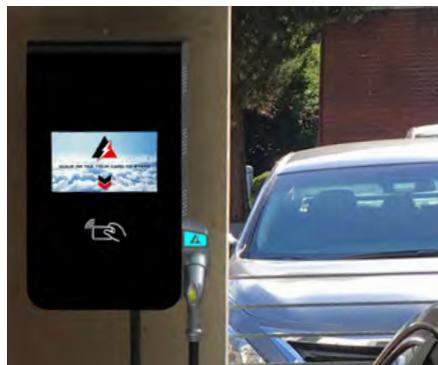
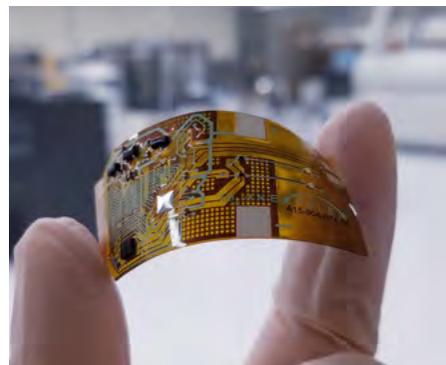
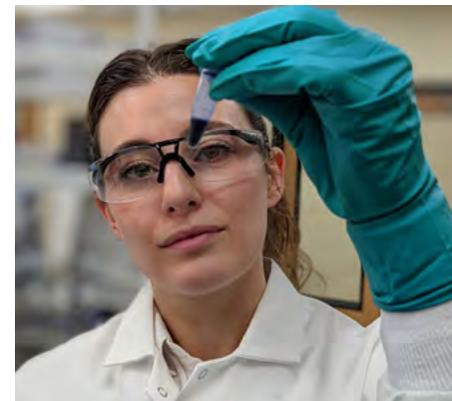


# 2023 ANNUAL REPORT





Check for updates

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The Manufacturing USA Annual Report represents the FY 2022 Report to Congress, along with institute activities and impact.

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## Message From the Interagency Team

This past year brought renewed collective focus on harnessing the power of technology to accelerate manufacturing and bolster economic and national security for communities and the nation. From once-in-a-generation legislation to bolster U.S. manufacturing via the CHIPS and Science Act<sup>1</sup>, the Bipartisan Infrastructure Law<sup>2</sup>, and the Inflation Reduction Act<sup>3</sup>, to increased leverage of public-private partnerships, Manufacturing USA is poised to deliver even more impact through advanced manufacturing technology, ecosystem growth, and workforce development efforts.

Through the Manufacturing USA® network, our agencies support a coalition of partners collaborating to secure U.S. global leadership in advanced manufacturing. Through large-scale technology, supply chain and ecosystem, and workforce development initiatives, we are helping ensure that what's invented here is made here by a skilled American workforce. The manufacturing innovation institutes sponsored by our agencies and participating in the network serve as unique public-private partners helping make our vision a reality.

In 2022, the institutes worked with more than 2,500 member organizations on more than 670 applied research and development technology projects of high priority to industry. Manufacturers represent 63% of institute members, with nearly three-quarters of those being small and medium-sized. Continued industry support is also evidenced by its investments in these efforts. The institutes attracted \$307 million from state, federal, and private funds in addition to \$109 million in base federal funding. This 2.8 to 1 investment match exceeds the program design of a 1-to-1 match, demonstrating how federal investment effectively catalyzes investment in industrial innovation.

The institutes also helped to recruit and train the current and future workforce. The number of people participating in institute and partner-led advanced manufacturing education and workforce programs increased by 25% over the prior year, engaging 106,000 workers, students, and educators. This reflects a significant 80% increase in post-secondary teachers trained over the prior year.

This year, the White House led an effort by the agencies and institute directors<sup>4</sup> to develop a more comprehensive set of advanced manufacturing scale-up and workforce development programs.

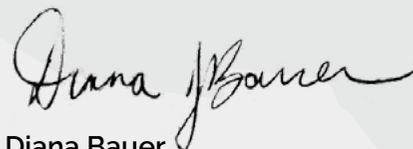
As this report highlights, the institutes and their members position the industry and the nation to deliver technical leadership, empower the current and next generation manufacturing workforce, and build a sustainable, resilient innovation ecosystem. We are pleased to share these accomplishments.



**Michael F. Molnar**  
Department of Commerce



**Tracy G. Frost**  
Department of Defense



**Diana Bauer**  
Department of Energy

<sup>1</sup> <https://www.congress.gov/117/plaws/publ167/PLAW-117publ167.pdf>

<sup>2</sup> <https://www.congress.gov/bill/117th-congress/house-bill/3684/text>

<sup>3</sup> <https://www.congress.gov/bill/118th-congress/house-bill/812/text>

<sup>4</sup> <https://www.whitehouse.gov/briefing-room/statements-releases/2022/10/24/readout-of-the-first-white-house-leadership-summit-with-manufacturing-usa-innovation-institute-network-directors/>

Institutes were created to help get inventions out of the lab and into products manufactured in the U.S. instead of other countries.

**Economic  
Competitiveness**



**Innovative  
Products in the  
Marketplace**

**National  
Security**



**Agile, Cost-effective  
Manufacturing  
Processes**

**Energy  
Security**



**Building a  
Sustainable  
Future**

# The U.S. Leads the World in

## About Manufacturing USA

The Manufacturing USA vision is to secure U.S. global leadership in advanced manufacturing. Manufacturing USA coordinates and catalyzes public and private investments in precompetitive advanced manufacturing technology to:

1. Increase the competitiveness of U.S. manufacturing;
2. Facilitate the transition of innovative technologies into scalable, cost-effective, and high-performing domestic manufacturing capabilities;
3. Accelerate the development of an advanced manufacturing workforce; and
4. Support business models that help the Manufacturing USA institutes to become stable and sustainable after the initial federal startup funding period.

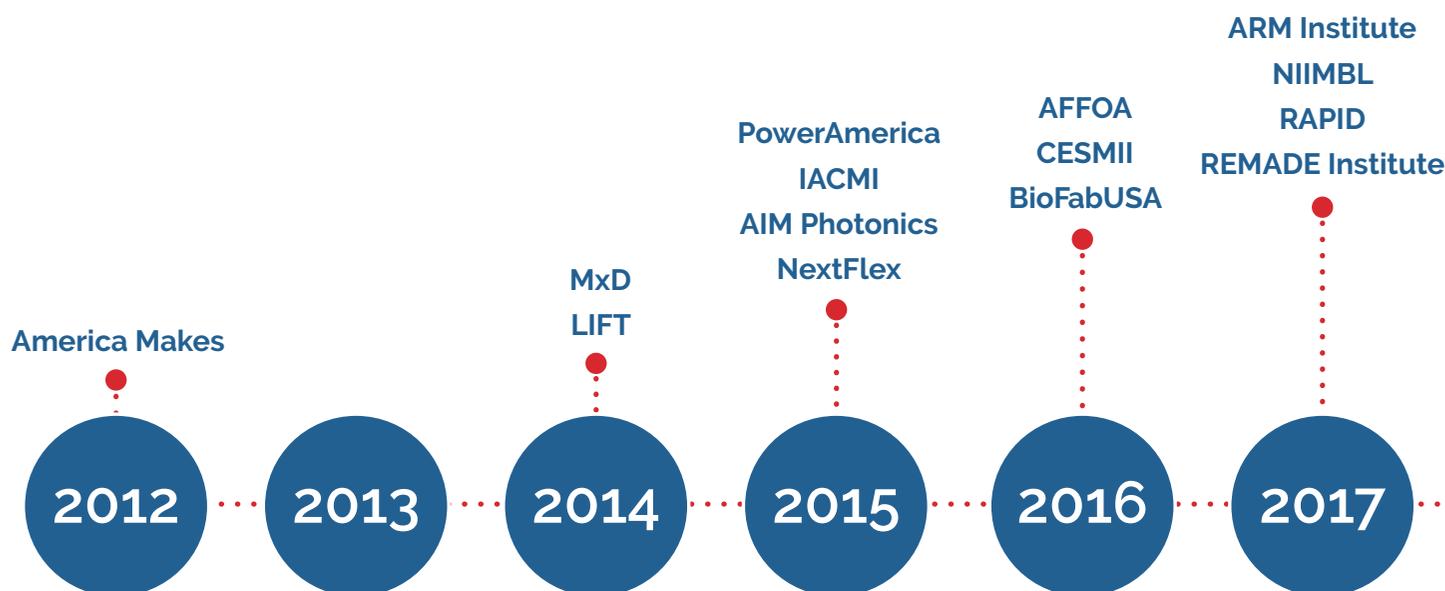
Manufacturing USA's mission is accomplished through a uniquely structured interagency and public-private partnership network. Participating federal agencies and Manufacturing USA institutes coordinate to collectively advance the goals and objectives of the Manufacturing USA program.

### Our Vision

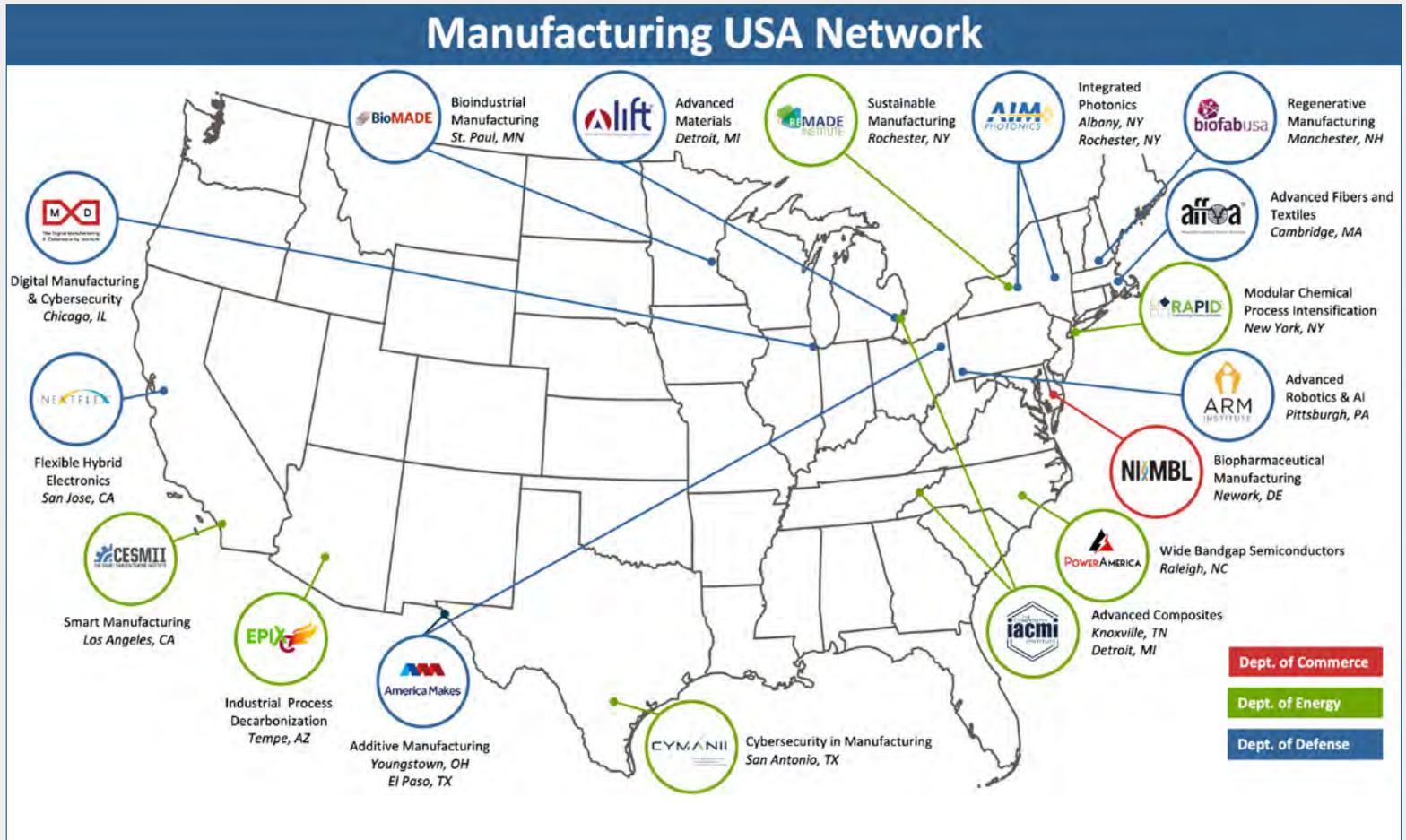
The vision for Manufacturing USA is U.S. global leadership in advanced manufacturing.

### Our Mission

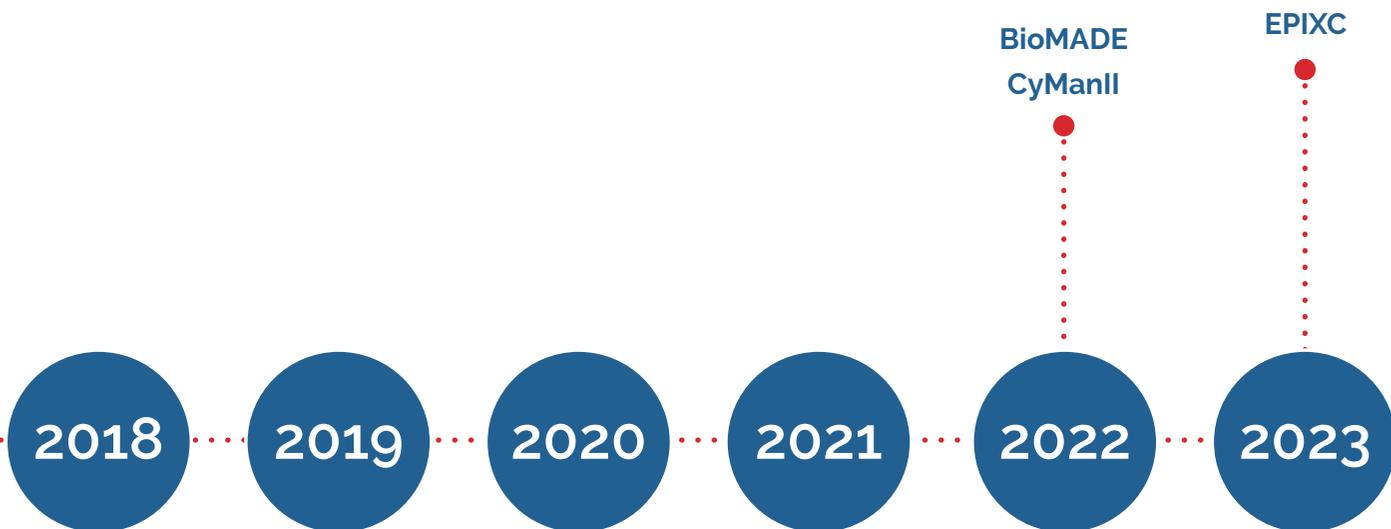
To support this vision, the mission of Manufacturing USA is to connect people, ideas, and technology to solve industry-relevant advanced manufacturing challenges, thereby enhancing industrial competitiveness and economic growth, and strengthening our national security.



# Inventions and Innovations



\*Manufacturing USA Network at time of publication, April 2024.



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 2022, the Manufacturing USA network included 16 institutes: one managed by the Department of Commerce (Commerce or DOC), nine through the Department of Defense (DoD), and six from the Department of Energy (DOE). The Advanced Manufacturing National Program Office (AMNPO) at DOC's National Institute of Standards and Technology oversees the coordinated activities of Manufacturing USA.

Each institute promotes the nation's leadership in advanced manufacturing by focusing on a unique technology. The institutes' flexible business models and a highly collaborative

approach to applied research and development (R&D) catalyze important new relationships across government, industry, and academia. Industry, academia, start-ups, and non-profits become members of the institutes to leverage their unique project and networking opportunities to collectively solve manufacturing technology challenges and educate the workforce needed to advance new technologies. These unique institute-led ecosystems also serve as invaluable resources for the Federal government to tackle agency-specific challenges.



