REPORT TO CONGRESS
FY 2021

August 2022

About This Document

This annual Report to Congress documents the progress of the Manufacturing USA program in meeting its goals and highlights accomplishments of the federal agency-sponsored manufacturing institutes that participated in the Manufacturing USA program in fiscal year 2021.

Disclaimer Statement

Any mention of companies or commercial products within this document is for information only and does not imply recommendation or endorsement by the National Institute of Standards and Technology (NIST) or the other federal agencies participating in Manufacturing USA.

Permissions

All tables, figures, and photos in this report, unless otherwise noted, were produced by participants in the Advanced Manufacturing National Program Office's Interagency Working Team.

Any permissions required for third-party materials provided by institutes for this document are the responsibility of the reporting institutes.

Copyright

Executive Summary

The Manufacturing USA® network continues to secure U.S. global leadership in advanced manufacturing through public-private collaboration on technology, supply chain and workforce development. This work enhances the nation's industrial competitiveness, economic growth, and national security.

In FY 2021, the Manufacturing USA network collaborated across agencies and institutes to share research progress and discuss lessons learned from the COVID-19 pandemic. Under the American Rescue Plan appropriations, NIST-sponsored grant competitions will fund projects to Manufacturing USA institutes to focus on domestic research, development, and testbeds to prevent, prepare for, and respond to coronavirus.

Institute-managed applied research and development (R&D) technology projects help to de-risk investment, advance manufacturing technology and processes, and improve innovation ecosystems.

In FY 2021 the institutes continue addressing the need for more skilled workers trained in advanced manufacturing technology. The pandemic prompted the institutes to augment their on-line tools to increase the accessibility of innovative advanced manufacturing education and training, which reached more diverse groups and communities.

In FY 2021, the 16 institutes:

- Worked with over **2,000+ Member Organizations** and **established 300 new memberships**
- Managed **700+ applied research and development technology projects** (33% increase in FY21)
- Engaged **85,000+ participants** in workforce and training **(25% increase in FY21)**
    - **30x increase in post-secondary teachers trained** (29 to 960)
    - **9x increase in certifications** (757 to 7,161)
- **$354M investment** from state, federal, and private funds beyond the $127M in base federal funds
    - **2.7 to 1 investment match**

Contents

Background

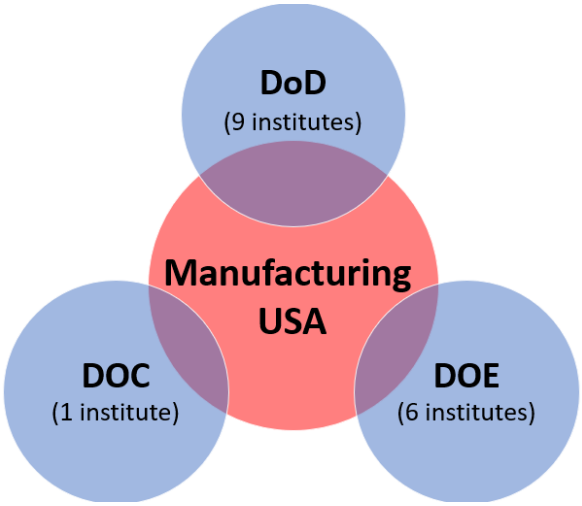


Figure 1: Manufacturing USA funding agency representation

Manufacturing USA brings together three federal agencies and their sponsored manufacturing innovation institutes to ensure U.S. global competitiveness in advanced manufacturing. Together, with institute members from industry and academia, this "whole-of-government" effort seeks to drive innovation in advanced manufacturing through technology and workforce development. In FY 2021, the Manufacturing USA network included 16 institutes: the Department of Commerce (Commerce or DOC) with one institute, the Department of Defense with nine institutes and the Department of Energy with six. The Advanced Manufacturing National Program Office (AMNPO) at DOC's National Institute of Standards and Technology oversees the coordinated activities of Manufacturing USA.

While each institute delivers on the mission of its sponsoring agency, they unite under the Manufacturing USA network to fulfill a common vision. Commerce's NIST Office of Advanced Manufacturing focuses on economic competitiveness via manufacturing technology and workforce development. The DoD-sponsored institutes, within the Office of the Secretary of Defense Manufacturing Technology Program, seek to revitalize the U.S.'s domestic manufacturing capability through domestic public-private partnerships that enhance America's strategic competitiveness while enabling the military of tomorrow. The DOE Advanced Manufacturing Office (AMO) within the Office of Energy Efficiency & Renewable Energy (EERE) is the only technology development office within the U.S. government dedicated to improving the energy and resource efficiency of manufacturers across the industrial sector. These interagency missions are committed to supporting manufacturers' efforts to build diverse and inclusive workplaces, provide high-quality jobs, and strengthen equal opportunity in our country.

The Manufacturing USA network continues to build on years of best practices through close collaboration across agencies and institutes. Agencies meet regularly to share their institutes' progress and discuss lessons learned. The institutes participate in standing meetings to explore opportunities for additional cross-institute projects and collaborations.

Mapping Manufacturing USA Institutes and Members

Each institute is established as a public-private partnership sponsored by a lead government agency. Each institute focuses on a critical technology area that promotes the nation's leadership in advanced manufacturing. The institutes convene members from, commercial manufacturers of all sizes, universities, community colleges, state and local governments, and NIST's Hollings Manufacturing Extension Partnership (MEP) Centers within their given technology area. Members leverage unique project and networking opportunities provided by the institute to collaborate to solve manufacturing challenges and educate the workforce needed to advance new technologies. These unique ecosystems serve as invaluable resources for the federal government to tackle agency-specific problems.

