report contained five recommendations, of which GAO directed one recommendation specifically to DOE and two recommendations addressed crosscutting issues relating to the Manufacturing USA program. DOE's Office of Energy Efficiency and Renewable Energy (EERE), Advanced Manufacturing Office (AMO) has reviewed the report and agrees with GAO's recommendations. The attached enclosure describes planned corrective actions for the recommendation addressed specifically to DOE. DOE will also work with the Department of Commerce and the Department of Defense to implement the crosscutting recommendations contained in the report.

GAO should direct any questions concerning DOE's response to Valri Lightner, Acting Director, Advanced Manufacturing Office at (202) 586-0937.

Sincerely,

Steve Chalk
Acting Deputy Assistant Secretary
For Energy Efficiency
Energy Efficiency and Renewable Energy

Enclosure

Department of Energy (DOE)
Management Response to GAO Draft Report:
***ADVANCED MANUFACTURING: Innovation Institutes Have Demonstrated Initial Accomplishments, but Challenges Remain in Measuring Performance and Ensuring Sustainability* (GAO-19-409)**

GAO Recommendation:

The Secretary of Energy should direct the Director of DOE's Manufacturing USA institutes to develop criteria to evaluate whether DOE-sponsored institutes can sustain their operations without additional federal financial assistance after their initial agreements. (Recommendation 5)

Management Response:

DOE concurs with GAO's recommendation. DOE will collaborate with the Directors of the DOE-sponsored institutes to collectively work towards updating institute sustainability plans and activities while collaboratively developing criteria and metrics to assess the institutes' progress towards financial sustainability. DOE will track metrics, as appropriate, after development.

Estimated Completion Date: January 2020

Appendix V: GAO Contact and Staff Acknowledgments

GAO Contact

John Neumann, (202) 512-6888 or neumannj@gao.gov

Staff Acknowledgments

In addition to the contact named above, Christopher Murray (Assistant Director), Darnita Akers (Analyst in Charge), Blake Ainsworth, Sarah Cantatore, TC Corless, David Dornisch, Kim Frankena, Gwen Kirby, Ben Licht, Patricia Moye, Sean Seales, Sara Sullivan, and David Wishard made key contributions to this report.