*\*FY 2022 data*

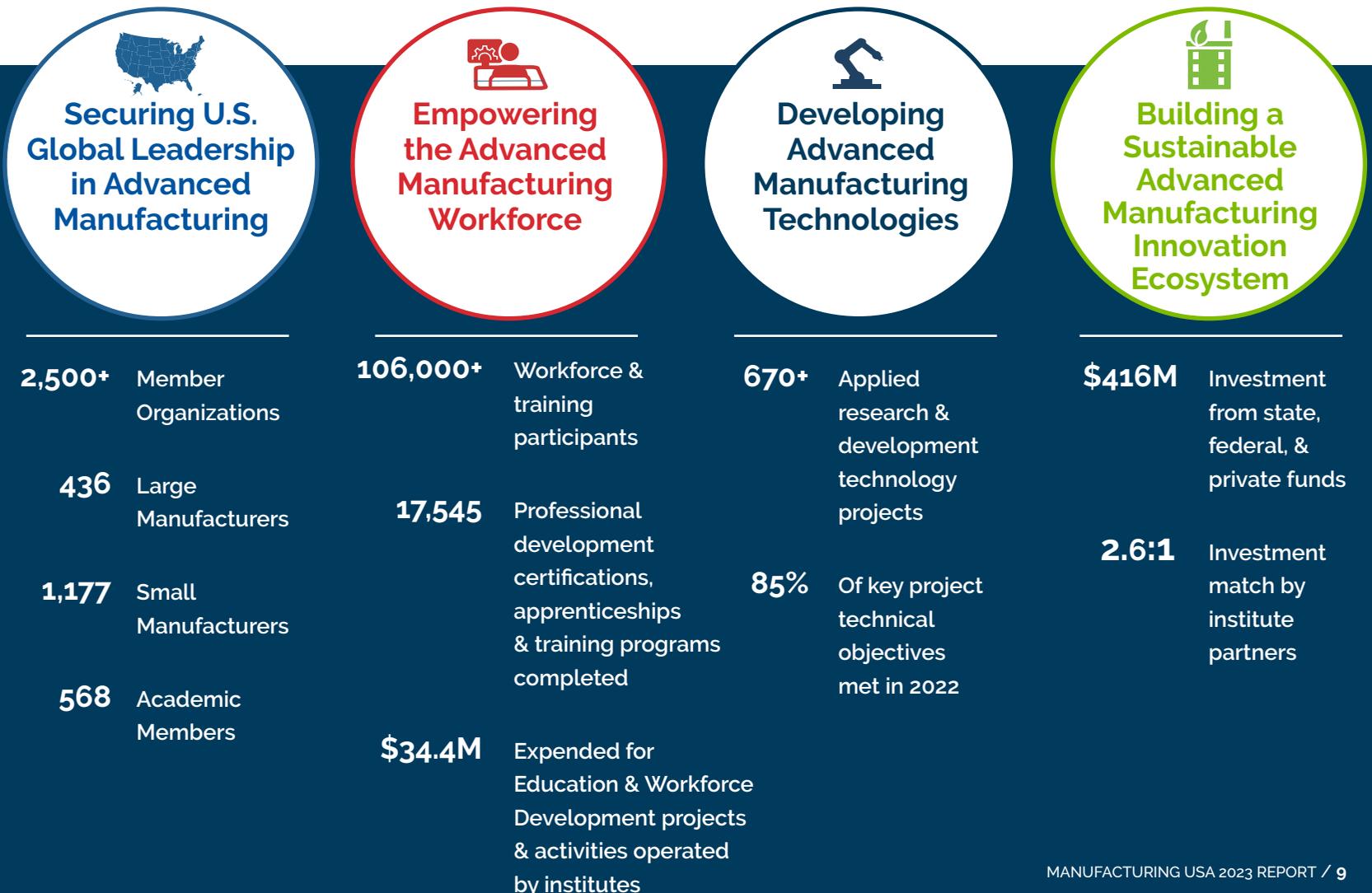
# Manufacturing USA at a Glance

Based on the vision and mission of Manufacturing USA, the participating agencies and institutes work toward four goals that flow from the purposes stated in Manufacturing USA's authorizing statute<sup>5</sup> and are consistent with each sponsoring agency's mission and own authorities: securing U.S. global leadership in advanced manufacturing, developing advanced manufacturing technologies, empowering the advanced manufacturing workforce, and building a sustainable advanced manufacturing innovation ecosystem.

These four program goals are embodied within the four themes listed below which comprise a robust strategy for supporting manufacturing innovation by reducing the time required to transition early-stage research to commercial development and, ultimately, deployment in U.S. manufacturing environments. These themes help guide the network of participating agencies and institutes to advance U.S. domestic manufacturing capability while leveraging the economic and national security benefits from other federal and private sector investments in fundamental research. The performance metrics and their mapping onto each of the corresponding goals are presented in more detail in Appendix A.

<sup>5</sup> 15 U.S.C. § 278s(b)(2). <https://uscode.house.gov/view.xhtml?req=granuleid:USC-prelim-title15-section278s&num=0&edition=prelim>

## 2022 Network Impacts



# Securing U.S. Global Leadership in Advanced Manufacturing

Advanced manufacturing is essential to our economic and national security. American manufacturers contribute more than \$2.8 trillion to the U.S. economy which on its own would represent the eighth-largest economy in the world.<sup>6</sup> Every dollar spent in manufacturing results in an additional \$2.60 added to the economy and creates jobs and economic opportunities in communities and regions throughout the country. Manufacturing USA institutes are integral to creating and catalyzing these opportunities:

**MxD Cyber Resource Hub:** Manufacturing is the number one targeted sector for cyber-attacks. To address this growing challenge, Manufacturing times Digital (MxD, a DoD-sponsored institute) has gathered a library of cybersecurity resources to create the MxD Cyber Resource Hub, launched in 2022. By consolidating resources ranging from the most high-level to in-depth tools that provide governmental guidance on cyber preparedness, MxD provides U.S. manufacturers the information needed to identify, protect, detect, respond, and recover from attacks of all types.



**Renewable Resources:** As a leader in the U.S. transition to a circular economy, REMADE (a DOE-sponsored institute) tackles barriers within the manufacturing cycle that limit recovery, reuse, remanufacturing, and recycling of metals, fibers, polymers, and electronics across the product lifecycle in such industries as automotive, consumer products, electronics, and heavy-duty equipment. The institute's research portfolio of 82 projects, worth \$85M, grew by 21 projects and \$15M. This portfolio has the potential to increase the use of recycled materials by more than 40 million metric tons annually, save 1.2 quads of energy per year, and reduce greenhouse gas emissions by 67.2 million metric tons each year, the equivalent of eliminating the emissions of 13.1 million cars.



<sup>6</sup> *Facts About Manufacturing*, National Association of Manufacturers, U.S. Bureau of Economic Analysis, International Monetary Fund.

# Developing Advanced Manufacturing Technologies

The institutes and their member organizations collaborate on pre-competitive applied research and development projects (R&D) that lead to innovations in products and processes with broad industry-wide application. Examples of the 670 ongoing R&D technology advancement projects include:

**Cost Improvement Opportunities in Wind Blade Fabrication:** This IACMI (Institute for Advanced Composites Manufacturing Innovation, a DOE-sponsored institute) project is reducing the cost of wind turbine blades by developing new manufacturing processes and materials that are more efficient, cost-effective, and environmentally sustainable. An on-going project since the inception of IACMI, a team of institute members developed a workflow to analyze the feasibility of four new manufacturing strategies. This project wrapped in FY 2022, ultimately selecting a 'One-Step Close' manufacturing concept that provided a clear indication of the viability of this approach for blade manufacturing and good validation of its economic impact.



**Physical Therapy Soft Robotic Glove:** Five million stroke survivors suffer from lasting hand impairment. Without high-repetition rehab (which is not achieved in standard care), many patients are left with little hope of recovery. The Advanced Functional Fabrics of America Institute (AFFOA, a DoD-sponsored institute) startup member Imago Rehab developed an innovative soft robotic glove solution to this problem and needed help to transition to production scale. AFFOA introduced Imago Rehab to apparel manufacturer ggDegrees to collaborate on development and prototyping the next iteration of the glove. The partnering companies focused on designing for manufacturability, simplifying the construction process, developing new actuators, and preparing the proper technical documentation for manufacturers to scale production.



# Empowering the Advanced Manufacturing Workforce

Alongside their members and workforce development partners, institutes are targeting diverse and underserved populations to bring opportunities to all Americans interested in manufacturing careers. In FY 2022, more than 106,000 workers, students, and educators participated in institute workforce programs that offered newly developed curricula and certificate pathways in specific technology fields in collaboration with industry. A few examples include:

**Expanding FlexFactor's Reach:** FlexFactor, NextFlex's (a DoD-sponsored institute) flagship education and workforce development program, addresses the skills gap and workforce shortage in the flexible hybrid electronics (FHE) industry. FHE combines traditional electronics with flexible, stretchable, and conformable materials, enabling the creation of new products and applications. Since its inception in 2016, FlexFactor has reached more than 10,000 K-12 students from around the country, with increased number of new participants every year. NextFlex's full workforce program portfolio extends from K-12 to college and university students, and the incumbent workforce, providing opportunities for students and adults to engage and consider a STEM career.



**Helping Military Personnel Develop New Skills for Careers in BioPharma:** NIIMBL (a DOC-sponsored institute) worked with Texas A&M University and its partners to develop the Military Service Members in Biopharma Manufacturing (MSMBM) program. MSMBM helps industry tap into a significant and underutilized talent source and offers veterans new career possibilities. Last year, the program was delivered to five cohorts—41 veterans and military spouses — in Texas and North Carolina. Students had the opportunity to interview with Merck & Co. and Pfizer, Inc. upon completion of the program. In addition, participants in North Carolina were invited to attend BioNetwork's Career Fair to interview with biotechnology companies. Of the 41 participants, half received offers from biopharmaceutical companies within three months of completing the program.



# Building the Sustainable Advanced Manufacturing Innovation Ecosystem

American manufacturing innovation is reliant on strong and robust manufacturing supply chains, and diverse collaboration among manufacturing stakeholders. Small, medium, and large manufacturing companies, academia, member organizations, training and educational organizations, and many others must work together to advance and strengthen U.S. manufacturing and ensure our nation's innovations become products here in the U.S.

**Creating a Robotics Manufacturing Hub:** The ARM Institute (a DoD-sponsored institute) received \$14.2M as part of a \$62.7M Build Back Better Regional Challenge<sup>7</sup> to create a Robotics Manufacturing Hub at its Mill 19 in Pittsburgh. The goal of this Hub is to de-risk the adoption of advanced robotics and automation technology for small/medium manufacturers and accelerate the use of robotics technologies. The ARM Institute will work closely with the other recipients to achieve the overall mission of the grant, including working with members to expand use of robotics in small and medium-sized manufacturers, promote the formation of start-ups in robotics and automation, design a regional upskilling and training system, and increase pathways for underrepresented populations in automation/robotics industries.



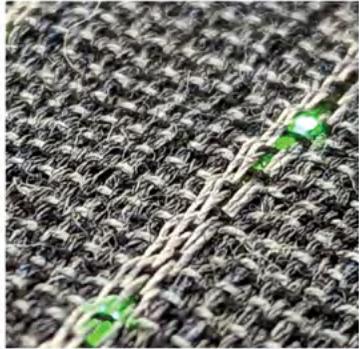
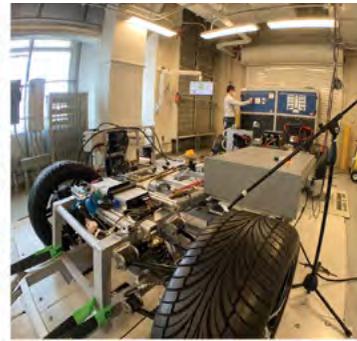
**BioFabUSA Removing Barriers to Work:** BioFabUSA (a DoD-sponsored institute) was part of a coalition awarded a \$44M Build Back Better Regional Challenge Award in late FY 2022 to establish a biofabrication cluster. With its partners, BioFabUSA is developing a “Work and Learn” program to remove barriers for youth and adult students interested in entering the biofabrication field. Barriers to entering the bioeconomy and regenerative manufacturing will be addressed, in part, through scholarships for targeted courses, certifications, and programs, while also tackling technological access, transit, and English language acquisition.



<sup>7</sup> <https://www.eda.gov/funding/programs/american-rescue-plan/build-back-better>

# INSTITUTE ACTIVITIES AND IMPACTS





# The National Institute for Innovation in Manufacturing Biopharmaceuticals



NIIMBL advances the capability to manufacture biopharmaceutical medicines through technology innovation, workforce training, and standards development.



Consortium Organizer: University of Delaware

## Institute Enables

- Consistent and efficient manufacturing for therapies that treat debilitating conditions that are untreatable with conventional pharmaceuticals including:
  - cancer
  - diabetes
  - autoimmune disorders
  - bacterial and viral infections
- Rapid and cost-effective manufacture of safe and efficacious biopharmaceutical products
- Improved health outcomes and more life-saving therapies available to patients



“ BMS is proud to work in partnership with NIIMBL to provide opportunities for students from underrepresented groups and help ensure that our industry reflects the rich diversity and demographics of our patient population.

–David Elkins, EVP and CFO, Bristol Myers Squibb



NIIMBL.ORG

Headquarters:  
Newark, DE

Established:  
March 2017

Members:  
218

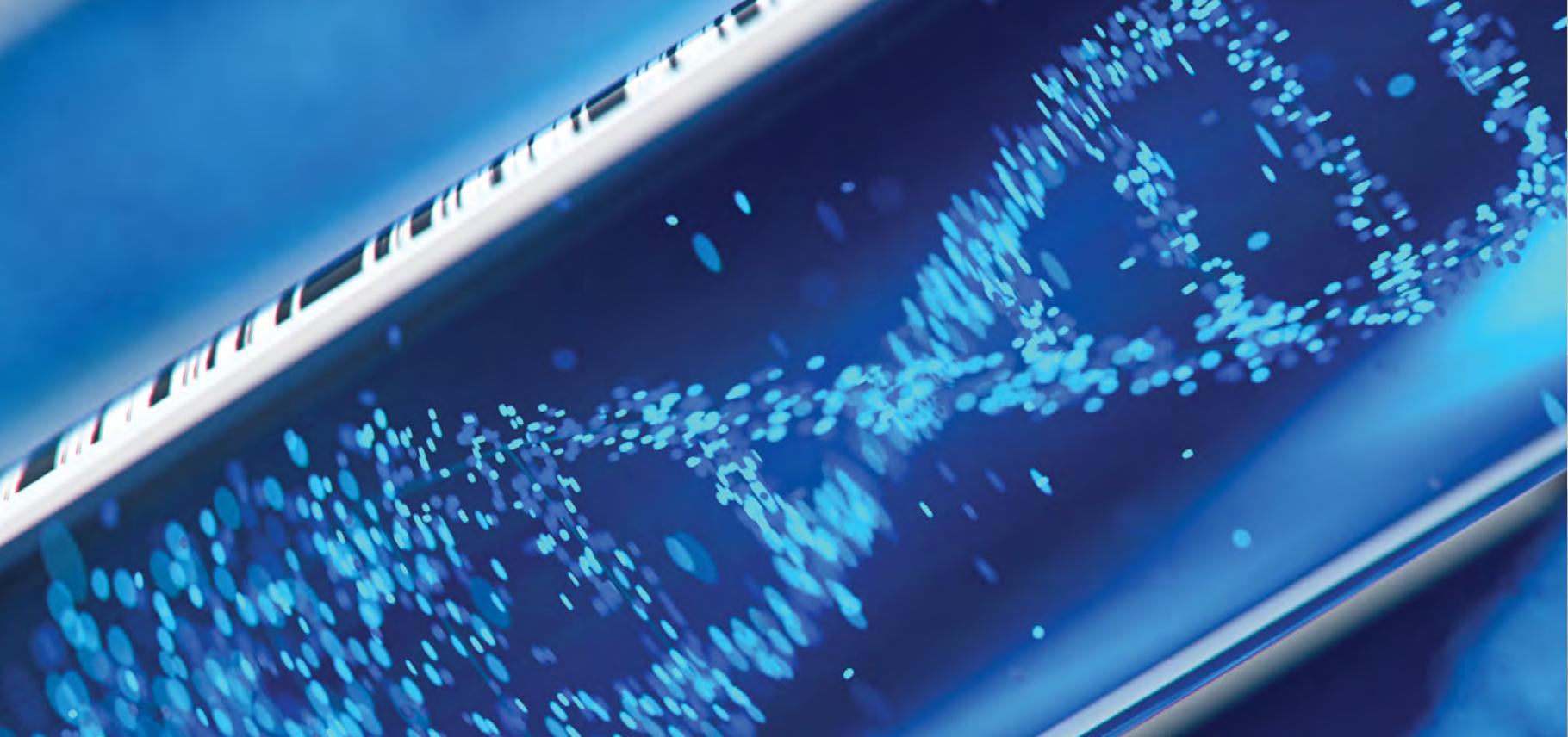
Funding: \$14M Federal  
\$16 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Providing Virus Proteins to Improve Testing Capabilities:** The healthcare industry needed high-throughput and accurate diagnostic tests to screen for SARS-CoV-2 virus-neutralizing antibodies in human blood. When the COVID-19 pandemic began, healthcare workers used a live virus to measure antibodies, increasing their risk of exposure. Developing a safer and faster method of antibody testing could help to screen quarantined workers before returning to work, identify convalescent patients for potential antibody therapy research, and serve as a benchmark to test the efficacy of future vaccines. A collaboration between MassBiologics and the Wadsworth Center resulted in the development of a validated, multiplexed Polyvalent Microbead Immunoassay (MIA) for SARS-CoV-2 antibody-based diagnostics. With its high correlation to live virus tests, the assay can serve as a safer, high-throughput surrogate. MIA reduced the screening time by 97% and has the capacity to screen nearly 100 samples within four hours. Furthermore, since the assay eliminates live virus tests, it reduces the exposure risk for healthcare workers. This MIA can be adapted for new antibodies and viruses in half the time of live virus assays, enabling the healthcare industry to more quickly meet the challenges of future health emergencies.



## WORKFORCE DEVELOPMENT

**Workforce Expansion in Biomanufacturing Emerging Technologies (WE-BET):** The rapid growth of the cell and gene therapy sector has resulted in an employment gap with the immediate need for more qualified graduates to fill positions in all areas, particularly entry level biomanufacturing associates. As the biopharmaceutical manufacturing industry is increasingly leaning on community colleges as a critical source of entry level talent, it is critical that 2-year community college biotechnology and biomanufacturing degree programs reflect the skills, knowledge, and abilities needed by the growing cell and gene therapy industry. This project focused on using an existing decades-long collaboration network of community and technical colleges to understand the labor market needs of the emerging cell and gene therapy sector and develop updated skill standards, curriculum, and faculty professional development opportunities to promote community college program development and workforce training to meet the demand of this rapidly growing sector.