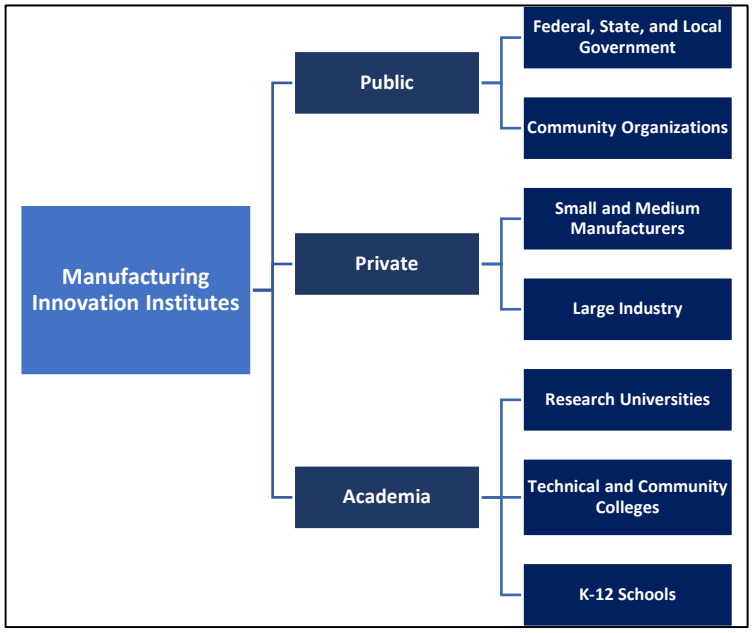


Figure 2: Manufacturing USA stakeholders

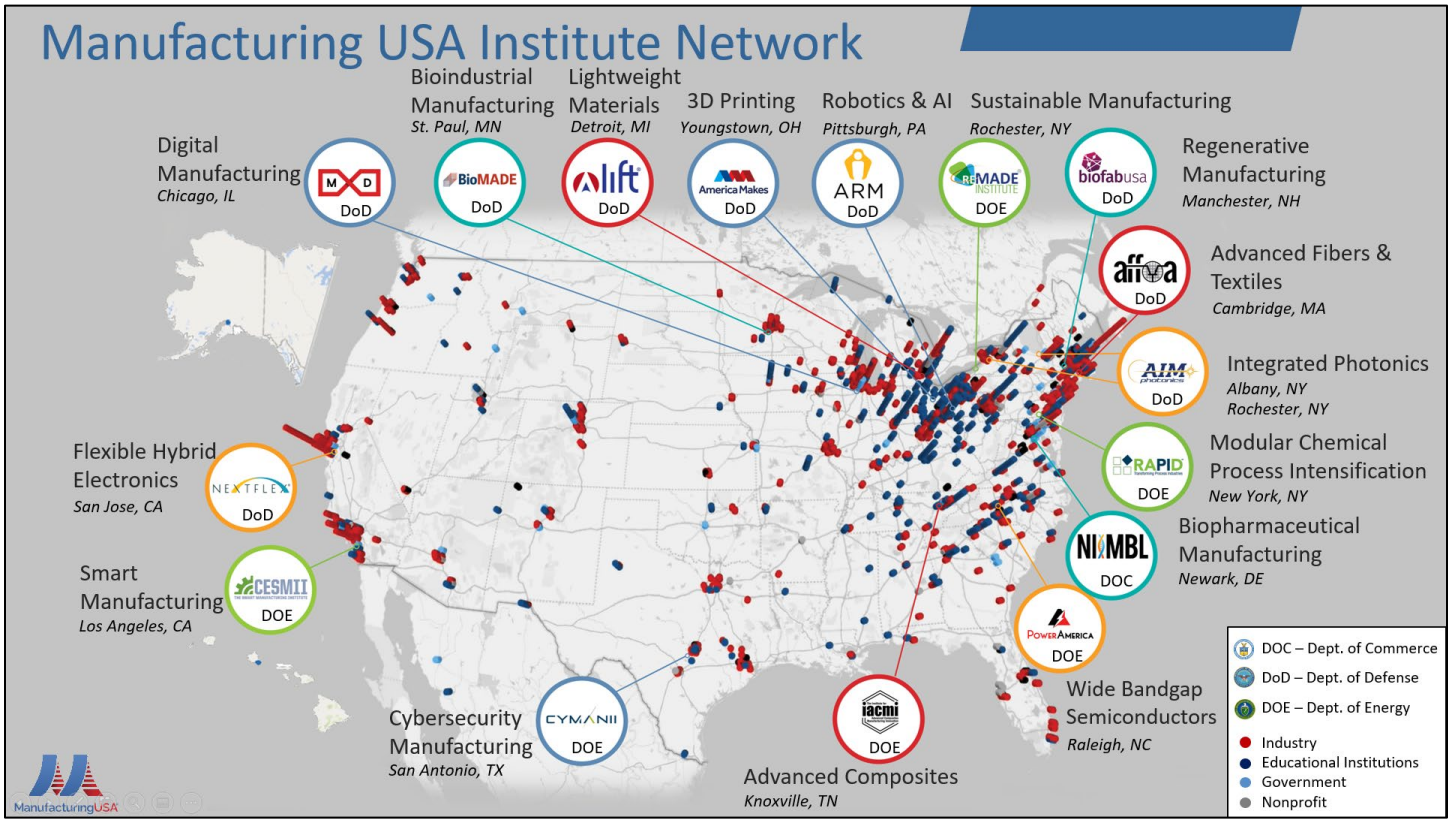


Figure 3: Location of 16 Manufacturing USA institutes and members

Table 1. The 16 Manufacturing USA Institutes					
Institute	Technology Focus Area	Agency	Headquarter Locations	Date Estab.	*Agency Agreement
America Makes The National Additive Manufacturing Innovation Institute	Additive manufacturing	DoD	Youngstown, OH	Aug 2012	Follow-on
MxD Manufacturing times Digital	Digital manufacturing and design/ Cybersecurity in Manufacturing	DoD	Chicago, IL	Feb 2014	Follow-on
LIFT	Lightweight materials manufacturing	DoD	Detroit, MI	Feb 2014	Follow-on
PowerAmerica Next Generation Power Electronics Manufacturing Innovation Institute	Wide-bandgap power electronics manufacturing	DOE	Raleigh, NC	Jan 2015	Pending**
IACMI Institute for Advanced Composites Manufacturing Innovation	Fiber-reinforced polymer composites manufacturing	DOE	Knoxville, TN	Jun 2015	Pending**
AIM Photonics American Institute for Manufacturing Integrated Photonics	Integrated photonics manufacturing	DoD	Rochester & Albany, NY	Jul 2015	Follow-on
NextFlex America's Flexible Hybrid Electronics Manufacturing Institute	Thin flexible electronics devices and sensors manufacturing	DoD	San Jose, CA	Aug 2015	Follow-on
AFFOA Advanced Functional Fabrics of America Institute	Sophisticated, integrated, and networked fibers, yarns, and fabric manufacturing	DoD	Cambridge, MA.	Apr 2016	Original
CESMII Clean Energy Smart Manufacturing Innovation Institute	Smart manufacturing, advanced sensors, and process controls	DOE	Los Angeles, CA	Dec 2016	Original
BioFabUSA Advanced Regenerative Manufacturing Institute	Engineered tissues and tissue-related manufacturing	DoD	Manchester, NH	Dec 2016	Original
ARM Institute Advanced Robotics for Manufacturing Institute	Transformative artificial intelligence and robotic technologies for manufacturing	DoD	Pittsburgh, PA	Jan 2017	Original
NIIMBL National Institute for Innovation in Manufacturing Biopharmaceuticals	Biopharmaceutical manufacturing	DOC	Newark, DE	Mar 2017	Original
RAPID Rapid Advancement in Process Intensification Deployment Institute	Modular chemical-process intensification for manufacturing	DOE	New York, NY	Mar 2017	Original
REMADE Reducing Embodied-energy And Decreasing Emissions	Sustainable manufacturing	DOE	Rochester, NY	May 2017	Original
BioMADE Bioindustrial Manufacturing	Sustainable & reliable bioindustrial manufacturing technologies	DoD	St. Paul, MN	Oct 2020	Original
CyManII Cybersecurity Manufacturing Innovation Institute	Cybersecure and energy efficient manufacturing	DOE	San Antonio, TX	Sep 2020	Original

* The period of performance for the initial agency Cooperative Agreement or Technology Investment Agreement establishing each institute is usually 5-7 years. DoD has established follow-on agreements with five of its sponsored institutes to enable them to continue to best leverage their partnership.

** DOE is providing no-cost extensions while evaluating agency agreements with these institutes.

Manufacturing USA Institutes Address COVID-19

COVID-19 hit with a force that commanded the best in government, academia, and industry to gather at an unprecedented pace to accelerate innovations that address the needs of our nation. The Manufacturing USA network assembled and utilized the flexibility, skills, and knowledge of their nationwide membership to address issues and begin developing solutions. Please see the Rapid Response to COVID-19 report for more details on the network's early response efforts.

Coronavirus Aid, Relief, and Economic Security (CARES) Act

Congress appropriated $10 million to NIST and $60 million to DoD under the Coronavirus Aid, Relief, and Economic Security (CARES) Act (Pub. L. 116-136) in March 2020. These funds were provided to support manufacturing for high impact projects to prevent, prepare for, and respond to coronavirus, including to support development and manufacturing of medical countermeasures and biomedical equipment and supplies. The funded institute projects have built out the nation's infrastructure or advanced technologies for future pandemic responses. For example, LIFT reached over 1,000 participants across 48 states by launching an online training curricula to reskill/upskill civilian workers impacted by the pandemic. America Makes established an interagency crisis response portal to expand production of medical countermeasure components such as personal protective equipment (PPE) using additive and digital manufacturing technologies. As well, BioFabUSA defined a roadmap to guide a wide variety of stakeholders on the technologies, platforms, and infrastructure needed to accelerate their response and recovery to COVID-19 and future pandemics.

American Rescue Plan (ARP) Act

In March 2021, Congress enacted the American Rescue Plan (ARP) Act of 2021 (Pub. L. 117-2) and provided funds to help the nation prevent, prepare for, and respond to coronavirus public health threats. NIST OAM obligated $83 million to NIIMBL for 32 projects across 14 states and the District of Columbia by July 2021 and launched a competition for current Manufacturing USA institutes not receiving financial assistance under 15 U.S.C. § 278s (3) to fund high-impact projects designed to support research, development, and testbeds to prevent, prepare for, and respond to coronavirus with awards expected in FY22. This funding will promote the research and development of vaccine and drug manufacturing, train a diverse manufacturing workforce, and strengthen the pandemic response supply chain.

Measuring Manufacturing USA Program Performance

Manufacturing USA's performance metrics are revised over time. The quantitative performance metrics measure progress toward overall Manufacturing USA program objectives, as shown in Table 2. Each metric category provides information for tracking progress toward four interrelated high-level goals [1] based primarily on the legislative program purposes.[2]

Currently there are 26 metrics (Tables 3 and 4), which are complemented by an additional 14 education and workforce metrics being piloted (Tables 5 and 6). Current metrics are compared with FY 2020 in this report.

In addition to the Manufacturing USA program metrics reported here, each lead funding agency has established metrics relating to the agency's unique mission requirements. Those additional metrics are separately collected and evaluated by the funding agency.

Table 2. Performance Metrics Mapped to the Manufacturing USA Program Goals

Institute Metric Category	**Goal 1** Increase competitiveness of U.S. manufacturing	**Goal 2** Facilitate the transition of innovative technologies into scalable, cost-effective, high-performing domestic manufacturing capabilities	**Goal 3** Accelerate the development of an advanced manufacturing workforce	**Goal 4** Support institute business models that help institutes become stable and sustainable
1. Impact to U.S. innovation ecosystem	●	●		●
2. Financial leverage		●		●
3. Technology advancement	●	●		
4. Development of an advanced manufacturing workforce	●		●	

[1] *Manufacturing USA Strategic Plan*, Advanced Manufacturing National Program Office, p. 6 (November 2019), https://www.manufacturingusa.com/sites/manufacturingusa.com/files/2021-01/2019%20MfgUSA%20Strategic%20Plan%2011-10-2020.pdf.

[2] 15 U.S.C. § 278s(b)(2). http://uscode.house.gov/view.xhtml?req=(title:15 section:278s edition: prelim).

Performance Metrics

Table 3 provides the aggregated performance metrics for the innovation ecosystem, financial leverage, and technology advancement for the 16 institutes operating in FY 2021.

