

LEVERAGING UNIVERSITIES TO ADVANCE MANUFACTURING INNOVATION THROUGH THE MEP NETWORK

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ASSOCIATION OF
PUBLIC &
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The Association of Public and Land-Grant Universities

The Association of Public and Land-grant Universities (APLU) is a research, policy, and advocacy organization dedicated to strengthening and advancing the work of public universities in the U.S., Canada, and Mexico. With a membership of 238 public research universities, land-grant institutions, state university systems, and affiliated organizations, APLU's agenda is built on the three pillars of increasing degree completion and academic success, advancing scientific research, and expanding engagement. The association's work is furthered by an active and effective advocacy arm that works with Congress and the administration as well as the media to advance federal policies that strengthen public universities and benefit the students they serve.

APLU's Office of Economic Development and Community Engagement catalyzes the success of public and land-grant universities in accomplishing their economic and community engagement objectives. By supporting member engagement, conducting research, and implementing best practices, OEDCE helps APLU members work with public and private partners to advance Talent and workforce development, Innovation, entrepreneurship and technology-based economic development, and Place development through public service, outreach, extension, and community engagement.

Innovation Associates

For more than 30 years, Innovation Associates (IA) has provided services that optimize and unleash the full potential of innovation and entrepreneurial ecosystems at universities, national laboratories, and research institutes. IA works with the institutions and the communities in which they are located to leverage their innovation assets and promote economic growth, opportunity, and competitiveness. IA's specialties lie in advancing technology transfer and commercialization, university-industry collaborations, innovation at national labs and research institutions, SBIR, SME and startup initiatives, advanced manufacturing, and federal relations around science, innovation, and economic development policy. Learn more at www.InnovationAssociates.us.

Acknowledgments

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Section 1. Introduction

Over the past two decades, the manufacturing industry in the United States has suffered a loss of over 5 million jobs and thousands of manufacturing establishments. Offshoring of production has been financially successful for large multinational companies, but it has led to closure of many of the small-and medium-sized manufactures (SMMs), whose numbers have fallen by nearly 100,000 since the 1990s.¹

While the causes for this decline are many, the factors include stalled manufacturing productivity growth, a loss in manufacturing expertise, and the competitive pressures of a globalized supply chain. Kota and Mahone, in their report *Reclaiming America's Leadership in Advanced Manufacturing*, review these factors and note that the survival of SMMs will depend on their ability to adopt the new "Industry 4.0" and other emerging technologies required to regain productivity growth and rebuild American manufacturing.

American universities have an important role to play in the development of new technologies that transform American manufacturing. Advances in digitization, the use of smart sensors, robotics, simulation technologies, advanced materials, nanomanufacturing, and additive manufacturing techniques are developed and advanced by university research, often in partnership with industry.

The National Institute of Standards and Technologies' Hollings Manufacturing Extension Partnership (MEP) is interested in exploring how universities can develop and scale partnerships with MEP programs to increase SMMs' capacity to adopt technologies that are key for their success in the evolution to industry 4.0.

The Association of Public and Land-grant Universities (APLU) and Innovation Associates (IA) agreed to explore this idea by gathering information from universities and MEP program managers. We examined information about current relationships, activities, and other elements involved in transitioning technologies to SMMs. This report provides some preliminary insights from this investigation on strategies and factors that may contribute to collaboration among universities, MEPs, and SMMs. It also makes recommendations for a next phase in the investigation to further assess selected approaches and test their effectiveness in different contexts.

¹ Kota, Sridar, and Thomas Mahoney. "Reclaiming America's Leadership in Advanced Manufacturing." *MForesight*, June 2019.

1.1 Objectives

As outlined in the project proposal, this project aimed to investigate the potential for partnerships between universities and MEPs to support adoption of new technologies by SMMs and set the foundation for further investigation in the second phase of the project. In particular, we explored the following:

- How is manufacturing strategically considered among public research universities that are most committed to regional economic development, as defined by those that have earned APLU's Innovation and Economic Prosperity (IEP) University designation?
- In what ways are universities and MEPs cooperating to transition technologies to SMMs and what are some specific challenges and opportunities?
- How are MEPs and universities leveraging their research and development (R&D) resources – including technology transfer, technical facilities and services, and related skill development to advance SMMs?
- Which types of partnerships between MEPs and universities or specific examples of SMM engagement offer an opportunity for further exploration with respect to effectiveness, scalability, and replicability in a second project phase?

1.2 Methodology

This first phase of the project was exploratory. We used several data sources to develop evidence of the exploratory questions posed above. These data sources included the following:

- Applications for designation as an Innovation and Economic Prosperity (IEP) university, which is given to universities that have demonstrated a substantive, sustainable, and campus-wide commitment to promoting regional economic development. These applications contain a detailed self-study of the institution's economic development strengths and areas of growth and improvement and offer evidence of relationships among manufacturers and universities;
- A Request For Information (RFI) sent to 195 U.S.-based APLU member universities with MEPs asking about their practices related to technology transition to SMMs;
- An RFI sent to all 51 MEP directors and directors of organizations with MEP Sub-Recipient Agreements asking about their partnerships with universities;
- Focus groups and/or discussions at the MEP Annual Conference, University Economic Development Association (UEDA), and International Economic Development Council (IEDC) Annual Conference; and APLU's Commission on Economic and Community Engagement (CECE)-Council on Research (CoR) Summer Meeting and IEP Universities Workshop;
- Brief interviews with at least eight university and/or MEP members of existing partnerships.

The remainder of this report describes our findings. In Section 2, we describe some of the ways that universities are currently engaging with MEPs, their clients and other SMMs, the departments within the universities that are active in this area, and the kinds of services that are provided. We also describe relationships with some Manufacturing USA institutes, national laboratories, and intermediary organizations related to transitioning technologies to SMMs. Next, we describe in greater detail specific activities and services universities engage in with MEPs to accomplish this work.

In Section 3, we provide snapshot descriptions of several examples of university/MEP partnerships that transition technologies to SMMs as well as university-SMM partnerships that do not involve the MEP. Section 4 provides a set of takeaways from this information, including characteristics of these partnerships and key challenges. Then we discuss next steps in testing different approaches to university-MEP partnerships. The appendices summarize the data collected through the first three data collection methods described above.