The project team produced a labor market report to understand cell and gene therapy needs and successfully disseminated report findings to community college faculty, administrators, and other stakeholders. The team convened industry listening sessions in multiple industry clusters across the country – gathering input from 27 cell and gene therapy companies which enabled the team to 1) publish a report on cell and gene therapy technician skill standards, 2) develop curriculum for small scale production of safe economical viral delivery systems, and 3) provide updated equipment to four partner community college training laboratories. The team then hosted two virtual faculty train-the-trainer sessions with a total of 126 participants and 199 total registrants. These virtual workshops provided instruction for faculty on multiple topics including an overview of cell and gene therapies, labor market information, use of updated skill standards, as well as lab protocols for viral delivery system production and analysis.

*Credit: iStock*



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Start-up Technology Moves from Concept to Field Testing with Help from NIIMBL:** NIIMBL funded a project led by a small start-up proposing significant improvements in testing time for a critical quality process for biopharmaceuticals. The project aimed to advance academic intellectual property from the technology concept to actual design specifications and development, which successfully resulted in reducing test result time from days to hours. The company is poised to begin field testing with a major prominent large industry NIIMBL member.

**NIIMBL Secures 1,940 Meetings Between Employers and Potential Candidates:** NIIMBL launched a pilot career fair in Spring 2022 providing opportunities for biopharmaceutical industry employers to connect directly with potential candidates for entry-level to senior-level positions. The result was 600 candidates across 122 institutions registered to meet with 258 recruiters across 35 different employers, resulting in an impressive 1,940 meetings over two days.

**600** CANDIDATES

**3%** Certificate/Associate    **24%** Masters  
**57%** Bachelor                **16%** PhD/PostDoc

**258**

RECRUITERS

**35**

EMPLOYERS

# The National Additive Manufacturing Innovation Institute



America Makes is the nation's leading public-private partnership for additive manufacturing (AM) technology and education.



**Consortium Organizer:** National Center for Defense Manufacturing and Machining, The W.M. Keck Center for 3D Innovation at The University of Texas at El Paso (El Paso, TX)

**Satellite Locations:** Texas A&M Engineering Experiment Station at Texas A&M University (College Station, TX), National Institute for Aviation Research at Wichita State University (Wichita, KS)

## Institute Enables

- Accelerated development and deployment of AM solutions to
  - enhance military readiness
  - strengthen alliances
  - improve business performance and overall manufacturing affordability adoption of AM
- Establishment of career pathways in AM and development of a robust AM workforce
- Collaborative infrastructure for the open exchange of AM information and research



“ TechSolve has been enriched by the opportunities to learn and grow our understanding of AM through participation in working groups and project teams. This experience is helping us grow our knowledge as the technology matures in ways that help us better respond to questions posed by our customers. –Susan Moehring, Programs Manager, TechSolve, Inc.



AMERICA  
MAKES.US

**Headquarters:**  
Youngstown, OH

**Established:**  
August 2012

**Members:**  
236

**Funding:** \$83M Federal  
\$153 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Advancing Hybrid Manufacturing Processes:** America Makes completed a project to develop and demonstrate the hardware and software tools required to fabricate and inspect tool and die components using a hybrid manufacturing (the combination of additive and subtractive processes in the same machine) process. Hybrid manufacturing technology greatly improves lead time and generative design for various types of tooling. For this project, teams from Youngstown State University (YSU), Georgia Institute of Technology, Oak Ridge National Laboratory (ORNL), and University of Texas at El Paso worked on process development and material characterization, progressing to the creation of industry-relevant sample test tooling. At least two different types of prototype tools have been constructed by YSU and ORNL using both additive-only and hybrid methods. These tools are being provided to industry partners for real-world usage and evaluation.

**Supporting Aerospace Using Additive Manufacturing:** America Makes executed a project to develop qualification data requisite for manufacturing a powerhead for liquid-fueled scramjet and rocket systems. Metal laser powder bed fusion (LPBF) is beneficial to key aerospace and defense industries by enabling geometric designs otherwise impossible to achieve with traditional manufacturing methodologies. While capable of building complex thin walls and internal passages, LPBF is limited by relatively small build volumes, so aerospace and defense suppliers require part joining to fabricate a final component. To address this issue, General Electric, Aerojet Rocketdyne, and the National Aeronautics and Space Administration (NASA) collaborated to decrease the number of parts needed by 90% for a powerhead propulsion system critical to both scramjets and space launch vehicles. This addresses the needs of the DoD and NASA to improve the supply chain resilience through part consolidation, efficiency, and heightened performance.



## WORKFORCE DEVELOPMENT

**Mapping Additive Manufacturing Training Assets:** America Makes, in collaboration with Quotient, Inc., and The Bush Consulting Group is creating the Additive Manufacturing Portal for Education (AMPED) to map AM training assets including promoting blue ribbon training and reducing training redundancies across the DoD and industry at large. AMPED identifies competencies required for critical additive manufacturing job roles, vets training available to gain those competencies, and maps programming for easy access by both the DoD and industry workforce. AMPED, including a 14-role demonstration of the technology, will be completed in December 2023.

“ These America Makes EWD programs are like gold to the chamber in terms of outreach and educational programming. They align directly to the chamber’s goals and objectives.

– Melissa Maiorano, Manager - Workforce Development, Youngstown - Warren Regional Chamber

*Credit: AMERICA MAKES*



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Supporting Underrepresented Populations:** America Makes, in collaboration with the Youngstown YWCA and Children's Science Museum, hosted a summer camp for underserved populations. America Makes developed a full strategy plan and deployed three, day-long Inspiration through Additive Manufacturing Community Outreach (IAMCO) events in the Mahoning Valley. IAMCO events give students and parents hands-on experience with local partners and pathways and, ecosystems resources, and teach them to use AM as a gateway into advanced manufacturing careers and opportunities.

**Equipping Small Manufacturers with Workforce Resources:** America Makes, in collaboration with the Robert C. Byrd Institute, the Mahoning County Manufacturers Coalition, and Ten80 Education created a guidebook to support recruiting and retaining 21st century talent and facilitate a world-class American manufacturing base and workforce. *America Makes Guide to 21st Century Talent* identifies talent acquisition best practices and customizable, scalable, and deployable programs for local ecosystems and manufacturers to successfully hire, onboard, and retain employees.



Our participation in America Makes was instrumental in catalyzing our efforts in the early stages of deciding the best path for developing a business in Additive Manufacturing. Access to information, experts and other new entrants helped enormously.

—Paul Prichard, Corporate Research Fellow, Kennametal

# Manufacturing Times Digital



MxD is where innovative manufacturers forge their futures. In partnership with DoD, MxD provides manufacturers with digital tools and expertise to begin building every part better than the last.



Consortium Organizer: MxD

## Institute Enables

- Assessment and implementation of digital improvements throughout the defense industrial base
- Increased productivity and business for members, powered by a workforce with the digital skills they need for a cyber-resilient industrial base
- Collaboration across industry, academia, government, and non-profit leadership to ensure the current and future workforce is fully skilled for the roles and competencies needed for digital and cybersecurity manufacturing applications



“ The networking, information exchange, and ability to leverage DoD R&D funding to extend and enhance our technology has opened doors that we could not have imagined even a year ago.

–Trevor Stansbury, CEO, Supply Dynamics



[MXDUSA.ORG](https://MXDUSA.ORG)

**Headquarters:**  
Chicago, IL

**Established:**  
February 2014

**Members:**  
275

**Funding:** \$92M Federal  
\$138 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Illuminating the U.S. Supply Chain:** MxD, together with members Dow, Lockheed Martin, Oshkosh, the Defense Logistics Agency, and others, completed the Supply Chain Risk Alert 2 (SCRA2) project in the summer of 2022. This resulted in a rapid analysis tool that provides policymakers and supply chain leaders a means to efficiently assess a wide range of value chain designs to optimize supply chain resiliency and agility while allowing for proactive risk mitigation. The platform converts supply chain data into a common data model based on partner requirements that can be used to mitigate foreseeable risks. This tool will enable manufacturers to make data-informed decisions in times of crisis or urgency and minimize impact on production capabilities.



## WORKFORCE DEVELOPMENT

**Hands-On Industry 4.0 Training:** MxD and Drexel University jointly launched the Drexel Digital Design & Advanced Manufacturing Program (D3-AMP), which targets industry professionals in automotive, aerospace, biomedical, naval, and other manufacturing companies who are seeking hands-on experience in current digital technologies. D3-AMP combines asynchronous and synchronous training, both remote and in-person, with an emphasis on leveraging the digital thread that links all steps of the engineering design process. A first delivery of the D3-AMP took place in the second quarter of 2022 with funding from the Defense Logistics Agency.

“ Drexel University is thrilled to partner with MxD in the creation and launch of the new Drexel Digital Design & Advanced Manufacturing Program. It will be imperative that academic institutions and businesses work together in order to train and upskill workforces so that individuals remain competitive in the evolving marketplace.

—Anna Koulas, Vice President, Drexel Solutions Institute



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Developing Supply Chain Guidance:** MxD established a stakeholder newsletter, ChainMail, to provide authoritative information about supply chains for its ecosystem to operate more effectively. MxD member EY is the exclusive sponsor of ChainMail for the first 30 issues. The newsletter's goal is to provide manufacturers with heightened education and awareness of critical supply chain issues so they can make better-informed decisions on how to plan, digitize, and secure the way they source components and equipment. Readers are then primed to take the next step to improve their supply chains — through, perhaps, an R&D project that increases their visibility and agility, attending a webinar, or entering a bilateral partnership with MxD to increase the security of their suppliers. Ultimately, improvements in supply chain will limit disruptions and make U.S. manufacturers from the commercial and defense sectors more efficient.

**Introducing a Cyber Marketplace:** To equip manufacturers, the MxD ecosystem, and others with tools to cyber secure operations, MxD partnered with RealCISO to create affordable and accessible resources. MxD focused on providing accessible cybersecurity guidance in an easy-to-understand format that removed barriers such as cost, loss of autonomy, and over-complex concepts. The resulting online e-commerce and self-assessment tool, the MxD Cyber Marketplace, guides users through a self-assessment process that outlines an organization's cyber posture followed by recommendations for securing their operations.



**As chair of the Military Economic Development Committee, it is great to see the MxD Cyber Marketplace innovating manufacturers' relationships with the U.S. government. It is critical that businesses have the tools to reach their full potential. This launch ensures SMMs have protection from cyberattacks so they can grow.**

—Juliana Stratton, Lt. Governor, Illinois

LIFT connects materials, processes, systems, and talent to drive American advanced manufacturing into the future.



**Consortium Organizer:** American Advanced Materials Manufacturing Innovation Institute (ALMMII)

## Institute Enables

- Development and deployment of new advanced materials manufacturing technologies and processes, including
  - light weighting
  - multi-material processing
- New advanced manufacturing curricula and training opportunities in immersive Learning Lab environment and to schools across the nation
- Information exchange across industries and collaborative solutions to pervasive problems



“ Through LIFT's educational endeavors, our partnership helps enable future generations around cutting edge, advanced technologies and building a base for securing our national manufacturing base.

–Andrew Snow, Senior Vice President, EOS North America



**Headquarters:**  
Detroit, MI

**Established:**  
February 2014

**Members:**  
149

**Funding:** \$83M Federal  
\$92Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Improving Aerospace Structures:** LIFT, with members Boeing and Bond Technologies, developed a method to reduce the need for rivets in aerospace structures. Together they investigated and developed a novel spot welding technique of thin materials not previously investigated, in support of the Apache attack helicopter program. Testing showed that the static strength of these welds can reach more than double the strength of an aluminum rivet in the same materials. Boeing is expected to report these findings to the Apache attack helicopter program and will develop a proposal for a full-scale follow-on program.

**Showcasing the Future of Smarter Manufacturing:** The Digital Twin Smart Factory Showcase (DTX) – a full-scale digital model of the tabletop Mechatronics System currently used by students in the LIFT Learning Lab-educates, stimulates, and supports large and small manufacturing companies along with students. In alignment with LIFT's mission to drive American manufacturing into the future, the project increases local awareness of smarter manufacturing and Industry 4.0 systems, processes, and advancements. The installation provides a demonstration sandbox for manufacturing companies and economic developers to explore smarter manufacturing technologies. The DTX is showcasing the future of smarter manufacturing for students and small businesses alike.



## WORKFORCE DEVELOPMENT

**Transitioning Military Veterans into Manufacturing Jobs:** LIFT works with partners located near military bases in 14 locations nationally to train transitioning military members for careers in manufacturing. Active military members, National Guard and reserve members, and their spouses and dependents often struggle to find work after a transition out of the military. Operation Next, currently funded through a Manufacturing Engineering Education Program (MEEP) grant, is helping these individuals with transferable skills that employers desire, such as effective communication, integrity, and teamwork, to find next-step careers in manufacturing. Operation Next graduates are recruited to work for many companies in the manufacturing industry such as the Aluminum Extruders Council, Siemens, and other LIFT members.

“ The GISD is excited to partner with LIFT to bring smarter manufacturing career awareness to students in Genesee County. These high wage, high demand career opportunities are important to the future success of Genesee County. Working together to help students and parents in our community understand the opportunities that exist is vital to our continued economic development.

—Diana Allard, Executive Director of Career and Technical Education, Genesee Intermediate School District

Credit: LIFT/NIST



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Expanding Reach to Puerto Rico:** LIFT, announced an expansion to Puerto Rico. Puerto Rico has a long history of manufacturing and a diverse manufacturing economy, including biotechnology, medical devices, pharmaceuticals, agroecology, aerospace, electronics, computing, engineering and construction, and apparel. LIFT is convening local stakeholders to initially assess how it can meet the innovation needs of the island's manufacturers as well as prepare the workforce to work in the advanced manufacturing sector. LIFT will bring both its technology program and its workforce development program to Puerto Rico, including Operation Next for active-duty military and National Guard and Reserve members on the island, enabling them to earn nationally portable, standards-based, and industry recognized credentials in high demand manufacturing fields.



**Puerto Rico is known for its specialized workforce, and LIFT Puerto Rico brings world-class advanced manufacturing technology development capabilities to Puerto Rico and provides a significant economic asset that will expand competitiveness, manufacturing readiness, economic, and workforce growth.**

—Pedro R. Pierluisi, Governor of Puerto Rico

# American Institute for Manufacturing Integrated Photonics



AIM Photonics advances the use of light for applications traditionally addressed through electronics to enable new technological opportunities in a wide range of areas critical to the defense industry.



**Consortium Organizer:** Research Foundation for the State University of New York

**Satellite Locations:** Santa Barbara, CA, Tucson, AZ, and Cambridge, MA

## Institute Enables

- Access to advanced technology, capabilities, and resources throughout the entire product development cycle, including the most advanced 300 mm semiconductor processing research fabrication facility in the world
- Education and workforce development initiatives in integrated photonics at every level of technical expertise

Process Design Kit Update

3-Day Integrated Photonics Bootcamp

85 Designs for MPW Runs

INSTITUTE @WORK

“ This industry-academia collaborative project illustrates both the power of photonics to improve people’s lives, and the key enabling role AIM Photonics plays in providing cost-effective access to world-class integrated photonics prototyping capabilities.

–William Price, Director of Government Business, Intelligent Fiber Optic Systems Corporation (IFOS)



AIMPHOTONICS.COM

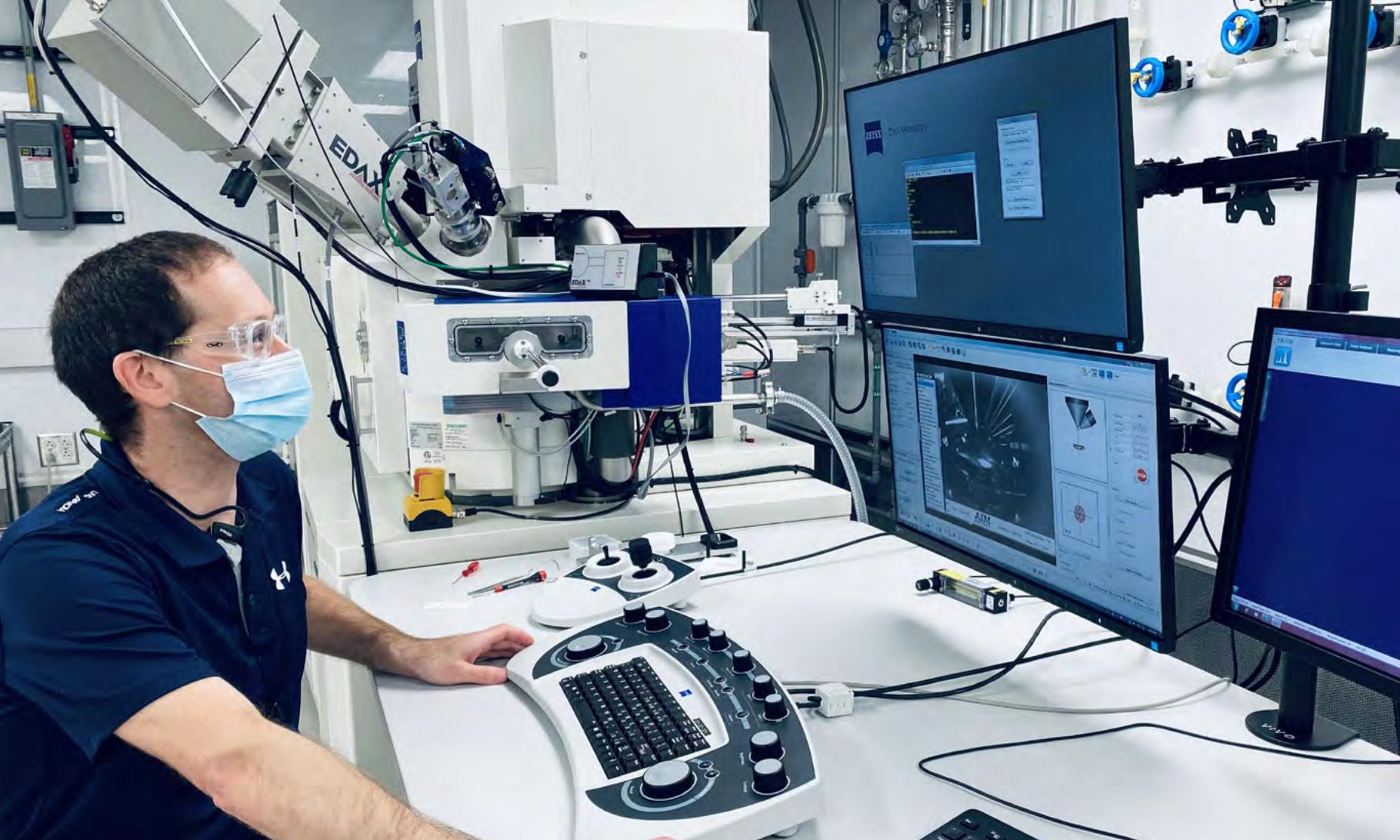
**Headquarters:**  
Albany/ Rochester, NY