Table 3. Technology and Program Development Performance Metrics – 16 Institutes			
Specific Metric	**Unit of Measure**	FY 2020	**FY 2021**
Metric Category 1 – Impact to U.S. Innovation Ecosystem			
Organizations with institute membership agreements	Total number of memberships	2,013	**2,320**
Diversity of member organizations	Number of large manufacturers (more than 500 employees)	355	**407**
	Number of small manufacturers (500 or fewer employees)	895	**1053**
	Number of academic members (universities, community colleges, etc.)	459	**516**
	Number of other entities (government members, government laboratories, not-for-profits, etc.)	304	**344**
Metric Category 2 – Financial Leverage			
Federal investment	Federal base funding in the fiscal year	$163 M	**$127 M**
Co-investment	Cost-share expended and federal funding not part of the base federal funding in fiscal year	$262 M	**$314 M**
Pandemic Response	Federal special pandemic projects funding	N/A	**$40 M**
Total Expenditure	Total institute expenditures in fiscal year	$425 M	**$481 M**
Metric Category 3 – Technology Advancement			
Active research and development projects	Number of ongoing projects	534	**708**
Key project objectives met	Percentage of key project milestones met	79%	**82%**

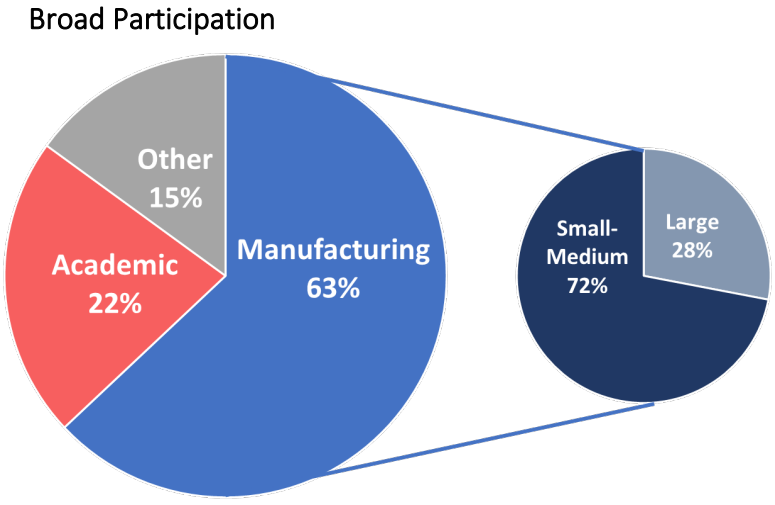


Figure 4. Institute membership demographics for FY2021.

In FY 2021, the institutes had 2,320 member organizations, including large and small manufacturers, community colleges, major research universities, and state and local economic development entities.

Of these member organizations, 63% were manufacturers (industry), and 72% of those manufacturers were small and medium-sized companies with 500 or fewer employees. Universities, community colleges, and technical training schools made up 22% of member organizations. The remaining 15% of other organizations included federal laboratories, regional economic development agencies, not-for-profit organizations, and state and local governments. This growth reflects an average of **14% year-to-year increase in membership** for FY 2021. While institute membership models vary, members participate in research and development project calls, education and workforce development efforts, road mapping, and other institute activities throughout the country.

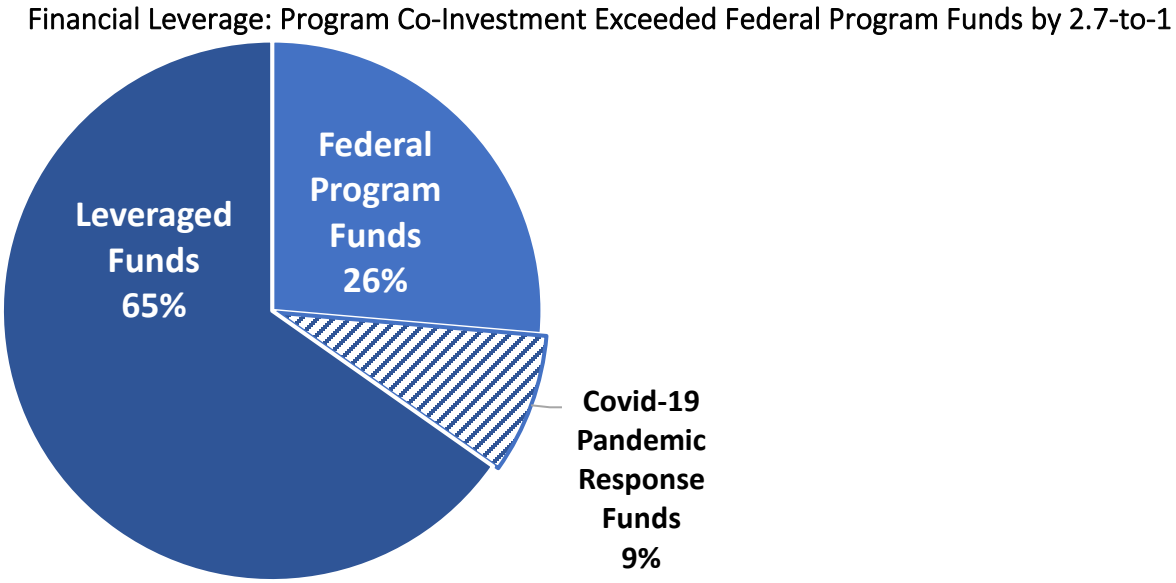


Figure 5. Program funding for the Manufacturing USA institutes in FY2021.

New to FY21 are special federal funding for pandemic response projects from the CARES Act that did not require cost-share. Matches from industry, academia, competitive government grants and contracts, and regional organizations totaled $2.7 for each $1 in federal base funding. Covid-19 pandemic response expenditures totaled $40M, federal base program funds $126.6 million and non-program matching expenditures totaled $314M bringing total annual institute expenditures to $481M.

Technology Advancement: Advancing Technology and Improving the Innovation Ecosystem

During FY 2021, the institutes managed 708 applied R&D projects. While R&D projects have inherent risks, an average of 82% of key technical milestones were met, which is above previous years.

Critical to each institute's success is a rigorous and inclusive approach to selecting project topics. Stakeholders from industry, academia, regulatory agencies, and end users develop roadmaps for key technologies and manufacturing processes. These roadmaps identify technological barriers, industry needs, and sector affinities via stakeholder engagement. The identified challenges are then prioritized and addressed in the context of the Manufacturing USA public-private partnership model. The subsequent R&D projects are selected based in part on their linkage to the institutes' technology roadmaps.

Below are nine of the over 700 projects conducted in FY 2021. They provide a snapshot of the far-reaching impact and innovative solutions the Manufacturing USA network developed in advanced manufacturing technologies, supply chain and ecosystem development, and COVID-19 pandemic response.

Next Generation Physiological Status Monitoring (Advanced Functional Fabrics of America Institute (AFFOA) – DoD sponsored institute)

Figure 6: PSM headband being tested in a simulated low-pressure environment Credit: AFFOA

AFFOA, in collaboration with the Defense Fabric Discovery Center at MIT Lincoln Laboratories, successfully developed and tested a headband used to detect hypoxia (insufficient oxygen at the tissue level), enabling action prior to impairment or injury. The fabric contains embedded microelectronic components that measure key physiological conditions, including temperature, heartrate, and blood-oxygen levels, that can be transmitted wirelessly and operate for 40 hours continuously.

90% Cost Reduction in Growing Cells for Biopharmaceuticals (National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL) – DOC sponsored institute)

Potomac Affinity Proteins teamed with the University of Maryland College Park to reliably scale the manufacture of cytokines, a critical growth component in cell cultures. Using its E. coli expression system, the team was able to produce and validate cytokines at a 90% cost reduction from a range of $1,000 to $50,000 to just $100 per milligram. The process allows for greater scale-up potential at a reduced cost, while expanding flexibility for the industry to adopt the novel purification process for other critical cytokines or proteins.

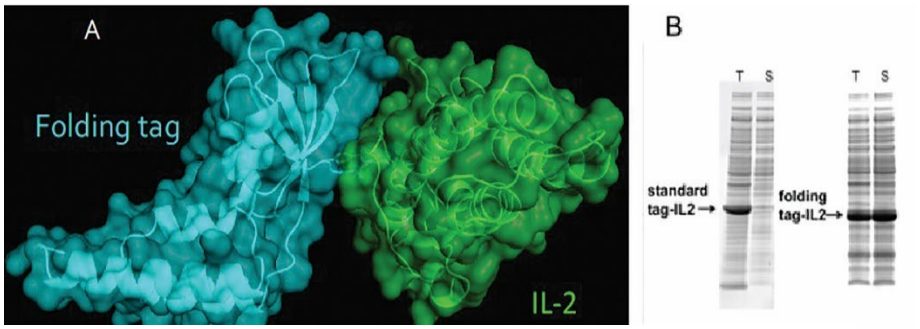


Figure 7: Cytokines Credit: NIIMBL

Sustainable Infrastructure Solutions with Composite Bridges (Institute for Advanced Composites Manufacturing Innovation (IACMI) – DOE sponsored institute)

Figure 8: First fiber-reinforced polymer vehicle bridge deck in Tennessee Credit: IACMI

IACMI and collaborators from academia and small-medium manufacturers built the first fiber-reinforced polymer vehicle deck bridge in Tennessee. It requires less installation time and reduces energy costs during construction. According to the American Society of Civil Engineers, about 8 percent of 617,000-plus bridges in the U.S. are structurally deficient and need repair. Engineered for high strength, the 16-by-25-foot-wide composite bridge deck, which has a 100-year lifespan, is 90 percent lighter than concrete. The two corrosion resistant deck panels were fabricated off-site and installed in one day using a forklift, greatly reducing installation time and energy costs by requiring less construction equipment for on-site preparation. The deck is embedded with smart sensors to monitor its health and performance.

Evolving the Factory Floor (Digital Manufacturing and Cybersecurity Institute (MxD) – DoD sponsored institute)

Siemens and Dow are leveraging MxD's process industry test bed to showcase the future of automation. This new test bed offers a hands-on demonstration of how innovative software and Internet of Things (IoT) come together with hardware to accelerate digitalization for the process industries. Companies can see firsthand how to design, monitor, and maintain products more effectively, securely, and even remotely, using data and digital tools to collaborate in real-time.