Section 2. Universities as Catalysts of Innovation in SMMs

This section is based on three sources of information. First, APLU asked its member universities to provide information about their engagement with SMMs with respect to technology transition and innovation. Second, the Small Manufacturers' Coalition and NIST-MEP National Office worked with APLU and IA to develop and distribute the RFI to MEP directors (and large subrecipients) regarding their experience partnering with universities and other research institutes to assist SMMs. A copy of both RFIs are provided in Appendices A and B; Appendix C is a summary of the data from the university and MEP RFIs (respectively). A total of 36 universities and 22 MEPs responded to the RFIs. The final source of information for this section was an analysis of applications to APLU's IEP Universities program, which identifies universities that are substantively committed to regional economic development while strengthening internal awareness, capacity building and strategy for university-based economic development. APLU requires potential designees to complete a rigorous self-study analysis and develop detailed descriptions of their holistic economic development enterprises. A total of 55 designation applications were analyzed. We looked for mentions of manufacturing in the application narratives, and the context in which they were described.

2.1. IEP Universities and Manufacturing

Our analysis shows that more than three-fourths of IEP universities (44 of 55) mentioned manufacturing in their IEP designation application. Twenty-two mentioned manufacturing in the context of all three pillars of university economic development:

- Talent and workforce development,
- Innovation and entrepreneurship, and
- Place stewardship through community engagement.²

² The IEP Universities program designates institutions based on a framework for economic engagement that describes the different ways in which universities work with their public and private partners to carry out talent and workforce development, innovation, entrepreneurship and technology-based economic development, and place development through public service, outreach, extension and community engagement. For more details on the IEP universities program, see <https://www.aplu.org/projects-and-initiatives/economic-development-and-community-engagement/innovation-and-economic-prosperity-universities-designation-and-awards-program/>

Universities that cited manufacturing in their applications are in many different types of urban and rural environments, although the largest number (17) are in large cities. Given that IEP designated universities see economic development as a core function of their mission, these institutions may be well positioned, interested, and able to scale partnerships with MEPs for technology transitions efforts to SMMs.³

2.2 University Technology Transition Support to SMMs

Universities that responded to the RFI reported engaging in a range of activities that assist SMMs in adopting new technologies. Of the 36 respondents, more than three-fourths (31) indicated that they transfer technologies to SMMs. Of the universities indicating that they transfer technologies (23), more than half (13) indicated that they worked with SMMs with fewer than 25 employees, and almost all (21 of 23) worked with SMMs with fewer than 100 employees. Moreover, almost half (14) also indicated that they provide support to the SMMs after transferring the technology, including advice, training, startup support, and assistance finding matching or supplemental funds. Ten indicated that they provide SMMs special provisions for technology transfer, including advantageous licensing fees, reduced royalty rates, and other arrangements that make it easier for small or startup companies to use university-developed technology. Most of the universities (25) indicated that this work is done through their technology transfer office.

Many of the total responding universities (23 of 36) provide training for SMMs, and the most common type is management training, followed by marketing and technical training. In a few cases (7), this training is related to technologies that the universities have transferred to the SMM.

Universities often provide shared facilities that SMMs can use. Thirty of the 35 respondents reported that they offer shared facilities including research parks, laboratories, testing and evaluation equipment, 3-D printing and digital manufacturing laboratories, wind tunnel, energy storage laboratories, and other types of facilities. Most charge a fee, although four of the universities indicated that in some instances the facilities were provided at no cost.

One strong area of interest in university collaboration with SMMs involves undergraduate and graduate student internships and research projects that can help with technology capacity building within the SMM. Twenty-seven (27) universities reported they have placed students in internships with SMMs, and two others indicated that students perform research projects such as capstones with SMMs. The capstones focus on increasing the technical capabilities of the SMM – for example, in robotics or systems engineering. Three also reported faculty externships and student exchanges with SMMs.

Aside from technology transfer and training services, universities provide a range of other types of services to SMMs. They provide assistance with strategic decision making, technical and professional education, proposal development for federal grants, participation in the Manufacturing USA institutes, and convening of manufacturing stakeholders to provide thought leadership around industry problems.

³Twenty seven (27) of the 36 universities responding to the RFI described in Section 2.2 have earned the IEP designation or are in the process of obtaining the designation (75%).

Universities noted that their work with SMMs differs in many cases from their work with larger manufacturers, primarily because of larger entities' ability to pay for the services, engage in partnerships that affect a larger subset of faculty and students, or partner over a longer timeframe. Larger manufacturers are more likely to have large sponsored research projects that might include the establishment of a research center with personnel co-located at the research center. However, in our interviews, some noted the opportunity for the university and MEP to partner in securing state or federal grants to fund university engagement with SMMs.

Fourteen (14) of the universities reported engagement with the Manufacturing USA institutes. Although all the institutes were mentioned at least once, those most frequently mentioned were America Makes and MxD. Universities participated with the institutes in a variety of ways, including funded research projects, workforce development, leveraging shared facilities, and participation on institute boards.

2.3 Collaboration between Universities and MEPs

Sixteen (16) of the 36 responding universities are affiliated with an MEP program. The affiliations are high-touch and low-touch, ranging from the MEP being fully hosted by the university with university employees as MEP staff (5) to membership or participation on the board (2). Some universities host a MEP regional office or provide staff for specific industries or needs (7), and some partner with MEPs at one of the manufacturing institutes (2).

We explored collaboration between MEPs and universities described in the results of the RFI sent to MEP directors. Among the 22 MEP respondents, six are operated by a university or other academic or research institution. Some that are not operated by the university or institution have other types of relationships, including board membership, sharing employees and facilities, and delivering services. Eight of the respondents listed more than one academic institution that they partner with. The MEPs work with various offices within the partner research institution, most often colleges of engineering or departments of industrial engineering. They also partner with schools of business and specialized programs such as the nanotechnology center, biomedical engineering, materials research institute, food science or other labs. Business school collaborations are especially valuable to equip SMMs with skills needed to do technology forecasting and market analysis for new products they would develop. The departments managing technology transfer and economic development are also sometimes involved, as are tech parks and discovery centers.