**Established:**  
July 2015

**Members:**  
72

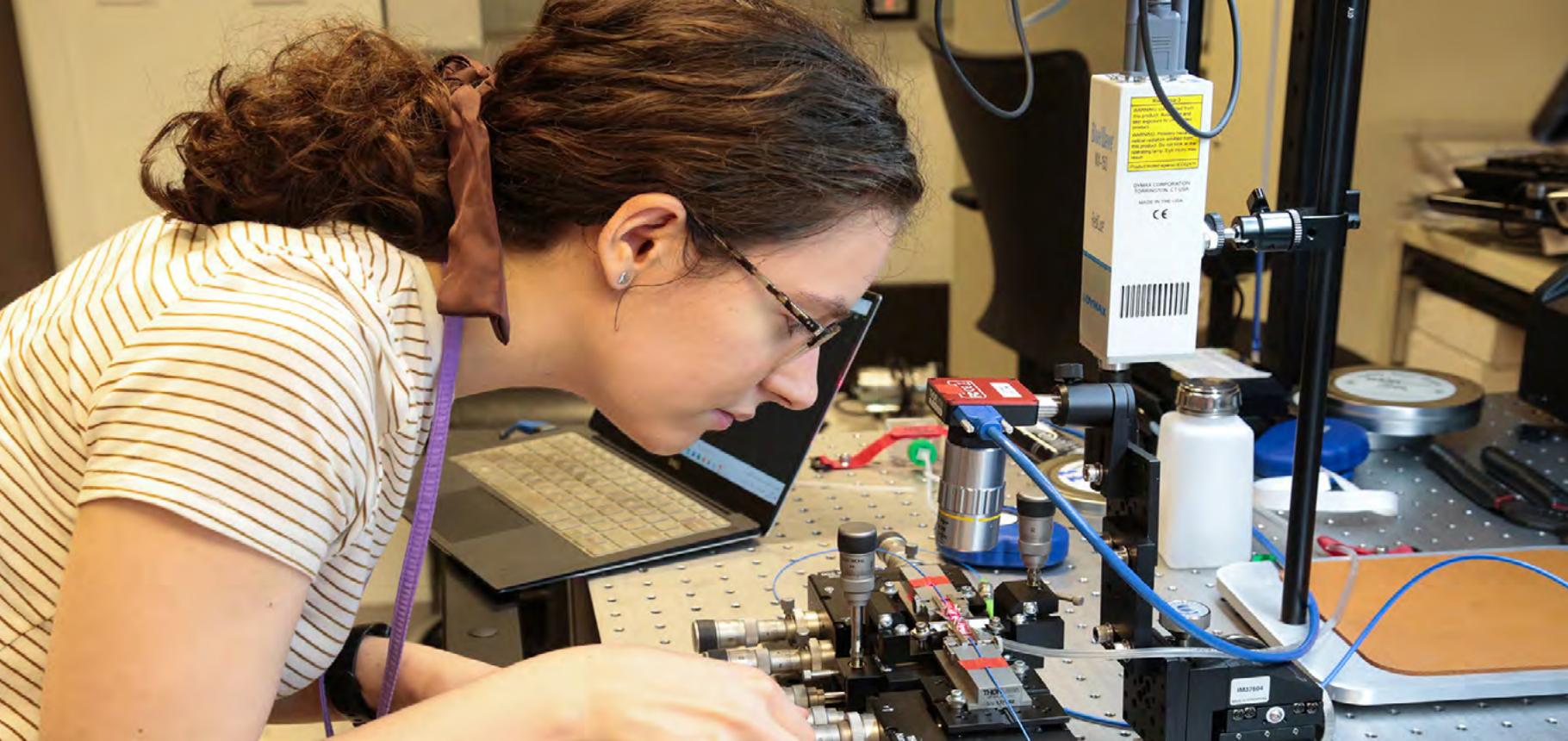
**Funding:** \$275M Federal  
\$659 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Expanding Access to Improved Photonics Design Software:** A major update to AIM Photonics' silicon photonics Process Design Kit (PDK) added new hardware verification models to address gaps between lab simulation and real-world performance, giving designers greater confidence that a fabricated chip will behave as it did during PDK simulation. Additionally, an improved distribution method using GitLab provides access for multiple users from the same organization under a single license agreement for on-demand downloads, immediate access to patches, or minor updates, and allows users to contribute their own verified components for the greater silicon photonics community, further expanding access to new and emerging technologies.



## WORKFORCE DEVELOPMENT

**Reviving Internships:** After a two-year hiatus due to the COVID-19 pandemic, AIM Photonics resumed its summer internship program in 2022. The AIM Photonics internship program provides highly qualified students with hands-on education and training opportunities in all aspects of photonic integrated circuit design, fabrication, and packaging. The 12-week summer internships are structured to provide upper-level undergraduate and graduate students with a learning experience that is challenging and useful, while providing opportunities to contribute directly to the advancement of technology. This year's students were instrumental in the testing and characterization of components designed by AIM Photonics engineers, creating new data processing tools, and contributing to the development of AIM Photonics' fiber attach capabilities.

**Addressing Industry Challenges through Education:** In April 2022, AIM Photonics held its second Integrated Photonics Bootcamp, focused primarily on photonic devices, their applications, and application-specific photonic device packaging challenges posed by this emerging technology. The bootcamp consisted of three days of intensive training in a blended learning environment with a strong hands-on experiential component supported by lectures by renowned industry experts.

Additionally, students worked with virtual simulation learning aids designed to intuitively teach photonic device functionality. The rapid skilling needed to support the integrated photonics industry requires training on costly, maintenance-intensive, advanced manufacturing tools like those available through AIM Photonics' educational partners, such as the Massachusetts Institute of Technology and Bridgewater State University. To ensure sufficient tool-time for all participants, enrollment in the bootcamp is limited to 12 participants, including college undergraduates, research university graduate students, and incumbent photonics industry workers.



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Continued Prototype Development:** During FY 2022, 85 designs were submitted for manufacture in AIM Photonics' active and passive multi-project wafer (MPW) runs. MPW is a manufacturing method that allows several different designs or projects to be fabricated at the same time on a single wafer. This approach enables multiple customers and projects to share common masks, materials, and process flows. With typical foundry processing costs between \$125K-\$350K per wafer, AIM Photonics' MPW services—combined with its process design kits (PDKs)—helps shorten design time, improve manufacturing efficiency, and lower the price of entry for companies to develop new silicon photonics applications.



Cost and density of photonics components continue to hamper widespread development and adoption of these technologies and new applications; a domestic prototyping capability like AIM Photonics that helps address these issues is a critical enabler for the broader ecosystem in microelectronics.

—Dev Shenoy, Principal Director for Microelectronics, Office of the Under Secretary of Defense for Research and Engineering

NextFlex advances FHE technology that integrates printed and additively-manufactured electronics with the performance of thin semiconductors to create stretchable, bendable, and flexible electronic devices.



Consortium Organizer: FlexTech Alliance

## Institute Enables

- Advancement of the design, development, prototyping, and pilot-scale manufacturing of flexible hybrid electronics (FHE) for a range of military and civilian applications
- Convening of institute members to collaboratively identify and actively overcome manufacturing challenges in commercializing FHE-enabled systems and devices
- Creation of the talent needed by industry partners over time

Wearable  
Stress  
Monitor for  
**Astronauts**

High Speed  
Wafer Feeder  
for Pilot Line

Updated  
**11 FHE**  
Technology  
Roadmaps

**INSTITUTE  
@WORK**

“ NextFlex has done a terrific job in terms of ROI for its members. As an early-stage, U.S.-based tech company, NextFlex has provided us with U.S.-based low-rate initial production capabilities when many manufacturers would simply turn us away.

–Zach Kiehl, CEO and Co-founder, Aptima-Sentinel



NEXTFLEX.US

**Headquarters:**  
San Jose, CA

**Established:**  
August 2015

**Members:**  
98

**Funding:** \$102M Federal  
\$133 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Physiological Monitoring in Space:** Under a project with NASA, NextFlex is developing a flexible, wearable stress monitoring device for astronauts in-flight. One project goal is to enable the fabrication of such devices in space using digital techniques. The system comprises an electrochemical cortisol sensor, a potentiostat, microcontroller, and Bluetooth chip to transmit data wirelessly. First generation benchmark prototypes have been assembled and tested. By the end of the project, the full circuit design as well as printed electrochemical sensors will be delivered to NASA. The cortisol sensor, which was developed by NASA Ames Research Center, will be a consumable part that is attached to the underside of the unit in contact with the wearer's skin. Long-term, this project will create a sensor platform for additional physiological monitoring while also demonstrating the capability to fabricate electronic devices in space.



## WORKFORCE DEVELOPMENT

**Helping Military Veterans Find Employment in Manufacturing:** In partnership with Hiring Our Heroes, a nationally recognized non-profit focused on military-connected employment, NextFlex co-hosted an employer panel on advanced manufacturing. The event included presentations on emerging technology, innovative thinking, the defense industrial base, and careers in advanced manufacturing. In addition, representatives from NextFlex member companies Boeing, Brewer Science, GE Research, and TTM Technologies participated on the employer panel to share expertise.

“UMass Lowell has really benefited from and enjoyed our participation in NextFlex. I've really been impressed with how well they have engaged the community by offering networking so that all ecosystem members can benefit and communicate amongst each other and create new friendships.

—Dr. Joey Mead, Center Director for SHAP3D Industry University Cooperative Research, UMass Lowell



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Expanding Headquarters Capabilities:** NextFlex added to its Technology Hub pilot line a new Universal Instruments Corporation (UIC) High Speed Wafer Feeder (HSWF). This integrates with the UIC production pick-and-place tool to enable high-speed placement of thin semiconductor die onto a variety of substrate types including flex, printed circuit boards, and conventional and advanced package substrates. This is the first machine that can simultaneously house many wafers of different sizes and types, and pick die from each within the same build, allowing high precision heterogeneous integration in a single manufacturing tool. The development of the HSWF was supported through a NextFlex Project Call with cost share from the New York node and UIC. The first two production units are housed at NextFlex and Binghamton University, and are commercially available.

**Enhancing Roadmaps:** NextFlex published updates to its eleven Flexible Hybrid Electronics Technology Roadmaps in early 2022 and produced the first Automotive FHE Technology Roadmap in mid 2022. These roadmaps help members coordinate activity with other ecosystem members (including customers and suppliers) and identify gaps that represent business opportunities. Several new and enhanced features were added to the roadmaps, including spreading best-practices among the technical working groups. Additionally, NextFlex published the first public summaries of each roadmap to extend coordination across the FHE ecosystem outside the NextFlex membership.



Through the various partnership opportunities, project calls, and working groups; it is a great way to get involved in the whole ecosystem and work both with companies in our area, large or small, government organizations, other funding organizations, and of course NextFlex itself.

—Dr. Joseph Kunze, CEO, Sl2 Technologies

# Advanced Functional Fabrics of America Institute



AFFOA's vision is a globally competitive, domestic supply chain in advanced fibers and fabrics. The institute delivers breakthrough capabilities and innovations for national security.

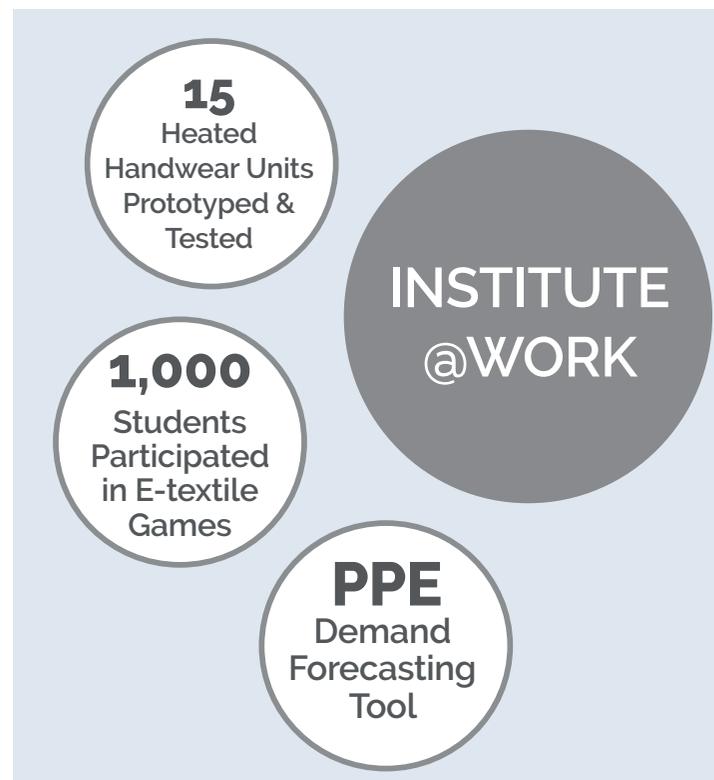


**Consortium Organizer:** Massachusetts Institute of Technology (MIT)

**Satellite Locations:** Drexel University (Philadelphia, PA), MIT Lincoln Laboratory (Lexington, MA), University of Massachusetts, Lowell (Lowell, MA)

## Institute Enables

- Development and commercialization of advanced fiber and fabric technologies that allow energy storage, temperature regulation, and health monitoring for commercial and defense applications
- Growth of the domestic textile industry's workforce
- Collaboration within the Fabric Innovation Network (AFFOA's ecosystem) and its four Fabric Discovery Centers
- Creation of a domestic supply chain and technology roadmaps to solve industry challenges



“ We have manufactured the first of its kind metamaterial fabric and demonstrated its anti-jamming and range boosting capabilities to U.S. government personnel.

–Shahriar Khushrushahi, CEO, Notch



**Headquarters:**  
Cambridge, MA

**Established:**  
April 2016

**Members:**  
156

**Funding:** \$75M Federal  
\$272 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Heated Handwear:** The human body responds to cold exposure by decreasing the amount of blood circulating in the extremities, greatly reducing dexterity, and making hands and feet particularly prone to frostbite in extreme cold. This greatly affects equipment and firearms operation and puts the warfighter at risk. In FY 2022, AFFOA led a project in support of a Congressionally funded U.S. Army Combat Capabilities Development Command (DEVCOM) Soldier Center's Combat Protective Ensemble (CAPE) effort. The project leveraged partnerships across the AFFOA Fabric Innovation Network to develop a heated handwear solution using research from the U.S. Army Research Institute of Environmental Medicine that showed 90% of trigger finger dexterity is retained through forearm heating. AFFOA served as the system integrator and partnered with various institute members to create a battery-powered, closed-loop heating system in a forearm sleeve and glove. Fifteen units were prototyped and tested in Alaska. The results of this work will significantly impact the development of a powered heating capability to mitigate injury for those that operate in extreme cold weather environments.



## WORKFORCE DEVELOPMENT

**Gamifying Learning and Educating Through Fun:** AFFOA funded startup member Nautilus Defense to create a STEM curriculum and kit featuring their proprietary SewIY conductive thread technology in an interactive e-textile game for kindergarten through 8th grade students. The SewIY Space Exploration with Intelligent Yarns STEM Game was designed to increase awareness of advanced fabrics to younger students and engages players by leveraging modular e-textile sensor components (representing light, heat, pressure, etc.) to help an astronaut reach a given mission objective in the simulation. The first game board with sensors was prototyped and tested at the SmartForce Student Summit in Chicago, at which more than one thousand students played the game and learned about advanced functional fabrics. AFFOA is helping SewIY continue to field test the game and is exploring the next steps necessary to commercialize the kit.

“ I was really surprised at how hands-on this week was. We got to experience so many different areas of textiles and technology. I have a much deeper understanding of clothing, how it's made, and how we can add technology to have it do incredible things.

—Kenneth Julmeus-Geffarrd, Cambridge Career Exploration Intern, High School Student

Credit: AFFOA/NIST



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Supporting PPE Development through CARES Act and RACER:** Access to Personal Protective Equipment (PPE) proved to be a challenge during the COVID epidemic, particularly as the U.S. had insufficient materials and product manufacturing capacity to satisfy the exponentially rising demand. Through funding from the Coronavirus Aid, Relief, and Economic Security (CARES) Act and later through NIST's Rapid Assistance for Corona Virus Economic Response (RACER), AFFOA partnered with many member organizations from academia, startups, and established companies to address the gaps identified in the PPE domestic supply chain.

The program teams created a PPE Demand Forecasting tool, established a PPE testing network to provide information about imported products and assist with developing new domestic production capacities, developed government-owned designs for PPE, invested in the development of electrospun filtration media to diversify the set of materials that could be used for filtration in respiratory protection, and established a manufacturing line capable of creating meltblown nonwovens and N95 respirators in the U.S. Further work is underway to create a portable, automated PPE manufacturing facility within a shipping container, capable of transport to locations in need, developing biodegradable products to reduce the environmental impact of PPE, and scaling up the production of electrospun materials to diversify the supply chain of raw materials that could be used to make respiratory PPE.