Modeling for Sustainable U.S. Fiber Recycling (Reducing Embodied Energy and Decreasing Emissions (REMADE) – DOE sponsored institute)

A REMADE project team developed a technology systems model to increase domestic fiber recycling and establish a profitable domestic recycling ecosystem in the paper manufacturing industry. They identified new process pathways for the U.S. fiber recycling industry to expand its domestic capacity, improve its profitability, and increase its environmental benefits. The Paper Recycling Integrated System Model (PRISM), allows fiber recyclers and Institute of Scrap Recycling Industries members to modify process parameters, technologies, and operating practices at material recovery facilities and reprocessing mills to identify specific technology and capacity addition pathways to achieve energy and emissions goals (e.g., increasing recycling rates and secondary feedstock use, and reaching cost parity). To broaden the potential benefits of this project, PRISM was built around a user-friendly public interface that fiber recycling users can access through a web-based platform. Initial beta tests identified pathways to reduce process energy use by 37% to 83% and greenhouse gas emissions by 15% to 60% in the facilities analyzed.

Developing Sustainable Biopharmaceutical Manufacturing of the Future (NIIMBL – DOC sponsored institute)

In an ambitious 10-year program, NIIMBL's process intensification program intends to transform biopharmaceutical manufacturing. Over 15 major companies and through six distinct workstreams, thought leaders are collaborating on an integrated approach to create flexibility, improve control and security of the supply chain, foster sustainability and reduce costs. This program establishes carbon-neutral bioprocessing with the combination of technological innovation, new materials, recycling, and new practices. These synergistic elements will align to address critical barriers to designing rapid, sustainable, and cost-effective biomanufacturing.

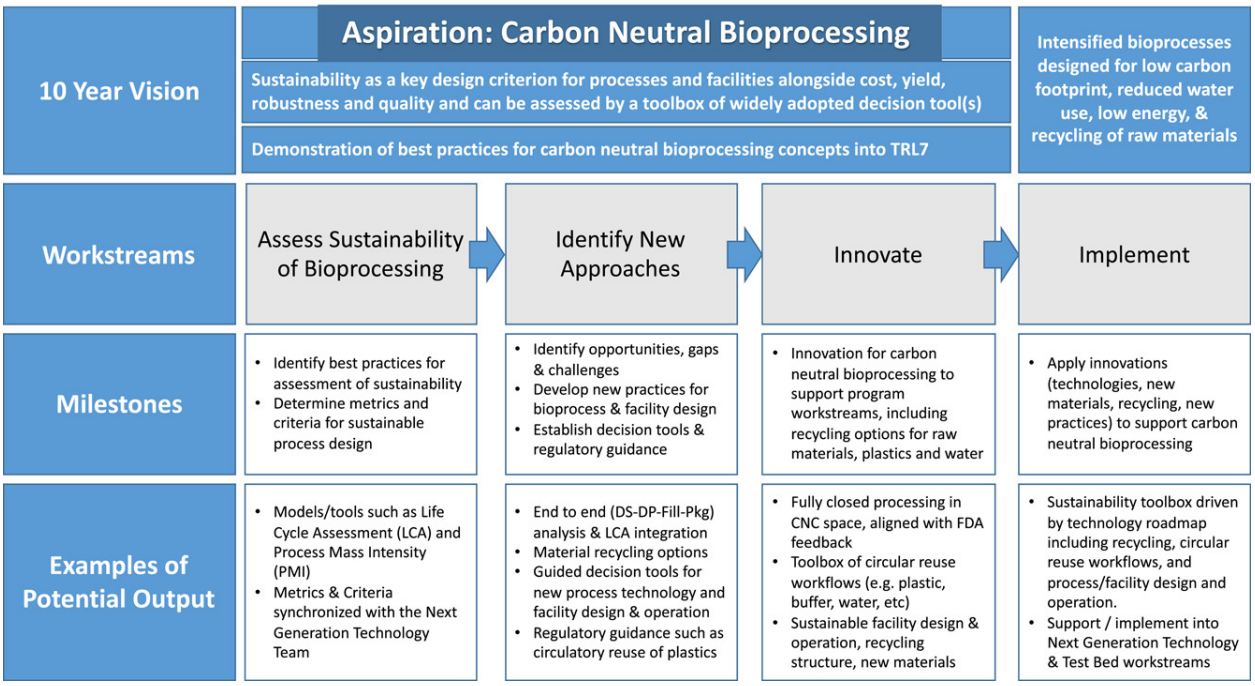


Figure 9:Erickson, J, Baker, J, Barrett, S, et al. (2021). End-to-end collaboration to transform biopharmaceutical development and manufacturing. Biotechnology and Bioengineering. 118, 3302– 3312. https://doi.org/10.1002/bit.27688

Forecasting Hospital Needs for Pandemic Response (Advanced Regenerative Manufacturing Institute (BioFabUSA) – DoD sponsored institute)

Using CARES Act funding, BioFabUSA completed a hospital demand forecasting model project to aid in the nation's response to COVID-19. The model was immediately used by a hospital system during a surge in cases in South Florida. BioFabUSA continues to work on anti-viral combination drug therapies, cell therapies, novel drug/vaccine delivery methods, and virus-free red blood cells to help recover from this and future pandemics.

Designing Safe, High-throughput COVID-19 Antibody Testing (NIIMBL – DOC sponsored institute)

NIIMBL members, MassBiologics of the University of Massachusetts Medical School, and the Wadsworth Center, developed a flexible, high-throughput assay for SARS-COV-2 anti-body-based diagnostics that reduces exposure risk of live virus assays to healthcare workers measuring antibodies. This test has the capacity to screen nearly 100 samples within 4 hours, compared to days with live virus assays, and provides an efficient method of antibody testing to screen quarantined workers before returning to work, identify convalescent patients for potential antibody therapy research, and serve as a benchmark to test vaccine efficacy.

Mapping and Manufacturing Domestic Critical Healthcare Capabilities (Rapid Advancement in Process Intensification Deployment (RAPID) – DOE sponsored institute)

RAPID worked with Virginia Commonwealth University and Procter & Gamble to develop a modeling tool to enable future domestic manufacturing of critical medicines. The RAPID team catalogued manufacturing assets of over 40 contract development and manufacturing organizations to map manufacturing capabilities in the U.S. These technologies can be implemented in all aspects of the supply chain, from pharmaceutical separation to increased manufacturing capability for personal protective equipment and other healthcare supplies. Modular production platforms allow for lower risk, faster capital deployment of manufacturing assets at the right scale and location for future domestic production of pandemic critical supplies and therapeutics.

Increasing Accesses to Medical Testing (American Institute for Manufacturing Integrated Photonics (AIM) – DoD sponsored institute)

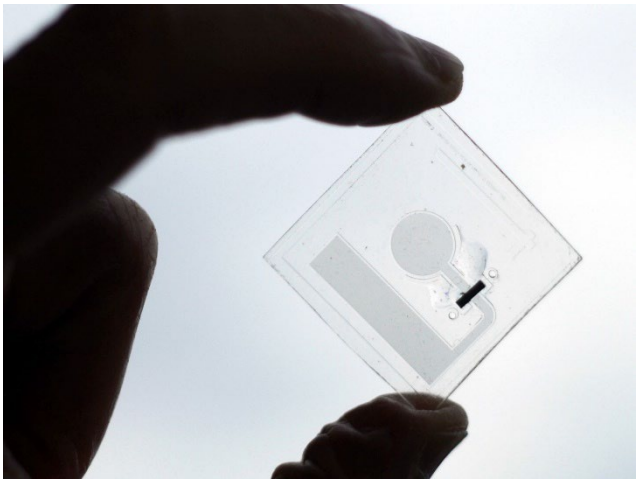


Figure 10: A passive microfluidics card able to carry a blood sample to a grain of rice-sized photonic sensor. The system is able to detect and quantify COVID-19 antibodies within a minute. Credit: AIM

AIM Photonics developed an optical chip on a disposable card that can detect exposure to multiple viruses – including the coronavirus – within a minute from a single drop of blood. Led by University of Rochester Medical Center researcher, Benjamin Miller, OSD ManTech funded the $1.7 million project using Congressional funding from the Coronavirus Aid, Relief, and Economic Security Act. Recently, the project team successfully demonstrated a "disposable photonics" approach to COVID antibody detection. The team provided Ortho-Clinical Diagnostics, an industry member and project participant, with prototypes and data sets to determine whether the product is sufficiently strong to transition to marketplace. Ortho-Clinical Diagnostics intends to continue to develop this technology for market to make "disposable photonics" a reality for clinical diagnostics.

Advanced Manufacturing Workforce

Workforce is a key enabler of America's leadership in advanced manufacturing. Our supply chains and innovation ecosystems have difficulty attracting, developing, and retaining skilled workers needed for advanced manufacturing jobs, which increasingly provide rewarding, quality career opportunities. A 2.4 million shortfall is projected by 2028, putting $454 billion of manufacturing GDP at risk annually by 2028[3]. Worker training and availability have risen to the top of manufacturing CEO's list of needs. The institutes have organized programs to provide additional training to existing workers, as well as programming that will create a pipeline of new skilled workers.

Table 4 summarizes Education and Workforce metrics from all 16 institutes active in FY 2021.

[3] *2018 Deloitte and the Manufacturing Institute Skills Gap and Future of Work Study,* Deloitte Insights (November 2018), https://www2.deloitte.com/content/dam/insights/us/articles/4736_2018-Deloitte-skills-gap-FoW-manufacturing/DI_2018-Deloitte-MFI-skills-gap-FoW-study.pdf .