More than three-fourths (18) of the MEP respondents said they worked with universities or other research institutions to transfer innovations to their clients. Of the 18 MEPs, most (11) reported that their institutional partner provided services to support the application of the technologies being transferred. The types of services provided were consistent with the responses from the university RFI. MEP centers also rely on universities to provide facilities (labs, equipment, incubators, testing facilities); research and analysis (product design material analysis, engineering, testing, market research); consulting and advice on issues such as supply chains and cybersecurity; and technical demonstration and instruction. They use faculty, staff, and students for this support.

MEPs report that training in collaboration with universities occurs on a variety of topics, including: automation and robotics; machining and welding; supply chain analysis; cybersecurity; digital manufacturing; food safety; and various management topics such as lean startup and ISO certification.

The MEP respondents reported being involved in nine (9) of the Manufacturing USA institutes, and some MEPs are involved in several. The institutes most frequently mentioned were MxD, IACMI, RAPID, CESMII, and ARM. They reported that the institutes provided support for training and workshops, demonstration and use of equipment, conferences, awareness and assessments, and networking.

Section 3. Examples of University-MEP Collaboration that Warrant Further Exploration

We gathered examples of how universities support SMMs with technology development and transition. Our objective was to identify different types of interaction that might be worth exploring in Phase II of the project. We gathered this information through the university and MEP RFIs, during national conference workshops, and through interviews with MEP and university officials.

There are a variety of ways universities work successfully with SMMs to transition technologies. Many of those include partnerships with MEPs but some do not; we hope to learn lessons for MEP from those not already partnering. Below we provide examples of different types of collaboration. The first set include MEPs, usually in a role of convener or connector between university resources and the company. The second set of examples doesn't involve MEPs. However, it would be interesting to explore whether MEP involvement might allow for increasing the speed or scale of these collaborations by providing a partner—the MEP—with deep knowledge of the SME community and an understanding of their culture.

3.1 Examples that Partner Universities and MEPs

MEP is hosted at a university and provides connection between SMMs and faculty. As noted in Section 2, six of the universities responding to the university RFI host MEP centers on their campus. In many of these cases, the MEP develops expertise on the needs of the SMM community and the expertise and resources available at the host university. This allows them to provide a critical link between the company and the university resource that is best able to assist them with technology transitioning.

An example of this approach is **Iowa State University's Center for Industrial Research and Service (CIRAS)** paired the University's Center for Nondestructive Evaluation (CNDE) and Accumold, a company that makes small plastic parts for a variety of technology and medical devices. CIRAS provided the company entrée to the CNDE for assistance in testing new parts they were developing for a prototype smart device. The CDNE program manager was able to use the CNDE's equipment for examination and testing of the new parts, which sped the company's time to market with the new parts.

Similar examples were provided by the **Tennessee Manufacturing Extension Partnership**. They are hosted at the **University of Tennessee** and worked with faculty to support a small manufacturer's switch from metal to lightweight composites. **Boise State University**, meanwhile, hosts the main office for **TechHelp Idaho** and provides SMMs connection to faculty for opportunities for joint grant proposals and the use of multiple engineering labs to assist with client projects.

⁴ "Accumold Proves Proficiency, Wins Business Thanks to CIRAS-arranged Tests" CIRAS News, volume 50(4) p. 4. <https://www.ciras.iastate.edu/ciras-newsletters/ciras-news-issue-list/>

Many university-based MEPs work not only with their host universities but also with other universities that can provide additional resources. For example, **CIRAS at Iowa State** partners with other universities when their expertise is more appropriate than what is available at Iowa State.

MEP is hosted at a university and provides opportunities for capstone students to assist in improving SMM operations. In Section 2, we described universities' interest in engagements providing students internships or other work-and-learn opportunities. One example of an ongoing program of this type is run by **Iowa State University's CIRAS**, which hosts the **Iowa MEP** program. Each year, the MEP facilitates over 150 capstone projects that allow students to gain valuable experience while giving companies the benefit of their work. The projects are spread across disciplines, and include developing prototypes, general engineering analysis, plant layout, test equipment design, automation equipment design, materials selection/analysis, and more. Students have access to space and equipment throughout the college that enables their work on these projects.

MEP is not hosted on campus but works with a university center. This is the case for the Center for High Performance Manufacturing at **Virginia Institute of Technology**. It has a long-term relationship with **GenEdge**, the Virginia MEP, providing a connection to SMMs that can benefit from student capstone projects. The projects are funded by GenEdge's SMM clients. Many of the student capstones focus on improving the firms' technological capabilities. For example, Concoa located in Virginia Beach has two teams working on robotics applications. The capstone is a systems engineering project to improve flow and inventory of the company. GenEdge has established similar relationships with six other colleges and universities elsewhere in Virginia. Some projects also involve graduate students as technical advisors. Of the approximately 40 teams, 10 have graduate students serving in this capacity.

Another example of this type of partnership is between **Pennsylvania State University** and the **Innovative Manufacturers' Center (IMC)**, the local MEP partner. Faculty from Penn State's Materials Characterization Lab worked with the IMC to solve a problem for Gilson Snow, a maker of snowboards and skis. Gilson was having a problem with an adhesive they were using in an innovative snowboard design. Solving this problem helped them move ahead with the production of the snowboard with an innovative design that has been important to its market growth.

Some non-university-based MEPs partner with multiple universities. **Ohio MAGNET** has signed MOUs with several universities, including **Case Western Reserve** (for metals and ceramics), **University of Akron** (for plastics and elastomers), **Ohio State University's** Center for Design and Manufacturing Excellence, as well as **Kent State** and **Cleveland State**. MAGNET became familiar with the key competencies of the universities and matched those to the SMMs. They also identified funding that could be used to pay universities to assist in innovation services to the SMMs.

MEP and university work through Manufacturing USA institute. Another example includes the introduction of universities to SMMs through the Manufacturing USA institute. For example, the **University of Massachusetts-Lowell** has a partnership for technology development with a company called SI2 Technologies through the **NextFlex** institute. SI2 also provides co-op employment to the university's engineering students.