# Advanced Regenerative Manufacturing Institute



BioFabUSA targets the raw material, equipment, measurement, automation, logistics, and analytics challenges that hinder scalable, consistent, and cost-effective manufacturing of engineered cells, tissues, and organs.



**Consortium Organizer:** Advanced Regenerative Manufacturing Institute (ARMI)

## Institute Enables

- Integration of innovative cell and tissue cultures with advances in biofabrication, automation, robotics, and analytical technologies
- Development of tissue-engineered medical products on an industrial scale
- Accelerated creation of numerous medical products for our wounded Warfighters
- Preparation of the workforce to meet the needs of this developing industry across the U.S.

**Microneedle Technology for Drug Delivery**

**INSTITUTE @WORK**

**180 Students at BioTech Summer Camp**

**Reducing Barriers for Companies to Enter Bioeconomy**

“ BioFabUSA is becoming the hub of the world's biofabrication, leading the country down a path to affordable, curative healthcare. That's quite a switch from the current, bank-account-breaking healthcare system that is focused on chronic treatment of disease.

—Michael Golway, President & CEO, Advanced Solutions



ARMIUSA.ORG

**Headquarters:**  
Manchester, NH

**Established:**  
December 2016

**Members:**  
188

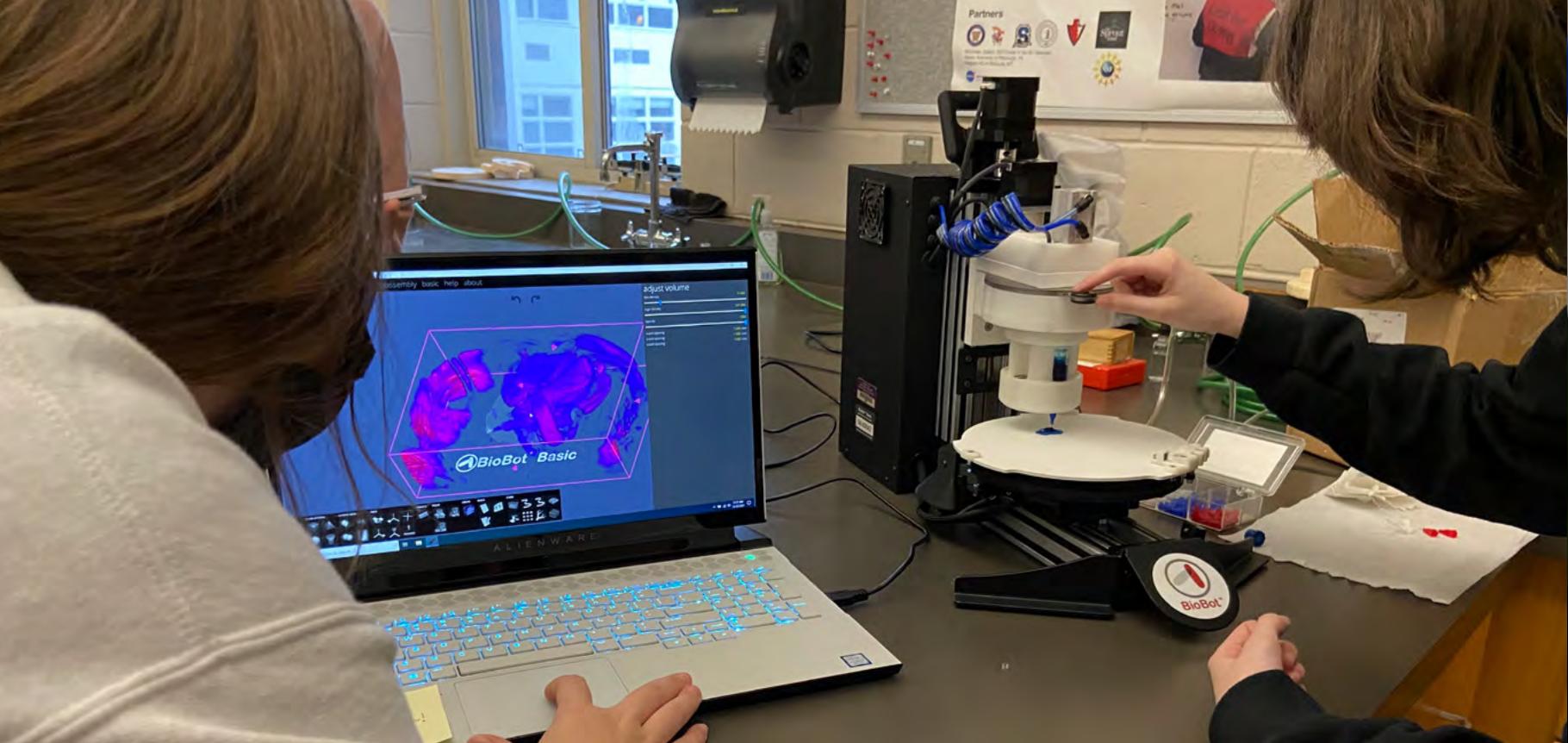
**Funding:** \$80M Federal  
\$214 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Advancing Drug Delivery Technology:** In the early days of the COVID-19 pandemic, critical medical supplies were in short supply, including syringes. And although the initial shortages have waned, the World Health Organization reported that, there could be a shortage of 1-2 billion syringes. In addition, injections with syringes require specialized training. To overcome these challenges, BioFabUSA, using 2020 CARES Act funding in partnership with DEKA Research and Development and NanoPass Technologies, began a project to develop a new drug delivery platform with microneedle technology. The microneedle technology features an easy manufacture and fill reservoir for vaccines or other drugs, and has an easy method for administration that requires no specialized knowledge or training. Intradermal delivery via microneedles may also substantially lower vaccine dose required, provide additional efficacy, and cause no pain upon administration. Patent applications are pending ideally with an update if expected Q3 trials have begun: Clinical trials are underway and FDA clearance anticipated by end of 2023. Once FDA clearance is received, the devices will be commercially available to the Military Health System.



## WORKFORCE DEVELOPMENT

**BioTech Summer Camp:** BioFabUSA worked with the University of New Hampshire to develop a BioTech Summer Camp. The Tech Camp provides programming designed to prepare students for potential career pathways and help address New Hampshire's current and future workforce development challenges. Sixteen projects were conducted by more than 180 students during three weeks in the summer. Planning is underway for Summer 2023.

“ BioTrek’s unique structure and cutting-edge science sparked an interest in our students that we have rarely seen. Our students were pushed to collaborate, think critically, and dive deep into research, which are all skills that this generation will need as they move into the world.

– Impressions of BioTrek from teachers at Winnacunnet High School



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Supporting Small Businesses:** CellDrop, a BioFabUSA member in West Virginia, developed automated cell counters and successfully completed a Phase I Small Business Technology Transfer (STTR) project. To further advance the technology in the STTR's Phase II, CellDrop sought assistance from BioFabUSA to develop an advisory board. The institute connected CellDrop to Elanco, another BioFabUSA Member, and a strategic partnership was launched. Elanco provided useful insights into market and cell therapy regulatory details, and committed assistance collaboration to CellDrop to assist and collaborate for the length of the Phase II STTR program.



The Build Back Better Regional Challenge will directly affect members of the Southern New Hampshire region. The BioFabrication Cluster will enhance U.S. competitiveness, establish southern New Hampshire as a global leader in the industry, and ensure a strong, regional economy for the future.

–Secretary Gina Raimondo, U.S. Secretary of Commerce

# Advanced Robotics for Manufacturing Institute



The ARM Institute is leading the way to a future where people and robots work together to respond to our nation's greatest challenges and to develop and produce the world's most desired products.



**Consortium Organizer:** Carnegie Mellon University

## Institute Enables

- The integration of diverse industry best practices and institutional knowledge about robotics technologies across many disciplines to realize the promise of a robust manufacturing innovation ecosystem
- DoD to meet its autonomy modernization goals by having programs centered on improving human-robot interaction; interoperability; artificial intelligence; reconfigurable, agile and flexible robotics systems; and easier technology adoption and risk reduction

**200+**  
Composite  
Layers on  
Laminate Parts with  
Robot System

**Virtual  
Reality**  
Robotic  
Technician  
Assessment

**Flexible  
Drilling  
System with  
Cobots**

**INSTITUTE  
@WORK**

“ This project is the beginning of an automation journey that is much needed in the garment manufacturing industry. The ARM Institute helped us connect with other members like Henderson Sewing Machine Company, Sewbo, Siemens, and Levi's to come together.

—Auralis Herrero-Lugo, Commercial Product Manager, Bluewater Defense



ARMINSTITUTE.  
ORG

**Headquarters:**  
Pittsburgh, PA

**Established:**  
January 2017

**Members:**  
370

**Funding:** \$80M Federal  
\$173 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Advancing Robotics for Manufacturing Composite Materials:** The ARM Institute, along with the University of Southern California, Southwest Research Institute, and Lockheed Martin completed a project to use robotic cells to reduce the time needed to lay down each individual layer of a composite material during the manufacturing process of complex tools. A four-robot system was developed that can add more than 200 delicate layers of composite material on a geometrically complicated laminate part. The composite material is two substances of different physical and chemical properties that when combined create a material that is both lightweight and strong. The process saves time, money, improves quality, and reduces human fatigue.

**Improving Flexible Drilling:** The ARM Institute, Air Force Research Lab, and Boeing developed a flexible drilling system that brings the flexibility of collaborative robots to drilling and other tasks where, until now, collaborative robots could not be used. The solution created through this project also addresses issues with high mix low volume manufacturing by being part agnostic, mobile, and highly flexible. The project team recently held demonstrations at the ARM Institute's Mill 19 facility in Pittsburgh, PA for experts and DoD stakeholders, and showcased the system's ability to self-attach to a decommissioned F-15 wing via suction on the end effector.



## WORKFORCE DEVELOPMENT

**Advancing Virtual Reality for Education:** The ARM Institute's new Virtual Reality Robotic (VR) Technician Assessment project is a collaborative effort with SimInsights, APT Manufacturing Solutions, and CMU's Block Center, with funding provided by DoD's Manufacturing Technology program. The purpose is to create the prototype for a VR environment in which potential and current manufacturing employees can undergo performance-based assessments that test their robotic and automation knowledge, skills, and abilities. The VR assessment provides a low-cost testing mechanism to validate competency levels that will alleviate the need for classes and shorten the hiring, onboarding, and time to productivity for new employees.

“**ARM Institute's RoboticsCareer.org resource is more than just a simple education posting site. It was created to make robotics careers more accessible by making resources organized and easy to find.**

—Brianna Wessling, Associate Editor, Robotics, WTW media

*Credit: ARM Institute*



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Strengthening Regional Defense Manufacturing Capabilities:** As part of the AIM Higher Consortium (a Defense Manufacturing Community), the ARM Institute named two fellows from ARIS Technology and ARIN Technologies to support the work of the Consortium. The fellows are working on projects to strengthen defense manufacturing capabilities in West Virginia and the Southwestern Pennsylvania region. The AIM Higher Consortium's mission is to ensure that the U.S. is unrivaled in military readiness and defense manufacturing capabilities through an industrial production ecosystem that melds advanced metals and materials with Industry 4.0 technologies like robotics, artificial intelligence, and additive manufacturing.

“ I have attended every ARM Institute meeting since the first one. The most valuable element is talking with others that are involved with working on projects and those with tangible problems in leveraging robotics in their factories. You just cannot replace those interactions.

—Matt Robinson, Program Manager, ROS-Industrial

# Bioindustrial Manufacturing and Design Ecosystem



BioMADE, the Bioindustrial Manufacturing and Design Ecosystem, is securing America's future through biomanufacturing innovation, education, and collaboration.



**Consortium Organizer:** Bioindustrial Manufacturing and Design Ecosystem

## Institute Enables

- Reducing barriers to scaling-up and commercialization for bioindustrial manufacturing, and lowering risk in relevant infrastructure investments
- Accelerating the commercialization of modern biotechnology products
- Creation of domestic supply chains for important materials by focusing on the pilot-scale Manufacturing Readiness Levels
- Building the workforce of the future by pairing industry-driven competencies with program development



“ BioMADE's dedication to innovation in bioindustrial manufacturing has allowed Amyris to take on ambitious technology process development projects to benefit the bioeconomy at a fraction of the ordinary cost, with exponentially faster speed.

–Paul Hill, Senior Vice President for Process Development & Engineering, Amyris



BIOMADE.ORG

**Headquarters:**  
Twin Cities, MN  
Emeryville, CA

**Established:**  
October 2020

**Members:**  
160

**Funding:** \$87M Federal  
\$187 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Advancing Biobased Separation:** BioMADE partnered with a team at University of Illinois Urbana-Champaign to develop a system of selective polyelectrolyte membranes to be used as the basis for electrochemical purification of organic acids, an important family of compounds produced via bioindustrial manufacturing. While this is very early-stage research, it may result in a substantial reduction of the cost and energy consumption associated with purifying organic acids from fermentation broth. If these systems prove to be exquisitely tunable, they may result in complex flow networks that can be used to separate wide arrays of compounds from water and collect single or small mixes of related compounds in much the way the petroleum industry uses complex distillation systems to isolate specific products.

**Domestic Rubber Production:** BioMADE is working with Goodyear and Farmed Materials to develop a domestic source of natural rubber from a specific species of dandelion. Natural rubber has been classified as a strategic raw material that serves as a critical ingredient in military, aircraft, and truck tires. Today, more than 90 percent of the world's natural rubber is made from latex derived from rubber trees and is primarily sourced from tropical locations outside of the U.S. Having a domestic source of natural rubber could significantly reduce U.S. reliance on overseas sources and strengthen our strategic posture.



## WORKFORCE DEVELOPMENT

**Community College Equipment Donations:** BioMADE worked with member Scientific Bioprocessing, Inc. to coordinate the donation of free bioprocessing equipment to community colleges. This equipment donation will have a significant impact on community and technical colleges that are educating and training the next generation of the workforce. The equipment – valued at up to \$368,000 – will bring real-time solutions to biomass monitoring and bioprocessing technology training in community college classrooms nationwide. Partnerships like this will help cultivate a diverse and deep talent pool for the bioindustrial manufacturing sector at large.

**Hosted Biomanufacturing Workforce Summit:** BioMADE hosted a National Capacity Building for Advanced Biomanufacturing Workforce Summit in partnership with Skyline Community College and Solano Community College with support from the National Science Foundation. Attendees identified strategies to address current and future bioindustrial manufacturing workforce needs and discussed new approaches and shared resources to enhance the bioindustrial manufacturing workforce.

“ I anticipate this is the first of many fruitful partnerships between Rice and BioMADE as the global biomanufacturing and biotechnology industry continues to experience unprecedented growth, leaning into key areas of expertise of our faculty and research programs.

–Paul Cherukuri, Chief Innovation Officer, Rice University



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Convening the Bio Industry:** BioMADE held its first member meeting in June 2022 with 214 attendees. Secretary of Agriculture Tom Vilsack provided comments about the important work of BioMADE and its members, and DoD leadership offered remarks on DoD's plan and partnership with BioMADE. Eric Schmidt, founder of Schmidt Futures and former CEO of Google, announced a special project call on bioreactor innovation. Large industry, startup companies, academia, and government attended the various meetings, speeches, and panels regarding the bioindustrial market and future. Government personnel hosted a marketplace session that allowed DoD to inform members of current DoD needs and project plans in the coming future.

**Aligning the Bio Industry with DoD:** BioMADE convened a working group of industry, government, academic, and non-profit representatives to identify areas of overlap and areas needing clarification between Manufacturing Readiness Levels (MRL) and BioMRLs. From those meetings, BioMADE developed a paper describing the DoD's use of MRLs in terms of bioindustrial manufacturing to help BioMADE's ecosystem translate their development work to the MRL scale. The BioMRL manuscript was published in pre-print after peer review in the Society for Industrial Microbiology journal.

PowerAmerica is a member-driven consortium of industry, universities, and national labs accelerating the commercialization of energy efficient power semiconductor technologies.



Consortium Organizer: North Carolina State University

## Institute Enables

- A network that spans the wide bandgap technology ecosystem of
  - Materials providers
  - Device developers
  - Power electronics fabrication facilities
  - Electronic module manufacturers
- Educational programming for graduate and undergraduate university students and working professionals
- Tutorials, short course, and hands-on laboratory training for the semiconductor-manufacturing workforce

Combined  
**3 GaN** Chips  
in EV Module  
Switch

**130+**  
Annual  
Short Course  
Participants

High-power  
Density,  
**3.3 kV Power  
Module**

**INSTITUTE  
@WORK**

“ PowerAmerica has advanced John Deere's wide bandgap power electronics R&D work by more than five years.