Table 4. Education and Workforce Development (EWD) Performance Metrics – 16 Institutes			
Metric	**Units of Measure**	FY 2020	**FY 2021**
STEM activities	Total number of students participating in institute projects or internship programs and training	55,478	67,115
	Workers completing a certificate, apprenticeship, or training program	9,284	14,676
Educators & trainers	Teachers or trainers completing institute-led training	5,411	5,610
	Total number of EWD participants	**70,173**	**87,401**
Source of funding for Institute EWD projects or activities	Base-funded projects: base federal funding from the original cooperative agreement or technology investment agreement	83	87
	Commercial-funded projects: support provided from industry, regardless of membership status	7	9
	Federal agency-funded projects: resourced from federal funding outside the base Cooperative Agreement (CA) or Technology Investment Agreement (TIA) funding	16	44
	State- or locally funded projects: resourced from state or municipal government funding	14	23
	Other funded projects: resourced from philanthropic organizations, nonprofits, foundations, or associations	9	29
	Total number of EWD projects and activities operated by institutes*	**117**	**192**
Funding amount expended for EWD projects and activities	Base funding expended: resourced by institute using base federal funding from the original CA or TIA	$10.51M	$10.75M
	Commercial expenditures: provided by industry, regardless of membership status	$0.41M	$1.39M
	Federal agency expenditures: resourced from federal funding outside the base CA or TIA funding	$4.50M	$12.46M
	State or local funding expended: resourced from state or municipal government funding	$2.17M	$1.41M
	Other expenditures: resourced from philanthropic organizations, nonprofits, foundations, or associations	$5.06M	$1.66M
	Total expenditures for EWD projects and activities	**$22.65M**	**$27.68M**

* This represents individual projects and does not represent a summary. The information above illustrates projects that may be funded by multiple sources. Therefore, the total projects are less than the sum of the projects funded by each source.

The institutes worked together with federal agencies to share best practices in the education and workforce development areas. In FY 2021, the cross-institute education and workforce development team launched an effort to identify needs and opportunities of interest for the institutes, including access to data and analysis. A NIST-funded study is synthesizing this information for the institutes, providing an actionable plan for workforce-related activities.

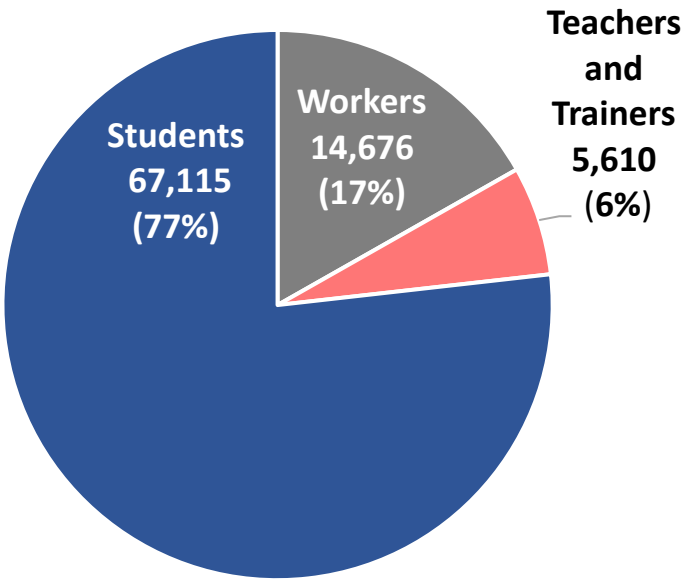


Figure 11. Number of individuals who received training in FY 2021.

The metrics indicate significant developments in the program in addition to the **25% increase in education and workforce participants**. The federal agencies lead the effort for education and workforce development projects with a **300% increase in funding and over 60% more projects in FY 2021**.

There was a **20% increase in training of teachers linked to existing educational programs**, ensuring that knowledge of work-relevant technologies reached more students, allowing incorporation of emerging manufacturing developments into curricula. The institutes also **increased certifications, apprenticeships, or training programs by over 150% in FY 2021**.

Training the Workforce of the Future

The COVID-19 pandemic changed the way manufacturers recruit and train their workforce. The institutes developed online learning initiatives for career pathways to higher-skilled positions needed for advanced manufacturing, offering:

- Competency-based vs. time-based learning
- Individualized curricula and targeting of specific skills
- Flexibility that expands the pool of participants

The latter consideration is especially important for many underrepresented populations for whom traditional classroom training programs may pose attendance challenges due to lack of transportation and inflexible time constraints. Institute initiatives are focused on complementing the work of other federal agencies, including the Department of Labor and local workforce boards, to reinforce sector partnerships. Three of the 192 education and workforce projects from FY 2021 are highlighted below:

Collaborating to Inspire High School Students (America Makes and NextFlex – DoD sponsored institute)
In FY 2021, America Makes launched a new project in collaboration with NextFlex called the Additive Edge to introduce youth to advanced manufacturing and provide the students with experience to place on resumes and college applications. Additive Edge is a national outreach program that inspires high school students in the U.S. to explore additive manufacturing (i.e., 3D printing) and entrepreneurship. The program will distribute printers to secondary schools that successfully recruit female students into additive manufacturing courses.

Expanding Diversity in the Biopharmaceutical Industry (NIIMBL – DOC sponsored institute)
In June 2021, 14 college freshmen and sophomores from across the country participated in the NIIMBL eXperience program and received a jumpstart on a career in the biopharmaceutical industry. The program gives African

American/Black, Latinx, and Native American students a chance to explore biopharmaceutical careers through direct interactions with industry professionals. The 2021 eXperience included the most expansive and diverse group of host institutions yet, from large biopharma manufacturers and small innovative companies to leading academic and non-profit institutions. Since the program's inception in 2019, students have secured internships at leading companies such as Merck & Co., Inc., Genentech, Millipore Sigma, and Eli Lily.

Launching Online Resources for Robotics Careers (Advanced Robotics for Manufacturing Institute (ARM)– DoD sponsored institute)

In FY 2021, the ARM Institute launched RoboticsCareer.org to connect those job seekers who desire robotics careers in manufacturing with over 13,000 programs offered by 2,300 educators and employers that provide the educational skills and competencies needed for thousands of unfilled advanced manufacturing roles. This national resource also recognizes the best educational programs through a vigorous ARM Endorsement process.

Increasing Smart Manufacturing Adoption Aptitude (Clean Energy Smart Manufacturing Innovation Institute (CESMII) – DOE sponsored institute)

CESMII and SME (Society for Manufacturing Engineering) announced a partnership for advancing education and workforce development around smart manufacturing. SME's training organization, Tooling U-SME, is the industry's leading learning and development solutions provider, working with thousands of companies, including more than half of all Fortune 500® manufacturers as well as 800 educational institutions across the country. CESMII has in-depth training content on smart manufacturing technology, business practices, and workforce development that allow increased access for underrepresented groups. Leveraging Tooling U-SME's extensive reach into industry and academia, the synergistically combined CESMII and Tooling U-SME training portfolios and new content collaborations will expedite smart manufacturing adoption, driving progress through transformational workforce development.

Figure 12: CESMII SMIP integration creates EWD platforms Credit:CESMII

Expanded Metrics – Reaching Learners at Different Depths of Participation

Additional metrics are provided in Table 5 and Table 6. This data expanded previous education and workforce development metrics to focus on targeted groups and depth of learning and participation. In FY 2020 the data represents only the nine DoD and one DOC institutes, however all the institutes were able to align and report these values for FY 2021. These expanded metrics demonstrate the institutes have been increasingly effective at reaching targeted groups, with substantial increases in K-12 and post-secondary students and those already in the manufacturing workforce seeking additional training.

The institutes emphasize cost-effective approaches by leveraging existing community-based educational institutions, including local public schools. Furthermore, exposing K-12 students to emerging high-technology manufacturing career opportunities before the students make formative career decisions can strengthen the pipeline of manufacturing workers for future years.

Table 5 identifies increased reported participation across almost all sectors with the addition of DOE institutes in the FY 2021 values. The **70% increase in reported institute-led education and workforce development project participants** in FY 2021 was led by over a **150% increase in postsecondary participants**. The number of individuals completing an institute-aligned professional development **certification, apprenticeship, or training program also increased by nearly three-fold** resulting from large increase in certification and apprenticeship models supplemented with online training programs. The FY 2021 did undergo a small reduction in the number of educators who completed an institute-led training activity, which may be a function of the pandemics impact on educational systems; however, **educators and trainers in postsecondary and the manufacturing workforce were over 3000% and 1000% larger, respectively**.