MEPs work with multiple partners, both academic and national labs, to help SMMs adopt new technology. An example of this was provided by **OMEPE**, describing the work they did to identify a user of a technology that was developed at the **Pacific Northwest National Lab**. The technology was an innovative heat exchanger, and was further developed by **ONAMI**, the Oregon Nanotechnology and Microelectronics Research Institute, which works with faculty at each Oregon university. In this case, further development and testing was completed by an **Oregon State University** professor. When the technology needed to be tested, the MEP identified Metal Products of Springfield, OR as a SMM that could benefit from implementing this technology.

Another example of this kind of collaboration is provided by **SUNY-Stony Brook**, which houses the MEP for Long Island, the **Manufacturing and Technology Resource Consortium (MTRC)**. MTRC works with more than 20 partners that include three Centers for Advanced Technology and two Centers of Excellence funded by New York State's NYSTAR, Stony Brook's Composite Prototyping Center (CPC), several regional community colleges, and Brookhaven National Laboratory. They provide SMMs with grants from MEP and the state of New York, business help including assistance with Small Business Innovation and Research (SBIR) Phase II proposals from the regional SBDC located at the university, and technical help from university centers and partners.

3.2 Examples that do not Involve MEPs

We identified some cases in which universities were working with SMMs to transition technologies that did not directly involve MEPs but provide good examples for MEP. One such example was provided by **Kansas State University; KSU** has worked with several small companies through their Technology Development Institute at the School of Engineering. They provided two examples of engineering assistance that allowed companies to improve their processes.

At the **University of Massachusetts-Lowell**, SMMs take advantage of discounted rates for research facilities using a voucher program funded by the State of Massachusetts. This program provides core research facilities for up to 70 percent off standard rates. The facilities are professionally staffed, and users can choose to obtain assistance from the staff for testing or the users may become certified to operate the equipment on their own.

The **Clemson University Center for Advanced Manufacturing** is a research and training center in advanced manufacturing covering areas such as robotics, AI, composites, and lightweight materials. One of their functions is to connect manufacturers with researchers and potential investors, particularly in materials and energy, and potential partners.

NC Growth at UNC-Chapel Hill provides technical assistance to growing companies, including small manufacturers. For example, NCGrowth partnered with P&A Industrial Fabrications by assisting with system automation projects. P&A is a manufacturer of woven fabrics that primarily manufactures paint roller fabrics for companies such as Sherwin Williams and heel pad fabrics for manufacturers like BMW and Mercedes-Benz. P&A had formulated an algorithm giving an optimal schedule for their loom production planning, but

the data generated by the system was in a raw form, making it impossible to interpret. NCGrowth assisted P&A in creating a tool that automates this process. The application reads the raw data and converts the same into a readable schedule. It also highlights the orders that are critical or of high risk.

Another example involves MBA students from the university identifying and defining regional industry clusters, creating value chain diagrams, analyzing economic data, and performing a gap analysis to determine where North Carolina-based motor manufacturers (Cummins Diesel, NACCO Materials Handling, Crown Equipment, VT Hackney, LS Tractor etc.) should focus their attention to further develop or strengthen the cluster.

Section 4. Lessons Learned and Next Steps

We briefly summarize some observations below, including current partnerships and activities that contribute to transitioning university technologies to SMMs, challenges that may hinder the process, and next steps.

4.1 Partnerships and Activities Contributing to Technology Transition and Adaptation

We observed a variety of University-MEP-SMM collaborations that facilitate technology transitioning and adaption by SMMs. These collaborations take many forms and support technology transitioning and adaptation in many ways. Some of the engagement that we observed included (but were not limited to) the following:

- University technology centers provide SMMs with access to expert research faculty for specialized research and technical analysis on wide-ranging areas (product design, material analysis, etc.).
- Technology transfer office assistance to SMMs sometimes includes special services and reduced fees not provided to larger companies.
- Engineering, business schools, and other schools/departments offer SMMs technical demonstrations, training and education on specific technologies, management, marketing and other areas.
- SMMs use university laboratories and other facilities for testing and evaluation, 3-D printing, digital manufacturing, and other functions.
- Universities provide consulting and advice on market analysis, supply chains, cybersecurity, and other areas.
- Student capstone activities and internships help SMMs adjust to new technologies and enhance business and management while providing students real-world experience and skills.
- Universities provide SMMs assistance with proposal development for state and federal grants such as SBIR.
- Universities convene manufacturers and manufacturing groups to provide thought leadership around industry and SMM issues.
- Manufacturing USA institute and national laboratory partnerships that extend those institutional developments and activities to SMMs through university-MEP partnerships.
- Universities develop curriculum and provide training for upskilling existing SMMs' workforce.

4.2 Perceived Challenges

From this limited exploration, we have learned that a few key challenges face universities interested in engaging with SMMs, and MEPs/SMMs trying to interact with universities:

- Faculty may not know how to identify candidates for partnerships to transition technologies;
- SMMs don't understand how to find university faculty with the expertise and interest that they need;
- Universities struggle to get the attention of busy SMMs and identify ways to support them;
- SMMs may not have the funding available to pay the faculty and/or students for the work;
- Faculty may not have the professional incentives or protected time to perform the work for SMMs; and
- The SMM's timeline for technology development and application may not fit with faculty and student schedules.

4.3 Issues Potentially Requiring Additional Exploration

In focus group discussions and other conversations with university and MEP representatives, we identified some additional issues and suggestions that may require some further exploration in the next phase of our analysis.

- There is a misconception that MEPs can or should only be engaged by the land-grant institutions in each state, perhaps because "extension" is included in the MEP name.
- Some regional universities perceive a lack of interest in collaboration from universities that host MEPs. This, in part, may be due to the competitive nature of universities, but also may result from a lack of awareness about the capabilities of other institutions. It appears this sentiment is felt most strongly when the university hosting the MEP is the state land-grant or flagship research institution.
- It may be helpful to better connect university-based MEPs with other economic development programs including Small Business Development Centers (SBDCs), I-Corp programs, EDA university centers, and Department of Transportation centers. It would be valuable for the organizers of these federal programs to convene and discuss ways in which there can be cross-pollination of ideas and networks with respect to SMM engagement around innovation and technology.
- Improving the effectiveness of SMM workforce training may require that universities and MEPs identify methods for assessing on-the-job skills and prior learning. Certifications and non-degree or stackable credentials like badges, certificates, or micro-masters can be valuable in equipping the SMM workforce with the skills they need to leverage new technologies and processes. Examples include the [ATMAE certification](#), lean, Six Sigma, quality, and safety certifications. Universities with robust online and distance education programs could be targeted for skills-based development of the SMM workforce.