–Brij Singh, Senior Staff Engineer, John Deere



POWERAMERICA  
INSTITUTE.ORG

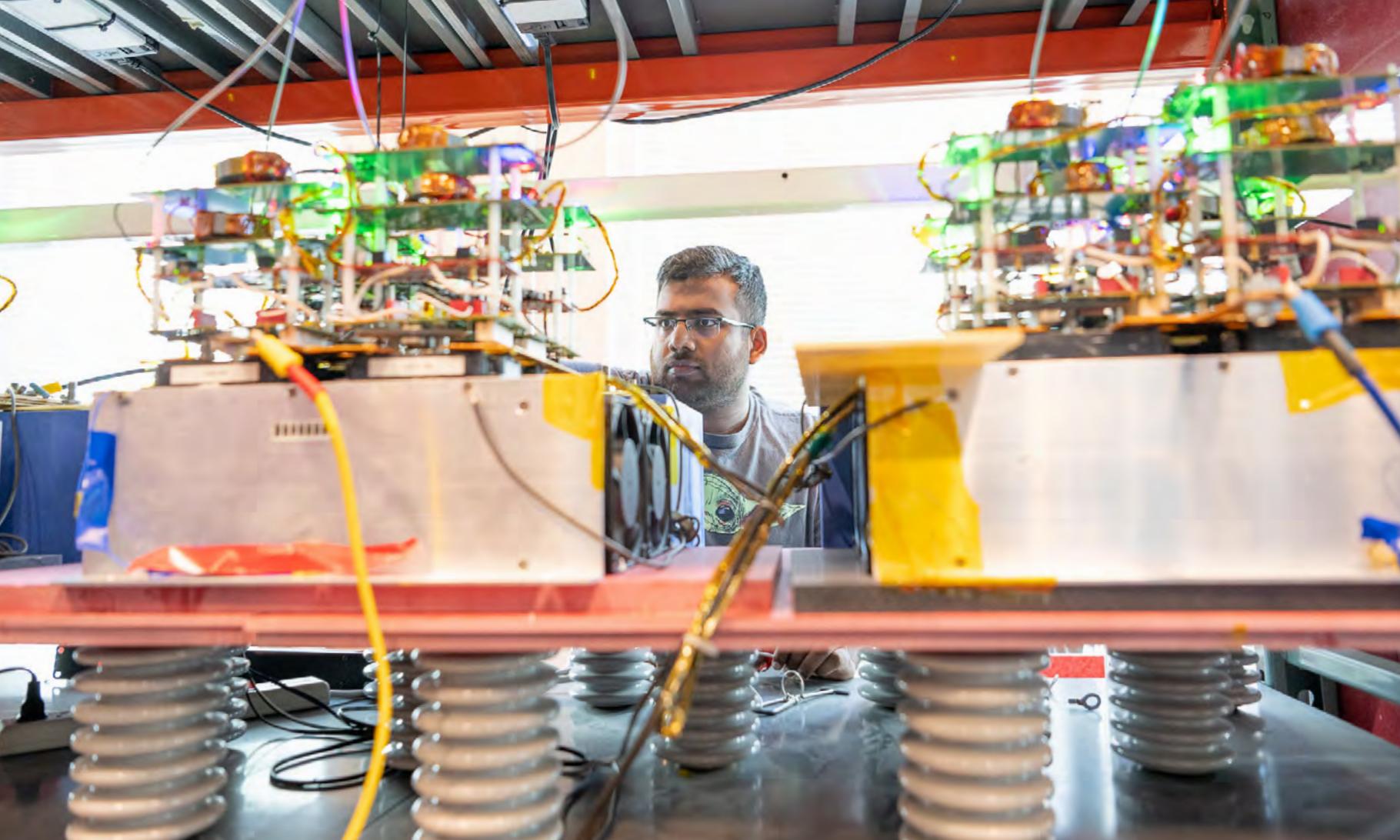
Headquarters:  
Raleigh, NC

Established:  
January 2015

Members:  
90

Funding: \$70M Federal  
\$76 Non-Federal  
from 2015 – 2021\*

\*Funding from April 2021 to 2022 non-Federal (membership dues): \$1.7M



## TECHNOLOGY ADVANTAGE

**Innovative Processes for High Power Applications:** Electric vehicle and other renewable applications require 650 V modules at very high current ratings. Implementing electric vehicle modules with GaN chips lowers CO<sub>2</sub> emissions due to their higher efficiency. Combining three chips in each module switch, and then testing/validating the modules operating in parallel allows for efficient high-power applications. This approach overcomes material, electrical, and thermal challenges for reliable operation of high power GaN modules. Energy efficient applications like electric vehicles and power supplies benefit from this technology. GaN module insertion in electric vehicles is a mass volume application with significant CO<sub>2</sub> emission reductions due to high efficiency. Soon the team from General Electric, North Carolina State University, and the National Renewable Energy Lab will push for the demonstration of three modules operating reliably in parallel to get to 1350 ampere output achieving a less than 5% current sharing deviation.



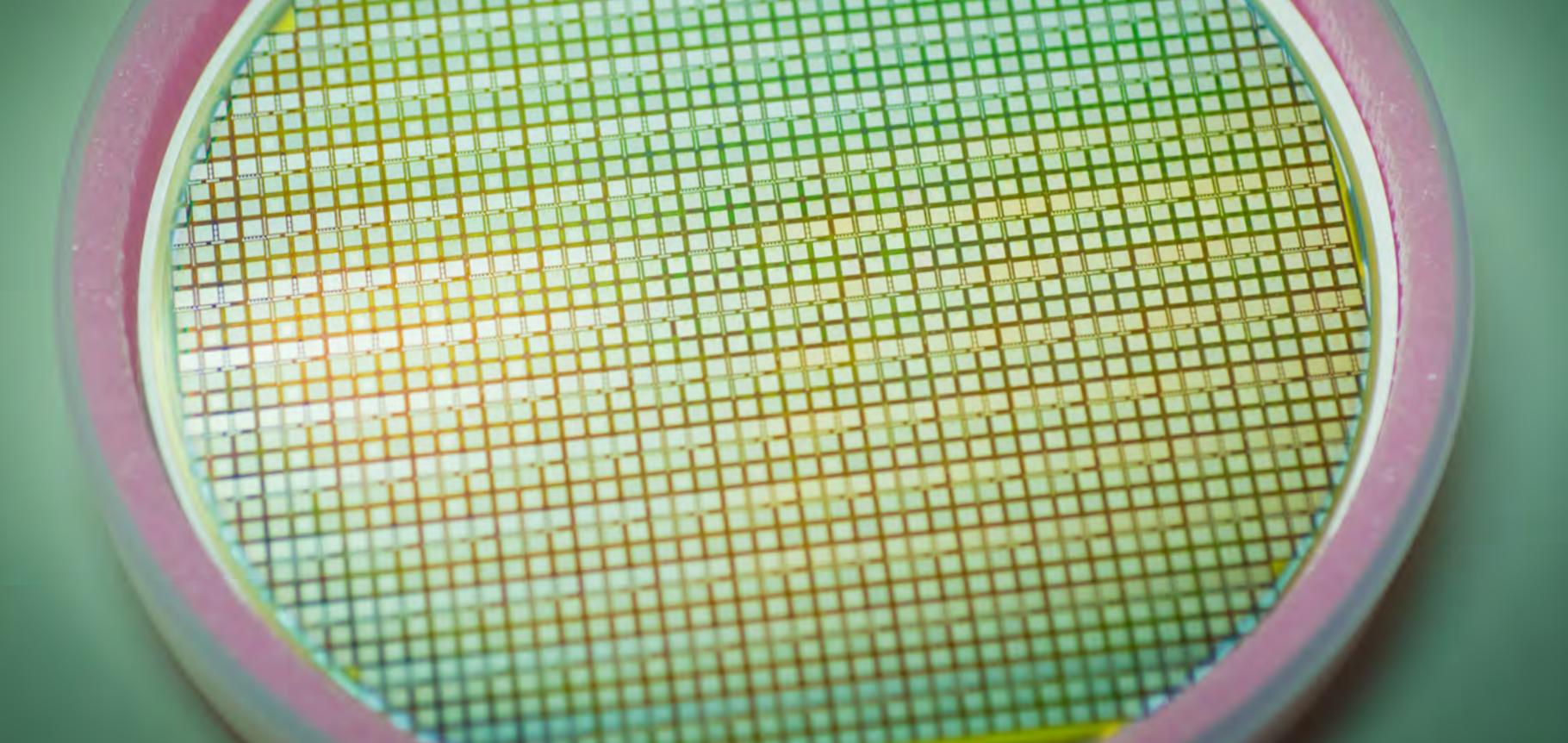
## WORKFORCE DEVELOPMENT

**Wide-Bandgap Short Course:** This two-and-a-half day course provides in-depth learning on all the facets of semiconductor chip manufacturing. Course instructors from more than a dozen universities and companies provide a strong mix of applied academic and industrial expertise. The annual Short Course attracts more than 130 working professionals, university faculty, and graduate students each year. As the technology evolves, the course instructors adapt the topics and course materials to teach the latest developments. formation, use of updated skill standards, as well as lab protocols for viral delivery system production and analysis.

“ Membership in PowerAmerica provides Texas Instruments (TI) the opportunity to influence the important research being done in wide bandgap technology.

—Stephanie Watts Butler, GaN Technology Innovation Architect, Texas Instruments

*Credit: PowerAmerica/NIST*



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**GE Aviation Systems, National Renewable Energy Lab:** GE collaborated with the National Renewable Energy Lab (NREL) in the development of its 1.7-3.3 kV power modules. NREL has world class facilities and expertise in thermal modeling, analysis, and design of thermal management for complex, power electronic systems. With NREL's assistance, GE developed and commercialized a high-power density, compact 3.3 kV power module for medium voltage industrial power applications.

**U.S. Naval Research Lab and North Carolina State University Collaboration:** North Carolina State University has extensive experience in the development of advanced power systems. The U.S. Navy must be able to operate anywhere in the world and connect to shore systems of varied specifications. NC State faculty utilized the core design of a medium voltage microgrid power control system and adapted it for use as a ship-to-shore power conversion system for the Navy. The system is built into a transportable shipping container and can condition the power flow from a 10 kV power ship system. The system is currently in testing at Port Hueneme naval base in California.



**PowerAmerica has been a great partner to Navitas in creating a next-generation high efficiency, high-density fast charger for mobile devices. This success would not have been possible without their financial support, vision for WBG devices and industrial and academic connections.**

–Gene Sheridan, CEO, Navitas

# Institute for Advanced Composites Manufacturing Innovation



IACMI – The Composites Institute is a 120+ member community of industry, academia, and government agencies leading the adoption of advanced composites in U.S. manufacturing.



**Consortium Organizer:** Collaborative Composite Solutions Corporation, a not-for-profit corporation under the University of Tennessee Research Foundation

**Satellite Locations:** IACMI Scale-Up Research Facility (Detroit, MI); Michigan State University Composites Lab (Lansing, MI); University of Dayton Research Institute's Composites Laboratory (Dayton, OH); The Composites Manufacturing Education and Technology Facility at the National Renewable Energy Laboratory's Flatirons Campus (Boulder, CO); The Indiana Manufacturing Institute at Purdue University (West Lafayette, IN); The University of Tennessee's Fibers and Composites Manufacturing Facility (Knoxville, TN); Oak Ridge National Laboratory (Oak Ridge, TN); Vanderbilt University's Laboratory for Systems Integrity and Reliability (LASIR) (Nashville, TN); The University of Kentucky Center for Advanced Energy Research (Lexington, KY)

## Institute Enables

- Greater deployment of advanced composites that provide strength and stiffness while being very lightweight
  - advantageous for many transportation, energy, and infrastructure applications
- Online and in-person training sessions designed to address the nation's critical manufacturing skills gap and improve productivity competitiveness

More Options  
for **High-rate  
Hybrid Molded  
Structures**

**3,500+**  
Student and  
Industry  
Trainees

SUV  
Liftgate Weight  
Reduced by  
**35%**

**INSTITUTE  
@WORK**



IACMI.ORG

**Headquarters:**  
Knoxville, TN

**Established:**  
June 2015

**Members:**  
122

**Funding:** \$10M Federal  
\$18 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**High-Speed Layup and Forming of Automotive Composite Components:** An IACMI thermoplastic tape layup project developed a system capable of increasing options for high-rate hybrid molded structures. The partnership through IACMI between DURAAutomotive Systems, Ford, BASF, Corporation, Michigan State University (MSU), and Purdue University enabled the development and demonstration of a composite sheet layup and consolidation process that can be commercialized for high-volume requirements. A composite seat design for a Ford vehicle utilizing fiberglass composite inserts instead of metal inserts to reduce the seat weight and increase strength was shared with mold suppliers for quoting & evaluation. A preferred vendor with past composite tape experience with larger injection molded parts was selected to design and fabricate the injection molds for this project.



IACMI provides us with leadership and access to the entire supply chain through projects with a complete lifecycle perspective. The broad network and vast resources within the institute bridge the gap for collaboration across industry, academia, and national laboratories.

—Rani Richardson, Aerospace & Defense Industry Technical Program Director at Dassault Systèmes



## WORKFORCE DEVELOPMENT

**America's Cutting Edge Machine Tool Technology Training Program:** America's Cutting Edge (ACE) showed impressive growth nationally in 2022. This IACMI-led workforce training program with DoD is designed to address the nation's critical manufacturing skills gap and improve productivity competitiveness. More than 3,500 student and industry participants in all 50 states have enrolled in the online training component. Nearly 300 participants have completed weeklong in-person training sessions. In 2022, IACMI expanded from a single test-bed site in Knoxville with education partners at the University of Tennessee (UT) and Pellissippi State Community College to more than 15 machine tool training centers across the country. In addition to UT, education partners now include North Carolina A&T State University, Texas A&M Engineering Experiment Station, Marshall University's Robert C. Byrd Institute, and the University of Florida, along with a network of regional community college partners – all offering in-person training. The program empowers manufacturers to adopt cutting-edge machine tool programming and technology for composites and metals. Using novel workforce training and education initiative helps manufacturers, particularly small and medium manufacturers, successfully deploy and implement modern tooling technology and sensors, enabling them to compete in today's evolving economy. ACE is supported by DoD's Industrial Base Analysis and Sustainment Program from the Office of Industrial Policy. Machining and machine tools are at the foundation of America's manufacturing capability and global competitiveness.

*Credit: IACMI*



## RESILIENT AND INNOVATIVE ECOSYSTEMS

Now in its eighth year, the power of IACMI is its unparalleled network, including innovation partners and shared infrastructure to “convene, connect, and catalyze” the U.S. composites industry. The development and efforts of IACMI have resulted in a world-class model that is accelerating the research, development and validation of new materials and processes, and EWD programs – all while providing a strong framework for collaboration through the entire composites supply chain.

IACMI and its resilient network are reshaping the future and the material innovation that addresses the lifecycle of composite products. With the help of IACMI members, Volkswagen developed a polymer composite solution that cut the weight of an SUV liftgate by 35% at a cost equal to or lower than steel. IACMI-inspired start-up Endeavor Composites teamed up with IACMI members Carbon Rivers and the University of Tennessee to develop a solution for recycling composite wind blades at end of life. Commercialization efforts are going so well that Endeavor Composites expects to grow from a 10-person operation to more than 100 employees in five years.

# Clean Energy Smart Manufacturing Innovation Institute



CESMII is committed to transforming the U.S. manufacturing market through increased energy productivity and global competitiveness via the application of smart manufacturing (SM) technologies.



**Consortium Organizer:** University of California at Los Angeles

**Satellite Locations:** North Carolina State University; Rensselaer Polytechnic Institute; University of California, Los Angeles; Purdue University; Pennsylvania State New Kensington Digital Foundry; Feyen Zylstra, Inc.; and Case Western Reserve University.

## Institute Enables

- Smart manufacturing adoption through the integration of advanced sensors, platforms, and controls
- Improvements in areas such as quality, throughput, costs and profitability, safety, asset reliability, and energy productivity
- Development of education modules and resources for an accredited Bachelor of Science degree program in Smart Manufacturing. Additional new projects are focused on workforce upskilling, credentials, and community college level education resources



“ We needed digital transformation expertise for our business, and CESMII put us in touch with Flexware Innovation. We never would have found them without CESMII.

—James Lawrence, Plant Manager, ECM Performance Materials Group



CESMII.ORG

**Headquarters:**  
Los Angeles, CA

**Established:**  
January 2017

**Members:**  
157

**Funding:** \$13M Federal  
\$16 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Using Smart Manufacturing to Enable Energy-Efficient Manufacturing of Pharmaceutical Products:** Significant market opportunity exists for the development of smart manufacturing (SM)-based platforms to produce pharmaceutical tablets, capsules, and other forms of medicines. Through a combination of advanced modeling, sensing and analytical methods, a project by Rutgers University with its pharma industry collaborators developed and integrated SM Innovation Platform tools to improve energy productivity and reduce the energy intensity of manufacturing a pharmaceutical tablet via wet granulation. The solution established advanced process models that combined process and product output and energy metrics for both batch and continuous wet granulation processes. Project results include significant reduction in energy, cost savings, and improved yield. For example, the optimized continuous process realized an 83% energy reduction.

Additionally, different front-end tools for data collection, model construction, and result visualization were integrated together into the developed front-and back-end framework, where the information could be communicated from front-end to the back-end MATLAB scripts for further analysis and simulation, and the simulation results pushed to front-end for visualization. This connection included table extension architecture interfaces, process parameter selection, and optimization results. The framework can be applied to both batch and continuous processes. Thirdly, the Rutgers team performed process optimization to reach a significant reduction in energy consumption while keeping the product capacity and quality within specified ranges for both batch and continuous cases. Moreover, these cross-cutting innovations could directly be adapted to other manufacturing industries like biologics, food, specialty chemicals, and more for overall energy and cost savings.



## WORKFORCE DEVELOPMENT

### **Smart Manufacturing for Small and Medium Size Manufacturers in a Predominantly Hispanic Workforce Region:**

University of Texas at El Paso worked with a group of regional industry, government, and academia partners including the Texas Manufacturing Assistance Center (TMAC), Becton, Dickinson and Company, Schneider Electric, Workforce Solutions Borderplex, Delfingen, and Keats. The team created a SM curriculum that represented use cases needed by the region's industry and a certificate program to increase SM skills across a region with a high Hispanic representation in the workforce. The project produced multiple seminars, workshops, and the first wave of 125 student participants through the developed five courses. The program will teach Smart Manufacturing technologies to about 150 students each year at the university and 250 students at local STEM-focused high schools.