Table 5. Aggregated Institute Education and Workforce Development Refined Performance Metrics			
Specific Metric	Unit(s) of Measure	FY 2020 (10 institutes)	**FY 2021 (16 institutes)**
Individuals participating in institute EWD projects or institute-led EWD activities	K–12 participants: students enrolled full-time in primary or secondary schools and GED candidates not employed full-time in current workforce	19,376	25,132
	Post-secondary participants: postsecondary students (full- or part-time) not employed full-time in the current workforce (e.g., college student or worker taking a career and technical education class to prepare for a new career)	12,751	33,202
	Manufacturing workforce participants: individuals employed full- or part-time in the manufacturing workforce, whether their participation eventually leads to a credential	22,839	34,856
	TOTAL – individuals participating in institute EWD projects or institute-led activities	54,966	**93,190**
Individuals completing an institute-aligned professional development certification, apprenticeship, or training program	Certification: Include substantive certifications recognized or otherwise valued by industry. Does NOT include certificates for minor courses	757	7,161
	Apprenticeships: Include arrangements in which someone has completed learning an art, trade, or job under another expert in that field	14	118
	Other Training Programs: Include other substantive training programs that would be recognized or otherwise valued by industry	3,711	5,411
	TOTAL – individuals completing an institute-aligned professional development certification, apprenticeship, or training program	4,482	**12,690**
Teachers and trainers completing institute-led training	K-12 educators who completed an institute-led training activity	4,613	3,897
	Post-secondary educators who completed an institute-led training activity	29	960
	Manufacturing Workforce teachers and trainers who completed an institute-led training activity	14	192
	TOTAL – teachers and trainers completing institute-led training	4,656	**5,049**

Table 6 differentiates the "intended learning depth" of planned activities. It measures the number of participants in education and workforce development, distinguishing shallower, shorter interactions from deeper, longer-term engagements, to determine how the entire spectrum of learning is being supported. The concept of learning depth uses a depth of engagement scale, from first topical awareness through advancement of technological frontiers, to recognize the value of the attained competency or advancement. The metric is not intended to measure a participant's success towards attaining the learning objectives.

Overall participation rates across learning depths increased by 70% in FY2021. **The pandemic and recent initiatives in workforce development shifted institutes to increase awareness and access as represented by the largest increase percentage (over 200%) in hands-on skills-learning components.** The Education and Workforce Development working

group will use this data to evolve with changing trends in society and modify education and training programs that provide the most effective outcome.

	Table 6. Participation in Education and Workforce Development Activities by Intended Learning Depth Assessment		
Metric	Unit(s) of Measure	FY 2020 (10 institutes)	**FY 2021 (16 institutes)**
Individuals participating in EWD activities	1. Awareness: Presentation of information with or without accompanying recall questions *Examples: a short class, presentation, demonstration, or event*	16,953	32,807
	2. Concept Learning: Learners understand facts and ideas by classifying, summarizing, comparing, or explaining principals, theories, or models *Example: introductory-level (101) course*	25,857	38,430
	3. Skills Learning: Practically oriented learning to apply conceptual knowledge and develop manufacturing-related procedural or process knowledge *Example: intermediate-level (201) course with significant interactive, laboratory, or hands-on components*	4,304	13,182
	4. Application: Learners solve problems, identify connections and relationships and how they apply in practical situations *Examples: long-term internship or apprenticeship, or through work-based or project-based learning*	6,305	7,486
	5. Creation: Original research or innovation activity that might advance the state of the art. Students critique and evaluate accepted procedural knowledge or create novel methods or combinations of accepted methods *Examples: graduate or post-doctoral research project, novel product design, or an R&D project*	1,547	1,285
	TOTAL – individual EWD participants (sum of DOC and DoD Institutes)	**54,966**	**93,190**

Other Agency Collaborations

National Science Foundation Support

In FY 2021, the NSF provided $11.1M in funding for projects which feature collaborations with Manufacturing USA institutes. The awards included a $3M Future Manufacturing[4] Research grant to pursue distributed artificial intelligence and machine learning techniques for manufacturing in collaboration with IACMI and a $7.5M award to support a new center for manufacturing workforce development which will work closely with AFFOA, CESMII and ARM Institute as several of NIST's Hollings Manufacturing Extension Partnership (MEP) Centers[5].

[4] NSF invests in future manufacturing projects that reimagine processes and protect the environment (Sept. 30, 2021). https://www.nsf.gov/news/special_reports/announcements/093021.jsp.
[5] https://www.ct.edu/newsroom/tunxis_will_be_home_to_nations_only_nation_science_foundation_next_gen_manu

Over the past five years, the NSF provided over $26M in funding for projects stimulated by three Dear Colleague Letters[6] that encourage researchers and educators to submit proposals that foster collaboration with the institutes and with Manufacturing Communities Partnerships, as well as supporting use of AIM's $1B foundry for research.

Summary and Assessment of the NIIMBL Report to the Secretary of Commerce

Institutes established under the Manufacturing USA statute are required to submit a detailed report to the Secretary of Commerce, with a summary and assessment of that report included in the Manufacturing USA annual report to Congress.[7] Currently NIIMBL is the only institute funded under Manufacturing USA's legal authority[8], and this section is a summary and assessment of the NIIMBL 2020-21 Annual Report to the Secretary of Commerce.

NIIMBL launched operations on March 1, 2017. Its annual report, submitted to the Secretary of Commerce in 2021, covers its fourth year of performance, and describes the institute's financial standing, key performance metrics, and accomplishments as of February 9, 2021. A public version of this report, without the financial reporting data was released in September 2021.[9]

NIIMBL seeks to promote U.S. global leadership in biopharmaceutical manufacturing innovation and to ensure that U.S. inventions become products made in America. The institute's success will promote economic development, with additional impacts on national security and public health, by strengthening the domestic supply chain and advancing the rapid scale-up of bio-manufactured therapies.

NIIMBL's mission is "to accelerate biopharmaceutical manufacturing innovation, support the development of standards that enable more efficient and rapid manufacturing capabilities, and educate and train a world-leading biopharmaceutical manufacturing workforce, fundamentally advancing U.S. competitiveness in this industry."[10] In alignment with this mission, NIIMBL's report presents activities, goals, plans, and accomplishments that support the statutory purposes of the Manufacturing USA program.

NIIMBL reports that, in its fourth year, the institute:

- Expanded its technical and workforce portfolio by more than 20%, to 70 projects with a cumulative value of over $65 M;
- Engaged 90% of membership in activities with 21 total NIIMBL-led projects across the biopharmaceutical manufacturing ecosystem to collaborate on the innovations needed to strengthen domestic manufacturing for gene therapy, antibody-drug conjugates, and bispecific antibodies, and vaccines;
- Grew its membership by 20% to 186 members with the addition of 39 new members.

---

[6] Dear Colleague Letter: Advanced Technological Education (ATE) Program Support for Manufacturing Innovation Institutes and Investing in Manufacturing Communities Partnerships (IMCPs), National Science Foundation (NSF 16-007), Susan R. Singer (October 9, 2015 https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf16007; Dear Colleague Letter: Supporting Fundamental Research to Enable Innovation in Advanced Manufacturing at Manufacturing USA Institutes, National Science Foundation (NSF 17-088), Barry Johnson (May 25, 2017) https://www.nsf.gov/pubs/2017/nsf17088/nsf17088.jsp; and Dear Colleague Letter: Research on Integrated Photonics Utilizing AIM Photonics Capabilities, National Science Foundation (NSF 21-015), Dawn M. Tilbury (October 15, 2020) https://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf21015.

[7] 15 U.S.C. § 278s(i). http://uscode.house.gov/view.xhtml?req=(title:15 section:278s edition:prelim).

[8] 15 U.S.C. § 278s(e). http://uscode.house.gov/view.xhtml?req=(title:15 section:278s edition:prelim).

[9] *NIIMBL 2019-20 Annual Report*, The National Institute for Innovation in Manufacturing Biopharmaceuticals (2020). https://niimbl.org/Downloads/NIIMBL_Annual_Report_2019-20_FINAL.pdf

[10] Ibid., p. ii.

Assessment of NIIMBL's Performance

The NIST assessment of NIIMBL's report on its fourth year of performance, on behalf of the Secretary of Commerce, addressed the institute's financial standing, key performance metrics, and accomplishments. The assessment is positive as indicated in the impacts summarized in Table 7. It is evident that Manufacturing USA's statutory purposes[11] form an important guide to institute decision-making and activities and that the institute showed progress in all areas. NIIMBL fully accomplished the activities and actions identified to NIST in its Year 4 Operating Plan.

[11] 15 U.S.C. § 278s(b)(2). http://uscode.house.gov/view.xhtml?req=(title:15 section:278s edition:prelim).

Table 7. NIIMBL FY 2020-2021Performance Snapshot						
Manufacturing USA Statutory Purpose	**Strategic Objective**	**Institute Performance Goals**	**Performance Measures**	**Performance Indicators**	**Explanation** (data as of February 9, 2021)	**Value or Descriptor**
A) Improve the competitiveness of U.S. manufacturing and to increase the production of goods manufactured predominately within the United States	Foster diverse membership base to facilitate an end-to-end advanced manufacturing ecosystem	Secure partnerships with critical US stakeholders	Growth in membership	# of members	Total members	**186**
				Growth over year	Yearly Increase	**20%**
			Membership diversity evident (size, type, and geographic distribution)	Percentage of members signed in each key stakeholder group	Industry members	**45%**
					Academic members	**34%**
					State and local non-profit entities	**21%**
				Geographic diversity	Number of states with NIIMBL members	**36**
B) Stimulate U.S. leadership in advanced manufacturing research, innovation, and technology	Provide leadership in activities that require industry sector-wide engagement to support advanced biomanufacturing	Convene and lead an ecosystem to industrialize advanced manufacturing technology	Prioritization and project call execution for technical investments	Technical workshops convened	Number of technology workshops since institute launch	**58**
C) Facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing manufacturing capabilities	Establish and support a robust technical portfolio to advance biomanufacturing capabilities	Demonstrate capabilities for establishing and maintaining a robust technology portfolio	Technology portfolio growth	Project calls designed and executed	Total number of technology project calls completed since institute launch	**9**
				Number of technical projects awarded	Technical projects awarded since institute launch	**58**
				Value of technology portfolio	Total value of technology portfolio	**$47.3 M**
D) Facilitate access by manufacturing enterprises to capital-intensive infrastructure	Develop a shared facilities network of biomanufacturing pilot facilities for testbeds, training	Establishment of NIIMBL HQ facility (non-federal funding)	NIIMBL HQ occupancy	1Q 2020 Occupancy of NIIMBL HQ	(Met or unmet)	**Met**
E) Accelerate the development of an advanced manufacturing workforce; and H) Create and preserve jobs	Establish a robust and industrially relevant workforce development portfolio to increase pipeline and skills	Demonstrate capabilities for establishing and maintaining a robust WFD portfolio	WFD portfolio growth	Number of WFD project calls executed	Total WFD project calls executed since institute launch	**7**
				Number of WFD projects awarded	Total number of WFD projects awarded since institute launch	**52**
				WFD portfolio value	Total portfolio value	**$14.9 M**