4.4 Concluding Comments and Next Steps

This Phase I project was a time-limited effort intended to quickly gather information on the constructs of MEP-university partnerships and some of their activities aimed at transitioning technologies to SMMs. Therefore, findings represented here are based on a small sample, and are not intended to attribute specific factors to successful technology transition. Phase I findings are intended to begin laying the groundwork for further examination and potential replication of selected outstanding examples of university-MEP partnerships.

In Phase II, we will engage in a deeper examination of examples of university-MEP partnerships transitioning technologies to MEP clients. This phase will include analyzing the potential elements involved in successful partnering for technology transitioning and will further identify specific examples for potential replication. Based on this more extensive and deeper information, we will develop pilots to be carried out by universities and MEPs. Then we will capture and develop the steps that can be used by others to enhance their partnerships and processes to support and advance technology transitioning for SMMs. Ultimately, the aim of both Phase I and Phase II is to increase the technological know-how and competitiveness of SMMs in an ever-increasing technological and competitive manufacturing environment.



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Appendix



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Appendix A. University RFI

1. Survey respondent:	
Full Name::	<input type="text"/>
Title::	<input type="text"/>
Institution::	<input type="text"/>
Email::	<input type="text"/>
Telephone::	<input type="text"/>

2. Is the institution affiliated with an MEP?	
<i>Select one.</i>	
<input type="radio"/>	Yes (Answer question number 2.1, 2.2.)
<input type="radio"/>	No

2.1 specify MEP(s):	
#1::	<input type="text"/>
#2::	<input type="text"/>
#3::	<input type="text"/>

2.2 In what way is it affiliated?

3. Does the institution transfer technologies -- products, processes or services -- developed by the university to small and medium sized manufacturers (under 500 employees)?

Select one.

<input type="radio"/>	Yes	(Answer question number 3.1, 3.2, 3.3, 3.4.)
<input type="radio"/>	No	

3.1 Is technology transferred through a technology transfer office or through another institutional office?

Select one.

<input type="radio"/>	Technology transfer office	
<input type="radio"/>	Other office: please specify: <table border="1"><tr><td></td></tr></table>	

3.2 Which size firms are the technologies transitioned to?	
<i>Select one.</i>	
<input type="radio"/>	1-25 employees
<input type="radio"/>	26-99 employees
<input type="radio"/>	100-250 employees
<input type="radio"/>	251-500 employees

3.3 Are there any special provisions for SMMs; for example more advantageous licensing fees, etc.?	
<i>Select one.</i>	
<input type="radio"/>	No
<input type="radio"/>	Yes, please specify:: <input type="text"/>

3.4 Does the institution provide services to support the application of the products, processes or services being transferred, (e.g., systems integration; instruction on new equipment/processes; etc.)?	
<i>Select one.</i>	
<input type="radio"/>	No
<input type="radio"/>	Yes, please specify what types of service:: <input type="text"/>

4. Does the institution provide training for SMMs?	
<i>Select one.</i>	
<input type="radio"/>	Yes (Answer question number 4.1, 4.2.)
<input type="radio"/>	No

4.1 What types of training are provided to SMMs and what offices, service unit, academic department or university center provide the training (e.g., technical training - engineering; marketing - business school)?

Select all that apply.

	<i>yes</i>	<i>no</i>
technical training	<input type="checkbox"/>	<input type="checkbox"/>
management	<input type="checkbox"/>	<input type="checkbox"/>
marketing	<input type="checkbox"/>	<input type="checkbox"/>
other	<input type="checkbox"/>	<input type="checkbox"/>
Comments		
technical training:	<input type="text"/>	
management:	<input type="text"/>	
marketing:	<input type="text"/>	
other:	<input type="text"/>	

4.2 Is the training directly related to technologies that have been transferred from the institution?

Select one.

<input type="radio"/>	yes
<input type="radio"/>	no
<input type="radio"/>	some: specify: <input type="text"/>

5. Does the institution provide evaluation and testing for SMMs (e.g. Faculty, staff, or students supporting testing, providing facilities and/or testing and evaluation, etc?)

Select one.

<input type="radio"/>	Yes	(Answer question number 5.1.)
<input type="radio"/>	No	

5.1 Specify:

--

6. Does the institution have shared facilities used by SMMs (e.g. testing and evaluation labs; clean rooms; etc.)?

Select one.

<input type="radio"/>	No		
<input type="radio"/>	Yes, please specify::	(Answer question number 6.1.)	
	<table border="1"><tr><td></td></tr></table>		

6.1 Are these facilities leased or provided gratis to SMMs?

Select one.

<input type="radio"/>	Leased
<input type="radio"/>	Gratis

7. Does the institution provide business development, management, marketing and/or other types of business related services to SMMs or the MEP?		
<i>Select one.</i>		
<input type="radio"/>	Yes	(Answer question number 7.1, 7.2, 7.3.)
<input type="radio"/>	No	

7.1 What types of services?	
<i>Select all that apply.</i>	
<input type="checkbox"/>	Business development
<input type="checkbox"/>	Management
<input type="checkbox"/>	Marketing
<input type="checkbox"/>	Human resources
<input type="checkbox"/>	Other: specify: <input type="text"/>

7.2 Are these services provided for a fee or at no cost to SMMs?	
<i>Select one.</i>	
<input type="radio"/>	For a fee
<input type="radio"/>	No cost

7.3 If you selected 'For a fee', Do you have different fee structures based on size of firm?	
<i>Select one.</i>	
<input type="radio"/>	Yes
<input type="radio"/>	No