“ Being a part of CESMII gives us access to a network of smart manufacturing technologies and users that can provide valuable insights and direction around technology development and education and training needs in the industry.

–Sherri McCleary, Executive Director, Digital Foundry at New Kensington (Penn State)



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Resilient and Innovative Ecosystems:** Smart Manufacturing Innovation Centers are a network of seven industry-centric centers of excellence throughout the U.S. focused on leading that industry's ecosystem in the field of Smart Manufacturing. They enable access to small, medium, and large businesses, connecting manufacturing assets to the SM Innovation Platform, national policy development, industry awareness, and workforce development. In FY 2022, CESMII added four Smart Manufacturing Innovation Center locations and seven satellite locations.

The Smart Manufacturing Innovation Centers represent a powerful ecosystem of manufacturing assets connected to a common Innovation Platform which provides CESMII members with a portfolio of EWD offerings to meet students' needs in their SM journey. The Smart Manufacturing Innovation Center team also increases CESMII's impact in underserved communities.<sup>8,9,10</sup>

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<sup>8</sup> North Carolina State University is ranked second in the U.S. among non-HBCUs for the number of bachelor's degrees in engineering awarded to African American students according to *Diverse Issues in Higher Education*. Additionally, North Carolina State University is in the top ten of military-friendly schools among tier one research institutions according to *Military Friendly*.

<sup>9</sup> El Camino Community College was selected for an EWD project and as a Smart Manufacturing Innovation Center satellite to UCLA. El Camino Community College was recently named one of the nation's Top 100 Colleges and Universities for Hispanics by *The Hispanic Outlook on Education Magazine*.

<sup>10</sup> Penn State and Case Western Reserve University Smart Manufacturing Innovation Centers are in economically impacted regions, working to bring back manufacturers by developing skills in the workforce.

# Rapid Advancement in Process Intensification Deployment Institute



RAPID was created to lead the nation's efforts to research and develop high-impact MCPI solutions for the benefit of members from industry, academia, national laboratories, and other nonprofits.



## Institute Enables

- Industrial operations that are more energy-and raw material efficient and safer to operate
- Risk reduction by building and operating modular, smaller footprint systems designed to produce the amount of product needed to satisfy low volume demand at any time
- Readily scalable systems for high demand needs to meet these emerging market needs

**60%  
Cost  
Reduction**

**ChemE  
Cube  
Design  
Competition**

**Virtual  
Network  
of Testbed  
Facilities**

**INSTITUTE  
@WORK**

“ Being a RAPID member has allowed M. Davis to be at the forefront of innovative ideas and to be part of the solution to bring them to scale. By connecting members on the research side of the solution, RAPID has created a synergy that benefits everyone involved.

—Sean Boston, M. Davis & Sons, Inc.



AICHE.ORG/  
RAPID

**Headquarters:**  
New York, NY

**Established:**  
March 2017

**Members:**  
85

**Funding:** \$70M Federal  
\$94 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Innovative Sustainable Hydrogen Generation System:** RAPID member Southern California Gas Co. (SoCalGas), SunLine Transit Agency, and STARS Technology Corporation unveiled an innovative hydrogen generation system. The project will produce hydrogen from renewable natural gas to help fuel SunLine's hydrogen fuel cell electric buses. At scale, this demonstration project has the potential to provide clean hydrogen at any location adjacent to a natural gas pipeline, which will help reduce greenhouse gas emissions and accelerate California's climate and clean air goals.

RAPID is proud to have contributed to the success of this demonstration through RAPID Project 10.4 in which experts at Pacific Northwest National Laboratory and Oregon State University carried out a cost/manufacturability study on the piloted STARS technology for solar steam methane reforming. RAPID's leadership believes that the technology is an exciting achievement that has significant potential to contribute to a net-zero future and demonstrates the application and commercialization of both process intensification and modular processing concepts.

**Transformative Approach to Help Manufacturers Run Processes Faster, Cleaner, and at Reduced Cost:** RAPID is focused on breakthrough process intensification technologies involving oil and gas, pulp and paper, and various domestic chemical manufacturers. In one RAPID project, a team at the University of Pittsburgh worked with The Lubrizol Corporation, a global specialty chemicals company, to convert one of their key legacy processes for chemical dispersants from batch to continuous processing and incorporate the principles of modular process intensification. The project team succeeded in building a continuous process production module about the size of a shipping container, reducing capital by ~65%, reducing operating costs by ~60%, and eliminating all emissions and reducing atmospheric heat loss by a factor of 10.



## WORKFORCE DEVELOPMENT

**The New Competition Challenges Students to Manufacture Innovative Engineering Processes in a One-Foot Square-Cube:** Launched by RAPID in 2021, ChemE Cube is an undergraduate competition challenging student teams to design and manufacture a chemical process that fits in one-cubic foot capable of scaling up to tackle real-world engineering challenges – from providing clean drinking water to remote regions to removing carbon dioxide from the atmosphere and contributing to net-zero goals. Students are challenged to: solve real-world problems by designing a process using creative engineering solutions; demonstrate the ability to safely build and operate a complete process at a small scale using advanced manufacturing and intensified processing technology; and calculate and clearly communicate the ways in which industry could expand the process to meet required product demand and pitch the product's business case to a panel of industry judges. Seven teams competed in 2022, demonstrating their on-demand modular water purification devices and impressing judges with their technology solutions and shark-tank style pitches. The 2023 ChemE Cube Competition Powered by RAPID | ExxonMobil will involve a new technical challenge—Direct Air Capture to remove carbon dioxide from the atmosphere.

“ The RAPID Virtual Internship Program is an excellent way for students to learn about industrial research with a focus on process intensification. The student gains relationships within the industry while developing the skills required to be an attractive full-time employee.

—Paul Witt, Dow

Credit: RAPID



## RESILIENT AND INNOVATIVE ECOSYSTEMS

**Virtual Process Development Testbed Network Facilitates Institute Collaboration:** RAPID has developed a virtual network of testbed facilities for use in development, testing, scale-up, and proof-of-concept demonstration of process intensification and modular process technologies. Starting in 2019, RAPID identified and assessed existing process development capabilities, including bench, pilot, and demonstration scale equipment and process systems, in universities, research institutes, government laboratories, and for-profit companies. The database has been disseminated to members for use in current and future RAPID-related process technology deployment work through an online catalog.

# Reducing Embodied-Energy and Decreasing Emissions



The REMADE Institute brings together industry innovators, academic researchers, and national labs to enhance the nation's industrial competitiveness and lead the transition to a circular economy.



**Consortium Organizer:** Sustainable Manufacturing Innovation Alliance, Inc.

## Institute Enables

- The U.S. transition to a circular economy by tackling barriers that limit the recovery, reuse, remanufacturing, and recycling of metals, fibers, polymers, and electronics
- Extension of product lifecycles in several industries:
  - automotive
  - consumer products
  - electronics heavy-duty equipment
- Development of unique and valuable course content for industries across the U.S. to improve sustainable manufacturing and accelerate the transition to a circular economy



“ There's such value in the research projects and access to funding, especially as a small business. Being able to leverage REMADE as a vehicle to go from R&D concepts all the way through to a commercial solution will continue to be a valuable asset to Solvus.

—Sean Kelly, Co-Founder & COO, Solvus Global



REMADE  
INSTITUTE.ORG

**Headquarters:**  
Rochester, NY

**Established:**  
May 2017

**Members:**  
156

**Funding:** \$70M Federal  
\$70 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Sustainable Shoe Manufacturing:** During the production of shoe midsoles, manufacturers mold crosslinked ethylene vinyl acetate (EVA) foam, which produces midsoles that provide the desired cushioning. Unfortunately, the molding process generates up to 30% scrap, and the permanent crosslinks cannot be re-processed, significantly limiting the recyclability of production scrap. The project team is redesigning the EVA foam material to maintain the desired properties while allowing the material to be re-processed. This means the scrap from manufacturing can be reused in the process. The technology is being validated on a bench scale and prototypes are being tested. Production trials will be conducted on a pilot scale by Allbirds. With billions of shoes produced globally each year, this process has widespread applicability and will allow manufacturers to increase their use of EVA scrap during shoe midsole manufacturing from 15% to 30%, saving material, energy, and emissions.

**Finding New Life for Retired Aircraft:** With more than 2,000 retired aircraft parked in the desert and another 12,000 retiring over the next 20 years, the aerospace aluminum contained in these planes has significant value. However, aerospace aluminum scrap rates are limited to about 20% due to the limitations of casting defect-free complex shapes using this scrap. This project developed and demonstrated a process to enable the reuse of aerospace aluminum scrap for production of high-performance automotive castings. By the end of this 18-month project, the team was able to cast defect-free engine cylinder heads at a commercial foundry and is disseminating the technology to the automotive industry.



## WORKFORCE DEVELOPMENT

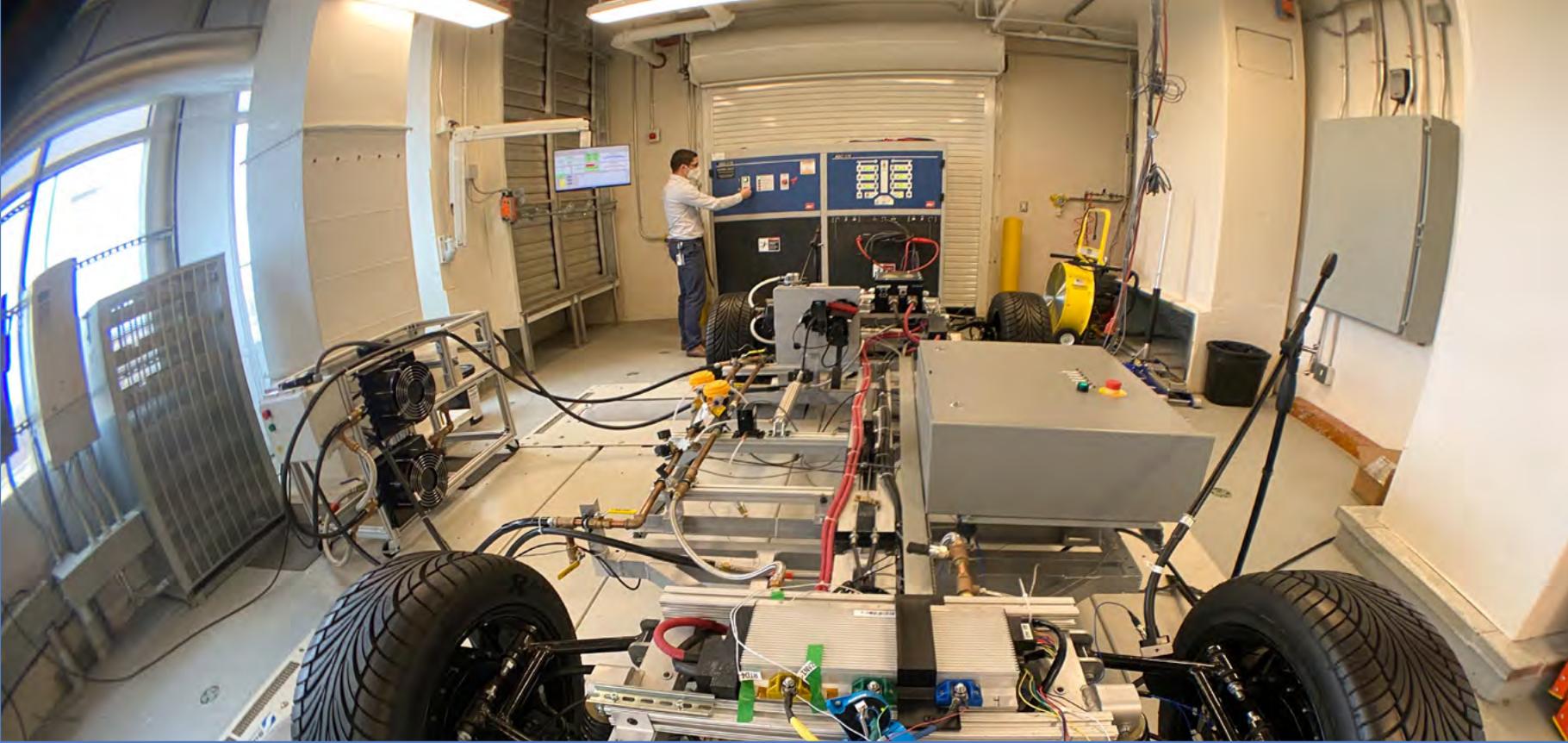
**Education for a Circular Economy:** REMADE's position at the crossroads of academia, industry, and government enables the institute to draw from the nation's top subject matter experts to create training opportunities tailored to the needs of industry for emerging and incumbent engineers and technicians.

With courses as diverse as *Additive Repair Technologies for Remanufacturing*, *Chemical Recycling for Plastics*, *Product Design Considerations*, and *End of Life Recovery for a Circular Economy*, REMADE is developing unique and valuable content for industries across the U.S. to improve sustainable manufacturing and accelerate the transition to a more circular economy.

**REMADE Academy**  
offers more than  
**70 Hours**  
of unique  
training content

**3,300+ Individuals**  
have taken part in the  
**REMADE Academy**  
tiered certificate  
pathways, short courses,  
and project webinars

*Credit: REMADE/NIST*



## RESILIENT AND INNOVATIVE ECOSYSTEMS

REMADE has created an ecosystem where industry, academia, national labs, and trade organizations share information, exchange ideas, trade best practices, foster technological development, and promote the deployment of technologies to advance the nation's transition to a Circular Economy. In this ecosystem, cross-industry collaboration is key. Cross-industry partnerships develop new technologies, drive the expansion of domestic markets, and develop new sources of high-quality materials.

At REMADE, 50% of industry members are classified as small and medium-sized businesses. One such company, a small electronics recycler in upstate New York, is collaborating with researchers at the University of Pittsburgh and Idaho National Laboratory to help them develop and commercialize technology. Elements of success from the REMADE Ecosystem include:

- 20% membership growth in 2022 and 98% retention rate.
- Members include industry powerhouses with the scale to develop and commercialize new technology, including companies such as Michelin, Nike, Braskem, Adidas, Dow Chemical, Caterpillar, John Deere, BASF, Alcoa, Unilever, Ford Motor Co., Allbirds, and more.
- Trade organizations, nonprofits, and affiliates expand REMADE's sphere of influence to more than 4,000 entities across the U.S., including the Institute of Scrap Recycling Industries, the American Chemistry Council, the American Forest & Paper Association, the Aluminum Association, and more.
- The consortium includes academic partners with a track record of innovation such as Rochester Institute of Technology, University of Illinois-Urbana Champaign, Yale University, Massachusetts Institute of Technology, Georgia Tech, Michigan State, Penn State, Ohio State, University of Michigan, and more.

# Cybersecurity Manufacturing Innovation Institute



The Cybersecurity Manufacturing Innovation Institute (CyManII – Cī-man-ē) was launched by the Department of Energy in 2020 to embed cybersecurity in energy efficient manufacturing.



**Consortium Organizer:** University of Texas at San Antonio

**Satellite Location:** Arlington, VA

## Institute Enables

- Defense-oriented architectures to secure the digital thread in connected manufacturing systems
- Technologies to support long-term security and decarbonization of U.S. manufacturing
- Embedding cybersecurity in energy efficient manufacturing
- Understanding the evolving cybersecurity issues that threaten U.S. manufacturers
- A cyber-informed workforce across U.S. manufacturing



“ At GE, we are driving a new age of industrial AI and digital transformation. Through our close collaboration with CyManII, we are developing the transformative and open defense-oriented architectures required to meet this challenge.

–Colin Paris, Vice President Software Research, GE



[CYMANII.ORG](https://CYMANII.ORG)

**Headquarters:**  
San Antonio, TX

**Established:**  
Date, 2020

**Members:**  
42

**Funding:** \$18M Federal  
\$15 Non-Federal\*

\*Planned from 2017-2022



## TECHNOLOGY ADVANTAGE

**Saving Energy with Secure Digitization:** The average cost of a cyber-attack to a company is nearly \$3.2 million. The manufacturing industry is the most targeted sector due to the rapid rate of digitization and the under-realized value of cybersecurity prevention, particularly among small and medium-sized manufacturers. Current innovations at CyManII in collaboration with GE Research (Niskayuna, NY), Dynics (Ann Arbor, MI), and Humtown (Youngstown, OH) have demonstrated both increased security and energy savings of around 10% (in select industry sectors) while significantly reducing the number of cyber-attacks. In an early demonstration, using legacy equipment, impacts include a 13% reduction in energy use while lowering cyber-attacks from 27 to zero—accomplished by introducing defense-oriented architectures that eradicated, rather than patched, software vulnerabilities.

These innovations expect to benefit manufacturers through energy savings of at least 10%. Collectively, these savings are anticipated to yield a quad of energy savings and \$1 billion in avoided costs. The institute next plans to demonstrate these technologies within business environments that represent critical manufacturing sectors, such as additive manufacturing, power generation, and small businesses undergoing digitization efforts.



## WORKFORCE DEVELOPMENT

**CyManII Training Module Development:** The institute's workforce training is specifically designed to train manufacturing and industry professionals with cybersecurity skills including, but not limited to, technical and operational management, information technology and operational technology technicians, operational technology asset managers, equipment developers, and operational technology maintenance technicians. To meet learners where they are, programs are focused on training modalities that include gamification using a cyber range, online and self-paced modules, and in-person training classes.