			Use of NIIMBL website and community portal	Public and member-only access to portal resources	Number of individuals using portal resources since institute launch	**2,368**
F) Facilitate peer exchange of the documentation of best practices in addressing advanced manufacturing challenges	Facilitate sharing and documentation of best practices for addressing advanced biomanufacturing challenges	Develop substantive mechanisms to foster knowledge sharing among ecosystem	Ecosystem participation in technical activities	Individuals participating in technology-focused meetings	Individuals participating in NIIMBL technology and roadmapping workshops since institute launch	**1,488**
				Unique organizations participating in technology and roadmapping workshops	Unique organizations (member and non-member) participating in NIIMBL technology and roadmapping workshops since launch	**379**
G) To leverage non-Federal sources of support to promote a stable and sustainable business model without the need for long-term Federal funding	Support membership structures that promote sustainable cost-sharing towards institute activities	Demonstrate non-federal leverage to fund institute activities	Meet and exceed Federal award requirements for NIIMBL non-federal cost-share	Non-Federal investment	Ratio of non-Federal to Federal investment reported for fiscal year ending February 28, 2021	**3.1 to 1**

It is also evident that industry is embracing this institute through membership and participation in NIIMBL technical and workforce activities. The high financial leverage indicates a consistently strong commitment by partners.

NIIMBL is the sole institute established under the Manufacturing USA statute. As such, the alignment of NIIMBL's mission and activities is more closely guided by the statutory purposes of the Manufacturing USA program than the Manufacturing USA institutes established by the DoD and the DOE under different authorities. This summary and assessment are an accurate reflection of the institute's significant accomplishments for the reporting period. The Secretary of Commerce has determined that NIIMBL's standing after its fourth-year positions NIIMBL to create the impacts for the U.S. economy intended by Congress for Manufacturing USA institutes and that NIIMBL continues to provide a successful model for any future institute funded under the same authority.

Funds Expended by the Department of Commerce

This Report to Congress is required to state the funds expended by DOC on the program. FY 2021 appropriations to NIST were $16M; approximately $4.9M was used for operation of the AMNPO, network services supporting Manufacturing USA, and other legislative requirements; $3.3M was competed via grants to institutes to respond to the pandemic; and $7.8M in financial assistance was provided to the National Institute for Innovation in Manufacturing Biopharmaceuticals (NIIMBL) under the on-going cooperative agreement. An additional $10M of Coronavirus Aid, Relief, and Economic Security (CARES) Act funding supported Manufacturing USA institutes addressing the national emergency. No waivers of cost-share requirements for NIIMBL were requested.

Manufacturing USA Interagency Working Team

Advanced Manufacturing National Program Office
Michael F. Molnar (Sponsor)
Frank W. Gayle
Robert Rudnitsky
Said Jahanmir
Kelley Rogers
Zara Brunner
Jessica Strickler
Hasan Khan
Lisa Fronczek
Zack Valdez
Christina Jones

Department of Commerce
Mojdeh Bahar
Mary Ann Pacelli
Ben Vickery

Department of Defense
Tracy Frost (Sponsor)
Steve Luckowski
Michael Britt-Crane
Mark Jackson
MicKenzie Roberts-Lahti
Mark Gordon
Abhai Kumar
Samantha Lewis
John Christensen
David Heckman

Department of Education
Gregory Henschel (Sponsor)
Robin Utz

Department of Energy
Becca Jones-Albertus (sponsor)
Diana Bauer
Nebiat Solomon
Sudarsan Rachuri
Chad Schell
Kathryn Peretti

Department of Health and Human Services
James Coburn, FDA (Sponsor)

Department of Labor
Robin Fernkas (Sponsor)
Mark Toal

National Aeronautics and Space Administration
John Vickers (Sponsor)
Frank Ledbetter
Justin Jackson

National Science Foundation
Bruce Kramer (Sponsor)
Celeste Carter
Andrew Wells

U.S. Department of Agriculture
World Nieh (Sponsor)
Daniel Cassidy
Suzanne Thornsbury

Appendix

Manufacturing USA Overview

Ensuring American Competitiveness

The federal agencies participating in the Manufacturing USA network have established a whole-of-government innovation framework that accelerates U.S.-based technology developments to the forefront of advanced manufacturing, allowing the U.S. to remain globally competitive in the ever-expanding frontiers of manufacturing. In FY 2021, three federal agencies sponsored 16 manufacturing innovation institutes: the Department of Commerce (DOC) with one institute, the Department of Defense (DoD) with nine, and the Department of Energy (DOE) with six.[12] The institutes are established by their lead agency as public-private partnerships that connect members from U.S. industry, academia, and government to collaboratively solve manufacturing challenges in key technology areas.

While lead agencies stand up their institutes with missions specific to their agency's needs, all institutes in the Manufacturing USA network share a common vision: ensure that *the Nation's highest priority inventions and innovations are scaled up and produced in the United States*. Each institute advances a different manufacturing technology, such as biopharmaceutical manufacturing, integrated photonic manufacturing, or wide-bandgap power electronics manufacturing. Other institute topics such as smart manufacturing and cybersecurity in manufacturing serve to improve the integration and security of advanced technologies used in all fields of manufacturing. The institutes advance technologies through collaborative pre-competitive research by their membership base made up of organizations from across industry, academia, and government. The institute provides their members shared access to capital-intensive infrastructure that equips U.S. innovators of all sizes to bring their ideas to reality. The institutes also partner with organizations to educate and train workers in the manufacturing skills needed by U.S. manufacturers in these new fields.

The United States continues to face significant manufacturing challenges. The threat to U.S. leadership in advanced manufacturing technology remains high, including serious supply chain difficulties, fierce international competition, and protection of intellectual property and research. Despite a long history of global leadership in advanced technology products, our trade deficit in these products continues to grow.[13] Additionally, there are not enough U.S. workers trained in the skills needed by today's manufacturers. Within each technology focus, the institutes provide the infrastructure and collaborative environment needed to help alleviate these shortfalls.

This Report to Congress[14] describes how the Manufacturing USA network addressed these challenges in FY 2021.

Organization and Management

Manufacturing USA includes nine member Federal agencies: The Departments of Commerce, Defense, and Energy, which each sponsor and oversee their own institutes; the Departments of Agriculture, Education, Health and Human Services, and Labor; the National Aeronautics and Space Administration; and the National Science Foundation. The Advanced Manufacturing National Program Office (AMNPO), at DOC's National Institute of Standards and Technology (NIST), oversees the coordinated activities of Manufacturing USA and convenes the Manufacturing USA interagency team.

DOC, DoD, and DOE coordinate with the other federal agencies through the AMNPO, enabling cooperation over a wide range of support activities. Manufacturing USA's national goals, while well aligned with each individual agency's mission,

---

[12] DOE and DoD held competitions for two new institutes in FY 2020, and awards were made in late FY 2020 and early FY 2021.
[13] The trade deficit in advanced technology products grew approximately 40% in 2020. https://www.census.gov/foreign-trade/balance/c0007.html#2020.
[14] 15 U.S.C. § 278s(i)(2), as amended. http://uscode.house.gov/view.xhtml?req=(title:15 section:278s edition:prelim).

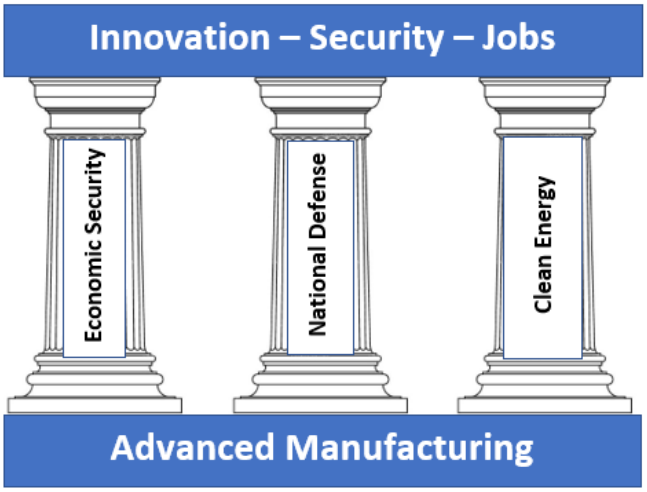
are best realized by a whole-of-government effort that focuses broadly on increasing U.S. advanced manufacturing competitiveness.