8. Does the institution have faculty exchanges, student internships and/or other personnel relationships with SMMs?	
<i>Select one.</i>	
<input type="radio"/>	faculty exchanges
<input type="radio"/>	student internships
<input type="radio"/>	Other: specify: <input type="text"/>

9. Does the institution provide other types of services, facilities, etc. for SMMs that have not been covered in earlier questions?	
<i>Select one.</i>	
<input type="radio"/>	No
<input type="radio"/>	Yes, please specify:: <input type="text"/>

10. Does the institution provide any other types of resources and services or engage in other activities with large manufacturers in addition to those already described for SMMs?	
<i>Select one.</i>	
<input type="radio"/>	Yes (Answer question number 10.1, 10.2.)
<input type="radio"/>	No

10.1 Specify

10.2 Why does the institution provide these resources or services to large manufacturers and not SMMs?

11. Does the institution participate in federal [Manufacturing USA institute\(s\)](#) (formerly known as National Innovation Institutes)?

Select one.

<input type="radio"/>	Yes	(Answer question number 11.1, 11.2.)
<input type="radio"/>	No	(Answer question number 11.1, 11.2.)
<input type="radio"/>	I don't know	

11.1 Which institute(s)?

11.2 in what ways does the institution engage with the Manufacturing USA institute(s)?

12. Does the institution have brief examples of successful engagement with SMMs that it would like to share?

Select one.

<input type="radio"/>	Yes	(Answer question number 12.1, 12.2.)
<input type="radio"/>	No	
<input type="radio"/>	Yes, but not at this time.	

12.1 Please describe in no more than 150 words per example.

i.:	<input type="text"/>
ii.:	<input type="text"/>
iii.:	<input type="text"/>

12.2 Can APLU/MEP publish the examples attributing them to your institution?

Select one.

<input type="radio"/>	Yes, unconditionally
<input type="radio"/>	No
<input type="radio"/>	Yes, with conditions (specify): <input type="text"/>

Appendix B. MEP RFI

1. Is the MEP operated by a university or other academic institution?

___ yes* ___ no

*(a) Name of academic institution(s): #1_____ ; #2_____ ; #3_____

2. Is the MEP affiliated with any other academic, research or technical institution(s) such as a university, community college or federal laboratory?

___ yes* ___ no

*(a) specify institution(s):**

#1_____ ; #2_____ ; #3 _____

** (b) in what way is it affiliated (for example, workforce development partner, official sits on MEP board, etc.)? Please specify:

Inst. #1:a_____ ; b_____ ; c_____

Inst. #2:a_____ ; b_____ ; c_____

Inst. #3:a_____ ; b_____ ; c_____

3. Has the MEP worked with a university or other institutions (including federal labs or non-profits) to transfer/transition advanced innovation(s) to provide products, processes or services to MEP clients?

___ yes* ___ no

*(a) Please specify the university or other institution**:

#1_____ ; #2 _____ ; #3_____

** (b) What departments or offices (such as the technology transfer office, engineering school, etc.) in the university or other institution did the MEP work with on transferring/transitioning the innovation(s)?

Inst. #1: ___ don't know; Dept./Office: a_____ ; b_____ ; c_____

Inst. #2: ___ don't know; Dept./Office: a_____ ; b_____ ; c_____

Inst. #3: ___ don't know; Dept./Office: a _____ ; b _____ ; c _____

** (c) Did the institutional partner provide services to support application of the innovation being transferred (e.g., systems integration; instruction on new equipment/processes; etc.)?

___ yes*** ___ no

*** (d) What types of services? Please specify:

Inst. #1:a_____ ; b_____ ; c_____

Inst. #2:a _____; b _____; c _____

Inst. #3:a _____; b _____; c _____

4. Has the Center referred MEP **clients** to other training (not related to a specific transferred technology) from a university, other academic or research institution including federal laboratories? (Examples might include technical, marketing, management, I-Corps, and others).

___ yes* ___ no

*(a) What institution(s)**?

#1 _____; #2 _____; #3 _____

** (b) What types of training were provided to MEP clients? Please specify:

Inst. #1:a _____; b _____; c _____

Inst. #2:a _____; b _____; c _____

Inst. #3:a _____; b _____; c _____

5. Have other resources and services been provided by a university, other academic or research institution including federal laboratories? (Examples might include laboratories, production facilities, testing and evaluation, workshops, seminars, mentoring, networking, and others.)

___ yes* ___ no

*(a) What institutions**?

#1 _____; #2 _____; #3 _____

** (b) What types of resources and services**? Please specify:

Inst. #1:a _____; b _____; c _____

Inst. #2:a _____; b _____; c _____

Inst. #3:a _____; b _____; c _____

6. Does the MEP interact or participate in other activities with a federal [Manufacturing USA Institute\(s\)](#) or other federal lab? (Examples might include workforce development, equipment use, MEP staff participation in planning, networking, and others.)

___ yes* ___ no

***(a) What Institutes or federal labs**?**

#1 _____; #2 _____; #3 _____

**** (b) What types of activities? Please specify:****

Inst. #1:a _____; b _____; c _____

Inst. #2:a _____; b _____; c _____

Inst. #3:a _____; b _____; c _____

7. Does the MEP have brief examples of successful engagement with academic, research or technical institution(s) such as a university, community college, federal laboratories or Manufacturing USA institutes that it would like to share?