**Expanding Access and Reach of Cybersecurity Training:** Through in-house training and strategic partnerships, the institute aims to train one million workers and students in cybersecurity skills. CyManII has also been tasked with providing cyber training to all 255,000 University of Texas System students. The program was developed with University of Texas at San Antonio, University of Texas at El Paso, and the Cyber Readiness Institute. The pilot reached nearly 1,000 students, and the full program will roll out to all UT system campuses beginning in 2023. Additionally, using non-federal funds, the institute launched the Cybersecurity for Manufacturing (C4M) hub, which will serve as a training platform (along with a mobile cyber training vehicle) that targets the underserved population of South Texas.

**The availability of a skilled cybersecurity workforce poses one of the greatest challenges to manufacturers. The U.S. needs approximately 1.2 million people skilled in cybersecurity, but only 436,080 of those jobs are able to be filled with skilled workers<sup>11</sup>.**

*Credit: CyManII/NIST*

<sup>11</sup> (ISC)2 (2022), Cybersecurity workforce study, <https://media.isc2.org/-/media/Project/ISC2/Main/Media/documents/research/ISC2-Cybersecurity-Workforce-Study-2022.pdf?rev=1bb9812a77c74e7c9042c3939678c196x>



## RESILIENT AND INNOVATIVE ECOSYSTEMS

CyManII brings together large OEMs, suppliers, U.S. national labs and world-class research organizations through its tiered membership strategy. An agile approach to innovation puts these stakeholders to work via daily SCRUM team meetings, where they focus on small problem subsets and pursue minimum viable products. A hyper-distributed membership and remote project management allows the institute to draw upon cutting-edge innovators and leaders in the fields of advanced manufacturing and cybersecurity from across the country. This strategy has allowed CyManII to make rapid progress on fundamental technology challenges, while still maintaining a deep connection to industry needs.

Next, institute research aims to demonstrate these innovations in real-world manufacturing environments through industrial use cases, moving from low-TRL (technology readiness levels) research to mid-TRL demonstrations with company champions to host and facilitate the integration.



**Partnering with CyManII has elevated the San Antonio Chamber of Commerce's understanding of what small businesses need when it comes to cybersecurity. With such a large community of small defense contractors in San Antonio, our partnership has been critical in helping to secure critical supply chains and build a more resilient community.**

—Jeff Fair, Vice President Cybersecurity & Economic Development, San Antonio Chamber of Commerce

# APPENDIX A

## Manufacturing USA Metrics Map and Performance Metrics Data

### MEASURING MANUFACTURING USA PROGRAM PERFORMANCE

Manufacturing USA's performance metrics are periodically updated. The quantitative performance metrics measure progress toward overall Manufacturing USA program objectives, as shown in Table 1. Each metric category provides information for tracking progress toward four interrelated high-level goals<sup>12</sup> based primarily on legislative program purposes.<sup>5</sup> Current metrics are compared with FY 2021 figures in this report (Tables 2 and 3).

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 1. 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				

<sup>12</sup> *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>

This whole-of-America approach is catalyzed and led by the Manufacturing USA institutes. The public-private partnerships at the institutes represent all the participants in the U.S. industrial base. Last year, the institutes collectively had more than 2,500 members, continuing the institutes' steady membership growth of 7-12% annually. Approximately 63% are manufacturers, nearly 72% of which are small and medium-sized companies. Other members include community colleges, major research universities (representing 22% of members), and state and local economic development entities (15% of members). Together, institutes and their members work together to develop and advance new products, processes, and workforce skills.

Table 2. Technology and Program Development Performance Metrics – 16 Institutes			
Specific Metric	Unit of Measure	FY 2021	FY 2022
<b>Metric Category 1 – Impact to U.S. Innovation Ecosystem</b>			
Organizations with institute membership agreements	Total number of memberships	2,320	<b>2,572</b>
Diversity of member organizations	Number of large manufacturers (each with more than 500 employees)	407	<b>436</b>
	Number of small manufacturers (each with 500 or fewer employees)	1,053	<b>1,177</b>
	Number of academic members (universities, community colleges, etc.)	516	<b>568</b>
	Number of other entities (government members, government laboratories, not-for-profits, etc.)	344	<b>330</b>
<b>Metric Category 2 – Financial Leverage</b>			
Federal investment	Federal base funding in the fiscal year	\$127M	<b>\$109M</b>
Co-investment	Cost-share expended and federal funding not part of the base federal funding in fiscal year	\$314M	<b>\$307M</b>
Total expenditure	Total institute expenditures in fiscal year	\$481M	<b>\$416M</b>
<b>Metric Category 3 – Technology Advancement</b>			
Active research and development projects	Number of ongoing projects	708	<b>678</b>
Key project objectives met	Percentage of key project milestones met	82%	<b>85%</b>

Institutes and their members and workforce development partners target diverse and underserved populations to bring opportunities to all Americans interested in manufacturing careers. They also develop curricula and certificate pathways in specific technology fields in response to and in collaboration with industry needs. In FY 2022, more than 106,000 workers (including veterans and those impacted by the pandemic), students, and educators participated in institute workforce programs – either virtually or through a hybrid approach.

**Table 3. Education and Workforce Development (EWD) Performance Metrics – 16 Institutes**

Metric	Unit of Measure	FY 2021	FY 2022
STEM activities	Total number of students participating in institute projects or internship programs and training	67,115	79,229
	Workers completing a certificate, apprenticeship, or training program	14,676	23,059
Educators and trainers	Teachers or trainers completing institute-led training	5,610	4,037
<b>Total number of EWD participants</b>		<b>87,410</b>	<b>106,325</b>
Source of funding for institute EWD projects or activities	<b>Base-funded projects:</b> base federal funding from the original cooperative agreement or technology investment agreement	87	43
	<b>Commercial-funded projects:</b> support provided from industry, regardless of membership status	9	22
	<b>Federal agency-funded projects:</b> resourced from federal funding outside the base Cooperative Agreement (CA) or Technology Investment Agreement (TIA) funding	44	44
	<b>State-or locally-funded projects:</b> resourced from state or municipal government funding	23	26
	<b>Other funded projects:</b> resourced from philanthropic organizations, nonprofits, foundations, or associations	29	19
<b>Total number of EWD projects and activities operated by institutes*</b>		<b>192</b>	<b>142</b>
Funding amount expended for EWD projects and activities	<b>Base funding expended:</b> resourced by institute using base federal funding from the original CA or TIA	\$10.75	\$8.7M
	<b>Commercial expenditures:</b> provided by industry, regardless of membership status	\$1.39M	\$2.3M
	<b>Federal agency expenditures:</b> resourced from federal funding outside the base CA or TIA funding	\$12.46M	\$22.3M
	<b>State or local funding expended:</b> resourced from state or municipal government funding	\$1.41M	\$4.9M
	<b>Other expenditures:</b> resourced from philanthropic organizations, nonprofits, foundations, or associations	\$1.66M	\$2.1M
<b>Total expenditures for EWD projects and activities</b>		<b>\$27.68M</b>	<b>\$35.4M</b>

\* 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.

## APPENDIX B

# Advanced Manufacturing National Program Office Interagency Working Team Participants, FY 2022

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### Advanced Manufacturing National Program Office

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#### Robin Fernkas (Sponsor)

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### National Science Foundation

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# APPENDIX C

## Federal Agencies Participating in Manufacturing USA

### Department of Commerce



The U.S. Department of Commerce (DOC) mission is to create the conditions for economic growth and opportunity for the nation. DOC more broadly increases regional and national capacity for innovative manufacturing through partnerships with state and local governments, academic institutions, and the private sector. Through its convening power, regional economic-development programs, and statistical and economic analysis, it empowers industry-driven solutions to the shortage of in-demand skills. Finally, DOC supports research and development leading to transformative changes in technology and promotes intellectual-property policy that supports and protects innovation. By all these means, the DOC helps accelerate technology development and strengthen the nation's position in the global competition for new products, new markets, and new jobs.

### National Institute of Standards and Technology



The DOC's National Institute of Standards and Technology (NIST) is the only research laboratory in the U.S. Government specifically focused on enhancing industrial competitiveness; its robust research portfolio is concentrated on the technical challenges associated with advanced manufacturing. NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life. In addition, the Manufacturing Extension Partnership National Network is a critical resource for engaging small and medium-sized manufacturers to develop new products, expand into global markets, and adopt new technologies, such as those being developed at the Manufacturing USA institutes.

The NIST Office of Advanced Manufacturing (OAM) helps to coordinate outreach in advanced manufacturing. The office works in partnership with other federal agencies to support the acceleration of U.S. innovation and to increase U.S. competitiveness in industrially relevant, cross-cutting advanced manufacturing products and resources. OAM is the headquarters and convener for the interagency Advanced Manufacturing National Program Office, coordinating with advanced manufacturing offices in the Department of Defense, Department of Energy, National Aeronautics and Space Administration, National Science Foundation, and the Departments of Education, Agriculture, Health and Human Services, and Labor to extend the impact of Manufacturing USA. Within NIST, OAM manages external outreach and provides federal financial assistance for ecosystem building initiatives such as technology roadmaps and public service awards for the Manufacturing USA network, and oversees the NIST-sponsored Manufacturing USA institute, NIIMBL.

### Department of Defense



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 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. The DoD established nine Manufacturing Innovation Institutes (DoD MIIs) through the Office of the Secretary of Defense Manufacturing Technology Program to help develop the technology and manufacturing ecosystems needed to support the Department of Defense's mission. 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 MIs 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 research and development 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, microelectronics, biotechnology, hypersonics, and autonomy, among other critical technology areas.

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 U.S. are manufactured in the U.S.

## Department of Education



The mission of the U.S. Department of Education is to promote student achievement and preparation for global competitiveness by fostering educational excellence and ensuring equal access. The Department of Education's Office of Career, Technical, and Adult Education (OCTAE) administers the Carl D. Perkins Career and Technical Education Act, the purpose of which is to develop more fully the academic and career and technical and employability skills of secondary education students and postsecondary education students who elect to enroll in career and technical education programs. OCTAE also administers Title II of the Workforce Innovation and Opportunity Act, the Adult Education and Family Literacy Act (AEFLA), the purpose of which is to help adults obtain the foundational skills they need to be productive citizens and enter and advance in the workforce. While playing a critical role in adult attainment of a secondary school diploma, AEFLA also supports adult learners to transition into postsecondary education and training through the use of career pathways.

## Department of Energy



DOE has two offices within the Office of Energy Efficiency & Renewable Energy (EERE), the Advanced Materials and Manufacturing Technologies Office (AMMTO) and the Industrial Efficiency and Decarbonization Office (IEDO), 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.

AMMTO provides planning, management, and direction necessary for a balanced program of research, development, demonstration, technical assistance, and workforce development to support domestic manufacturing that is critical to achieving a clean, decarbonized economy. While IEDO provides investments across a variety of activities including direct funding opportunities, knowledge-sharing consortia, funding to national labs, and prizes. By addressing energy related manufacturing challenges and reducing risk through merit-based research and development, adoption of AMMTO and IEDO-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.

## Department of Health and Human Services



The mission of the U.S. Department of Health and Human Services (HHS) is to enhance and protect the health and well-being of all Americans. The Department achieves this mission by providing for effective health and human services and fostering advances in medicine, public health, and social services. The HHS considers robust manufacturing to be critical to public health security and resilience in the U.S.

The Food and Drug Administration (FDA), an operating division within the HHS, is responsible for protecting public health by ensuring the safety, efficacy, and security of human and veterinary drugs, biological products, medical devices, our nation's food supply, cosmetics, and products that emit radiation. The FDA continues to support development of new tools, standards, and approaches to evaluate the advanced manufacturing of FDA-regulated products. The FDA also has several Working Groups that monitor the technology landscape and work closely with Manufacturing USA Institutes. Promising technologies 5 to 10 years in the future are explored by the FDA Emerging Sciences and Technology Working Group. Technologies that are ready for implementation and adoption are considered by the FDA Advanced Manufacturing Technologies Working Group. Furthermore, the FDA awards projects through the FDA's Broad Agency Announcement to support emerging and enabling technologies for advanced manufacturing. Several of the FDA product centers also have programs to facilitate and foster use of advanced technologies in medical products.

## Department of Labor



The U.S. Department of Labor's (DOL) Employment and Training Administration (ETA) is the principal workforce development agency in the federal government. ETA supports sustainable economic growth through leadership and a national investment portfolio that develops workforce skills necessary to support the jobs of today and is positioned to support the jobs of tomorrow, to the benefit of American job seekers and job creators. This portfolio includes significant investments in employment and workforce development solutions for diverse applicant types, including institutes and their partners.

ETA oversees a diverse portfolio of programs and services provided by the public workforce system, a network of federal, state, and local government-funded agencies and programs. The public workforce system delivers quality job opportunities and assistance in acquiring skills and credentials to workers and connects businesses with skilled workers to meet their workforce needs. Partnerships at the federal, state, and regional levels connect employers, educational institutions, the public workforce system, and economic development partners to address the workforce needs of industry sectors, such as advanced manufacturing. These partnerships ensure that job creators have the talent they need to grow and thrive and provide job seekers the opportunity to develop in-demand skills through work-based learning and Registered Apprenticeships and to earn industry-recognized credentials.

ETA supports and is part of the Manufacturing USA Interagency Working Team and the Manufacturing USA Education and Workforce Subcommittee. The agency continues to engage in partnerships, share tools and resources, and identify funding opportunities and strategies that can be leveraged to expand pathways into good manufacturing jobs and to support the Manufacturing USA institutes. To foster strategic alliances nationally, ETA also works with DOL's Veterans' Employment and Training Service (VETS), the federal government's principal agency for service members, veterans, and military spouse employment. VETS' recent support of the Defense Industrial Base (DIB) Initiative and numerous member organizations, academic members, and training partners across the 16 institutes that comprise the Manufacturing USA ecosystem led to greater visibility of program initiatives, employment opportunities, and training opportunities within advanced manufacturing.

## National Aeronautics and Space Administration



The National Aeronautics and Space Administration (NASA) is the United States government agency responsible for aeronautics, space exploration, space technology, space, and earth science. NASA contributes to our nation's economic competitiveness, fueling growth in American industry and supporting quality, high-paying jobs across the country. NASA emphasizes leadership in climate change, as a leading provider of Earth systems science and data. NASA also inspires young explorers, scientists, and technologists who will lead our nation's skilled STEM workforce.

The Space Technology Mission Directorate (STMD) is the NASA organization most closely related to Manufacturing USA. STMD invests in transformational technologies that help offset future mission risk, reduce cost, advance capabilities that enable NASA's missions, and support space industry growth and high-quality job creation. STMD identifies and promotes research and technology development, demonstrates applicability, and supports the infusion of these technologies into NASA's exploration and science missions as well as commercial space activities.

Advanced manufacturing research and development within STMD is focused on several areas, including in-space manufacturing, additive manufacturing, advanced materials, polymer matrix composites, metals processing and joining, digital transformation, and other technology development areas critical to achieving NASA's missions. Research and development are conducted through a combination of in-house activities at NASA centers, competitively funded research with universities and industry, and collaborations with other agencies. The rapid infusion of advanced manufacturing technologies into mission applications is a major emphasis of NASA's technology investment strategy.

## National Science Foundation



The National Science Foundation (NSF) works to promote the progress of science and maintain our nation's scientific leadership and global competitiveness. It supports basic research and education in all fields of fundamental science and engineering to create knowledge that transforms the future.

NSF supports fundamental advanced manufacturing research, education, and workforce training through awards from almost all its Directorates and Offices. The most targeted support is provided through the Advanced Manufacturing Program, and through the Future Manufacturing solicitation. NSF also promotes advanced manufacturing innovation through a variety of use-inspired and translational research programs, including the NSF Regional Innovation Engines (NSF Engines), Convergence Accelerator, Innovation Corps (I-Corps™), Partnerships for Innovation (PFI), Small Business Innovation Research (SBIR), and Small Business Technology Transfer (STTR) programs in its new Directorate for Technology, Innovation, and Partnerships (TIP), the Grant Opportunities for Academic Liaison with Industry (GOALI) program, and by partnering with industry, state/local/tribal government organizations and other agencies.

Advanced manufacturing is also supported through the Engineering Research Centers (ERC), Industry-University Cooperative Research Centers (IUCRC), and Advanced Technological Education (ATE) programs. With an emphasis on two-year colleges, the ATE program focuses on the education of technicians for the high-technology fields that drive our nation's economy. NSF strives to encourage the full participation of all Americans in STEM and to remove barriers to their doing so.

All NSF programs welcome the submission of proposals to collaborate with Manufacturing USA institutes on cutting-edge research and educational projects, and it is expected that the incorporation of the resources, expertise, and experience of the institutes and their member companies will increase the competitiveness of such proposals in merit review.

## U.S. Department of Agriculture



The U.S. Department of Agriculture (USDA) provides leadership on food, agriculture, natural resources, rural development, nutrition, and related issues based on public policy, the best available science, and effective management.

USDA focuses on collaborative science which aligns work in fundamental and applied research funded through extramural and intramural research programs and recognizes that manufacturing is part of value-added innovations that have an important role in maximizing the benefits of a sustainable rural economy. Of specific interest is the expansion of the bioeconomy, which has the potential for the sustainable harvest and use of substantial renewable biomass in the U.S. to support existing food, feed, forest product, and fiber markets while creating new jobs. The bioeconomy is supported by innovation in biomanufacturing, biotechnology, and bioproduct development. Innovation in scaling up biomanufacturing can improve technology to more efficiently and sustainably process biological materials to produce high-value bioproducts. Biotechnology can create new or improved biomaterials, and engineer forestry and agriculture crops to adapt to vulnerabilities from climate change to sustain the production of food and non-food products.

USDA supports research, development, and deployment of forest and agricultural feedstocks to produce biobased products such as biofuels, industrial chemical intermediates, performance polymers, and finished higher-value products, as well as biotechnologies to support new markets, such as cellular agriculture, alternative proteins, and precision nutrition.

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