Vision, Mission, and Goals

As articulated in the program's strategic plan, the vision of the Manufacturing USA network is "*U.S. global leadership in advanced manufacturing.*" [15]

To achieve this vision, the network's mission is:

> *"Connecting people, ideas, and technology to solve industry-relevant advanced manufacturing challenges, thereby enhancing industrial competitiveness and economic growth, and strengthening our national security*." [16]



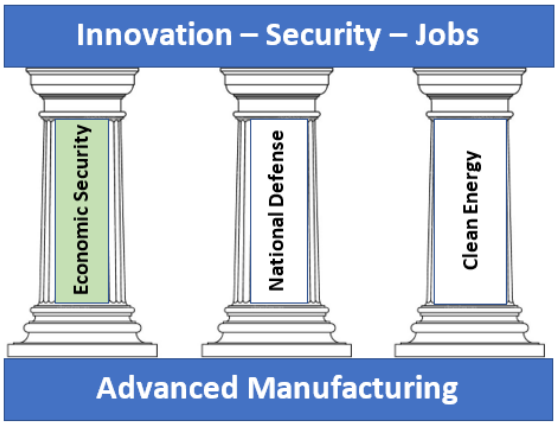
Manufacturing USA's four goals are to:

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

The institutes serve as core resources for meeting the Manufacturing USA goals. DoD, DOE, and DOC established and oversee institutes that help unify the country around technology development ecosystems. The DoD Manufacturing Innovation Institutes (MIIs) have the additional mission to develop innovative technologies that aid the warfighter. The DOE Office of Energy Efficiency & Renewable Energy, Advanced Manufacturing Office also establishes Clean Energy Manufacturing Innovation Institutes to bolster U.S. energy efficiency and innovation.

Department of Commerce: NIST Office of Advanced Manufacturing

The NIST Office of Advanced Manufacturing (OAM) helps coordinate advanced manufacturing outreach by working with other federal agencies. OAM serves as the headquarters for the AMNPO, which is authorized by the Congress to collaborate with federal departments and agencies with missions that contribute to, or are affected by, advanced manufacturing.



OAM also sponsors the National Institute for Innovation in Manufacturing Biopharmaceuticals, or NIIMBL (the DOC-sponsored Manufacturing USA institute). The DOC institute's focus is exclusively on the U.S biopharmaceutical industry and economic competitiveness via manufacturing technology and workforce development.

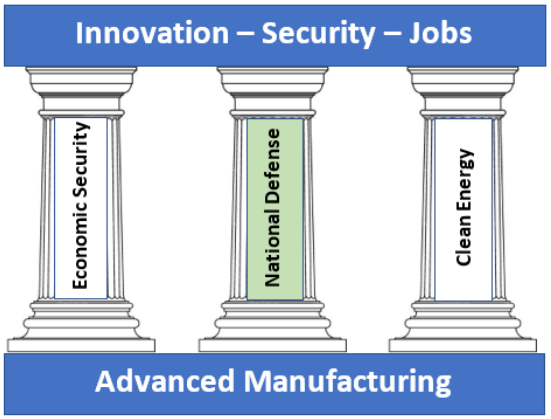
---

[15] *Manufacturing USA Strategic Plan*, Advanced Manufacturing National Program Office, p. 4 (November 2019), https://www.manufacturingusa.com/reports/manufacturing-usa-strategic-plan

[16] Ibid.

Department of Defense and the Defense Manufacturing Technology Program

DoD provides a staffed, trained and equipped military force needed to deter aggression and protect the security of our nation. To transition DoD science and technology advances into production, the Department of Defense must have access to a robust and responsive U.S. industrial base equipped with advanced manufacturing technologies that deliver critical products and systems affordably and rapidly. To help develop the technology and manufacturing ecosystems needed to support the Department of Defense's mission, the DoD established nine Manufacturing Innovation Institutes (DoD MIIs) through the Office of the Secretary of Defense Manufacturing Technology program. Unlike the other manufacturing institutes, the DoD-sponsored institutes have the additional mission to develop innovative technologies that will ultimately aid the warfighter.



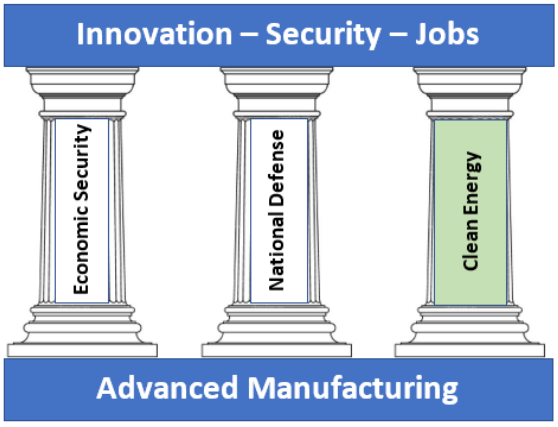
The DoD MIIs address commercial and defense manufacturing needs via public-private partnerships with active participation and support from the military departments and defense agencies. The institutes' flexible business models and focus on highly collaborative R&D catalyze important new organizational relationships across government, industry, and academia. Under the leadership of the Under Secretary of Defense for Research and Engineering, DoD continues to foster long-term engagement with its institutes to support the DoD critical technology areas. Already, the institutes have shown progress in support of cybersecurity for manufacturing, micro-electronics, biotechnology, hypersonics, and autonomy, among other technology priorities.

The DoD intends to continue strategic partnerships with their institutes to further enable the development of defense-critical technologies into affordable, domestic defense products. Continued engagement helps to maintain and enhance manufacturing innovation ecosystems. By fostering Department engagement, these public-private partnerships help ensure domestic and defense manufacturing needs can be met while protecting intellectual property and providing overmatching technology to the warfighter. The DoD institutes further the Department's vision for a national technology innovation base and help ensure that key advanced technologies that are invented in the United States are manufactured in the U.S.

In FY 2021, the DoD awarded a ninth institute, BIOMADE, focused on bioindustrial manufacturing of non-medical materials.

Department of Energy: Advanced Manufacturing Office

The DOE Advanced Manufacturing Office (AMO) — within the Office of Energy Efficiency & Renewable Energy (EERE) — is the only technology development office within the U.S. Government dedicated to improving the energy and resource efficiency of manufacturers across the industrial sector. Effective and efficient use of energy, water, and material resources in manufacturing is essential for the nation's energy security, economic competitiveness, and environmental stewardship.



AMO partners with manufacturers, not-for-profits, universities, national laboratories, and state and local governments to develop technologies that will improve energy productivity and make the U.S. manufacturing sector more competitive and efficient. By addressing energy related manufacturing challenges and reducing risk through merit-based research and development, adoption of AMO-developed technologies can save energy and lower expenses for industry, reduce emissions, industrial waste, materials, and water usage, and improve the life cycle energy of manufactured goods.

At the end of FY 2020, DOE awarded a sixth institute, Cybersecurity in Manufacturing Innovation Institute (CyManII), focused on cybersecurity in manufacturing.

Functions, Governance, and Coordination

Manufacturing USA's four governance operating principles, outlined in the network charter, are:

1. "The network supports its member institutes in meeting the goals of the program and creates a collective impact greater than the sum of constituent parts. Individual institute governance is the purview of the lead funding agency and respective institute members. Legislatively mandated reporting on individual institute performance is the responsibility of the respective lead funding agencies."
2. "Network governance is a shared responsibility amongst the network membership. Mechanisms and structures are necessary to collect inputs and needs of key stakeholders, including those in the private sector."
3. "Decisions concerning inter-institute issues in the network should be made at the lowest responsibility level. In resolving issues, there should be a general preference towards empowering action at the institute level."
4. "The AMNPO is responsible for supporting network functions. The AMNPO, working with the lead funding agencies and other participating federal agencies, is also responsible for reporting to Congress on the Manufacturing USA program and related institutes." [17]

To ensure effective management and coordination of the network, federal agency members meet monthly to discuss policy decisions for defining and improving the network functions. The agencies coordinate through the AMNPO in support of the program's national purposes and in recognition that those national purposes are best realized by an integrated whole-of-government effort. The federal agencies embrace this unified effort, while ensuring that the value delivered by their respective institutes remains closely aligned with their agencies' statutory requirements and agency mission. Maintaining this balance between Manufacturing USA's national programmatic goals and each agency's needs helps ensure that all major stakeholder base requirements are addressed.

Collaboration is also important to the institute directors, who share best practices through their Institute Directors Council meetings. Formalized in the *Charter of the Institute Directors Council: Manufacturing USA*, the council directly supports the goals of the Manufacturing USA Program. The council facilitates collaboration among the institutes with advice, as needed, from the federal institute sponsors and other federal agencies, and from the AMNPO. [18]

Manufacturing USA has developed a powerful network brand and logo to help foster awareness of the institutes as applied manufacturing technology centers that belong to a larger network. The logo helps create instant awareness when furthering the cause of advanced manufacturing to nonmember entities, as well as to the media and public. ManufacturingUSA.com and the networks' social media pages boost agency and institute visibility with key stakeholders by offering regular updates on network activities. AMNPO also helps to coordinate with the agencies to release public materials and facilitate industry events.

---

[17] *Network Charter: Manufacturing USA Program*, Advanced Manufacturing Series (NIST AMS) - 600-4 Revision 1, Section D, Network Operating Principles, Department of Commerce, National Institute of Standards and Technology, p. 3 (October 2019). https://nvlpubs.nist.gov/nistpubs/ams/NIST.AMS.600-4r1.pdf.

[18] *Charter of the Institute Directors Council: Manufacturing USA*, NIST Advanced Manufacturing Series (NIST AMS) - 600-1, C. Blue, L. Brown, Y. Fink, N. Justice, M. Liehr, T. McDermott, E. Morris, pp. 1-2 (November 2016). https://www.nist.gov/publications/charter-institute-directors-council-manufacturing-usa.