___ yes* ___ no ___ Yes, but not at this time

***(a) Please describe the institutions and the activities in no more than 150 words per example.**

i. _____

ii. _____

iii. _____

***(b) Please share any comments on whether your interactions with higher ed institutions have been positive or negative**

***(c) Can MEP and APLU/IA publish the examples attributing them to your institution?**

___ yes, unconditionally

___ yes, with conditions**

**Please specify conditions: _____

___ no

Appendix C. RFI Data Summaries

Results Summary: Request for Information from Universities

1. Respondent Universities

Number of responses = 36

2. Is the institution affiliated with an MEP?

Yes = 16

2.1 Specify which MEP:

Table 1: Respondent Universities and the MEPs they work with (If applicable)

University	MEP affiliation
University of Memphis	
University of Michigan	
UC Davis	
Ohio State University	
University of Cincinnati	Techsolve
Michigan State University	
Georgia Institute of Technology	GaMEP
University of Alabama Huntsville	
University of Kansas	
University of Missouri	
Texas Manufacturing Assistance Center Paso del Norte (University of Texas El Paso)	Texas Manufacturing Assistance Center (TMAC)
University of Alabama	Alabama Technology Network
U of Houston	
Georgia Southern University	
University of Nebraska-Lincoln	Nebraska MEP
California State University, Northridge	CMTC (California Manufacturing Technology Consulting)
University of South Florida	
Alabama A&M University	
Ohio University	OSU Endeavor Center; the Ohio State University South Centers

University of Colorado Boulder	
Wayne State University	
Purdue University	IN MEP Center
University of Pittsburgh	Catalyst Connection
UC San Diego	
University of Hawaii	Innovate Hawaii
UMass Lowell	Massachusetts MEP
Kansas State University Technology Development Institute (TDI)	
Iowa State University	CIRAS, Iowa MEP
MISSISSIPPI STATE UNIVERSITY	Mississippi Manufacturer's Association-MEP
Texas Tech University	
MTRC Long Island- SUNY Stony Brook	MTRC, NY-MEP for the Long Island Region
University of Louisville	
University of Alaska Anchorage	Alaska MEP
University of Virginia	
Oklahoma State University	Oklahoma Manufacturing Alliance
Washington State University	

2.2 In what way is it affiliated? (open-ended):

- As Member/Participant (2)
- MEP center is housed at the university: (5)
- University houses a regional office or provides staff for specific industries or needs: (7)
- Partner in a Mfg USA Institute: (2)

3. Does the institution transfer technologies -- products, processes or services -- developed by the university to small and medium sized manufacturers (under 500 employees)?s:

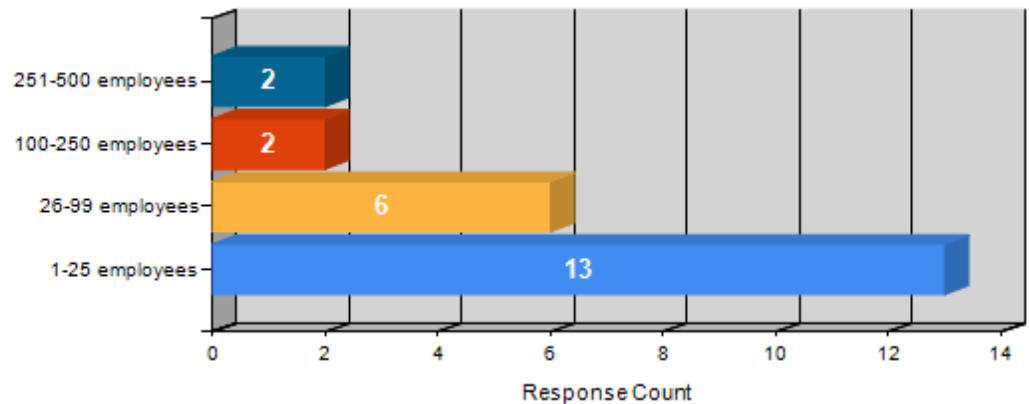
Yes = 31

3.1 Is technology transferred through a technology transfer office or through another institutional office?

- *Yes = 25*
- *Other office: 6*

3.2 Which size firms are the technologies transitioned to?

23 respondents - 8 skipped



3.3 Are there any special provisions for SMMs; for example more advantageous licensing fees, etc:

Yes = 10 (of 31 respondents)

- Advantageous licensing fees
- It depends on faculty engagement
- Reduced royalty rates
- Arrangements that won't disrupt cash flow
- Express licenses
- Advantageous licensing fees; equity (instead of cash); delayed payment schedule
- Provide innovation matching funds through state agency with federal (EDA) funds
- Waive license fees for startups; longer milestones
- Validation license

3.4 Does the institution provide services to support the application of the products, processes or services being transferred, (e.g., systems integration; instruction on new equipment/processes; etc.)?

Yes = 14 (of 31 responses)

- Matching funds
- Variety of research services
- Separate knowhow agreement
- Incubation/Start-up assistance and facilities
- Instruction, training, guidance, advice, consulting, systems integration
- Logistics support via Russ College, eg. Six Sigma, Lean, etc.
- Start up assistance, funding access, technical services
- Technology and business development services through TDI

- Research and development support services
- Varies by circumstance; general
- Mechanical engineering, design for mfg, increasing innovation capacity

4 Does the institution provide training for SMMs

Yes = 23 (of 36 responding)

4.1 What type of training?

- Technical training: 20
- Management training: 22
- Marketing: 20
- Other: 12

4.2 Is the training directly related to technologies that have been transferred from the institution? (23 responding)

- Some: 7*
- No: 15
- Yes: 1*

* Note: many that said some or yes noted that this is case dependent

5. Does the institution provide evaluation and testing for SMMs (e.g. Faculty, staff, or students supporting testing, providing facilities and/or for testing and evaluation, etc.)?

Yes = 2 (of 11 responding)

6. Does the institution have shared facilities used by SMMs (e.g. testing and evaluation labs; clean rooms; etc):

Yes = 30 (of 35 responding)

These are open ended so it was hard to characterize them precisely. These are some of the phrases used most often:

- Research park/business park/Incubator
- Equipment; testing services
- Analytical facilities/testing and evaluation
- Labs/wet lab
- Materials characterization
- Clean room
- NMR
- Testing and evaluation equipment
- 3D printing/digital mfg lab
- Energy storage
- Wind tunnel

- Many core facilities
- Maker Space
- Yes, but only for sponsored projects or through other kinds of agreements

6.1 Are these facilities leased or provided gratis to SMMs?

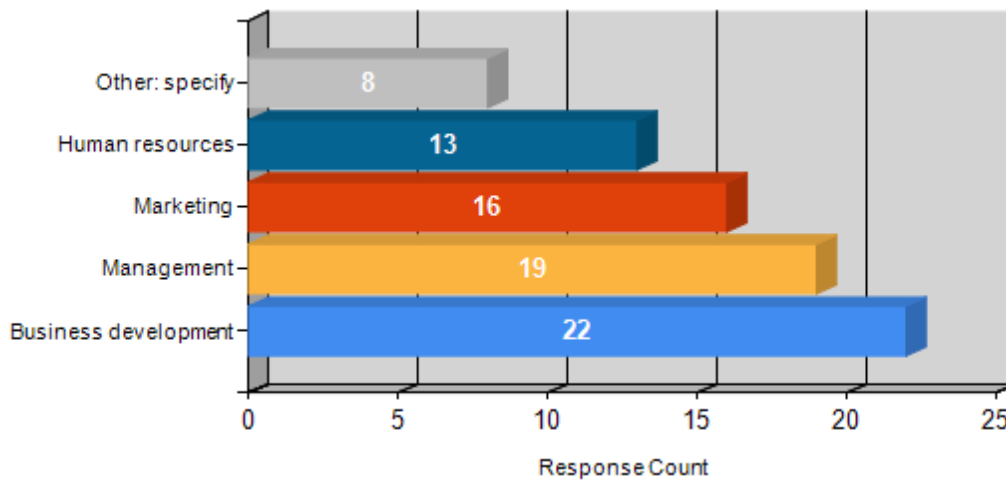
- Leased = 23;
- Gratis = 3

7. Does the institution provide business development, management, marketing and/or other types of business related services to SMMs or the MEP?

- Yes = 25
- No = 10

7.1 What types of services:

**note this was a select all that apply. 24 respondents answered this question.*



7.2 Are these services provided for a fee or at no cost to SMMs?

25 responded to this question

- No cost = 12
- Fee = 13

7.3 If you selected 'For a fee', Do you have different fee structures based on size of firm?

No = 10;

Yes = 4

8. Does the institution have faculty exchanges, student internships and/or other personnel relationships with SMMs?

- Student internships: 27
- Other: 6
- Faculty exchanges: 0

**Other includes both faculty and students in 3 cases*

9. Does the institution provide other types of services, facilities, etc. for SMMs that have not been covered in earlier questions?

Yes = 13

No = 20

- Strategic decision making
- Policy
- Issue education and industrial consortiums
- Digital readiness
- Manufacturing day assistance
- Meetups, co-working spaces, modular lab spaces
- Small Business Development Center
- Convening of thought leadership around industry-wide problems (Pitt)
- Assistance with SBIR/STTR, other federal applications
- Funding through Mfg USA institutes

10. Does the institution provide any other types of resources and services or engage in other activities with large manufacturers in addition to those already described for SMMs?:

Yes= 18

No = 16

- Sponsored and co-sponsored research and research centers
- Internships, scholarships, pipeline opportunities.
- Advisory boards
- DoD mentor protégé program
- Co-location
- Additive manufacturing in minority businesses

10.2 Why does the institution provide these resources or services to large manufacturers and not SMMs?:

- Small can't afford them
- Needs are different

11. Does the institution participate in federal [Manufacturing USA institute\(s\)](#) (formerly known as National Innovation Institutes)?

Yes: 14

No: 10

Don't know: 11

11.1 Which Institute?

- LIFT: 2
- IACMI: 3
- America Makes: 6
- MxD: 5
- NIMBL (2)
- RAPID: 3
- Power America (1)
- CESMII: 3
- AFFOA (2)
- AIM (1)
- ARM (2)
- Nextflex (2)
- Remade (2)
- Biofab (1)
- All of them (2)

11.2 In what ways does the institution engage with the Manufacturing USA institute(s)?

(16 respondents; difficult to characterize open-ended responses)

- Funded research projects
- Board member
- Workforce development

Results Summary

RFI to MEP directors and MEP subrecipient organizations

Number of responses = 22

Respondents:

- Impact Dakota
- TechHelp Idaho (Boise State University with other locations at Idaho state and the University of Idaho)
- Arizona MEP
- Illinois Manufacturing Excellence Center
- Tennessee MEP (University of Tennessee)
- Industrial Technology Assistance Corporation (NY MEP affiliate for New York City)
- Center for Industrial Research and Service, (Iowa State University)
- Innovative Manufacturers Center (Pennsylvania)
- Georgia MEP (Georgia Tech)
- Montana Manufacturing Extension Center (Montana State University)
- Ohio Development Services Agency
- Arkansas Economic Development Commission
- Wisconsin Center for Manufacturing & Productivity
- New Mexico MEP
- Alliance for Manufacturing and Technology
- Polaris MEP
- Arizona MEP
- Oregon MEP
- MassMEP
- Alaska MEP (University of Alaska Anchorage)
- CONNSTEP
- Oklahoma Manufacturing Alliance

1. Is the MEP operated by a university or other academic institution?

- Yes = 6
- No = 17

2. Is the MEP affiliated with any other academic, research or technical institution(s) such as a university, community college or federal laboratory?

- Yes = 9
- No = 14

2a. In what way is it affiliated?

A few mentioned other partnerships with other universities, community colleges, and some national labs. They mentioned arrangements that included board membership, sharing employees, providing space, delivering services.

3. Has the MEP worked with a university or other institutions (including federal labs or non-profits) to transfer/transition advanced innovation(s) to provide products, processes or services to MEP clients?

- Yes = 19
- No = 4

3b. What departments or offices (such as the technology transfer office, engineering school, etc.) in the university or other institution did the MEP work with on transferring/ transitioning the innovation(s)?

Research and Economic Development	MSU Tech Transfer
College of Engineering	Technology Transfer
College of Business and Economics	Nanotechnology Center
School of Food Science	Discovery Center
ASU Tech Park	Manufacturing Outreach Center
Engineering	President's Office
Engineering & STEM Innovation	Tech Transfer Office
Non-Credit / Professional	Economic Development and Partnerships
Engineering & STEM	Division of Research and Econ Dev
Bio-Med	Brown University
Food	Tech Transfer Office
Engineering & STEM	Engineering School - Poly Tech Campus
Non-Credit / Professional	Tech Transfer
Business	Special Projects
Industrial Engineering	Tech Transfer
Industrial Engineering	CORIS
Industrial Engineering	Product Development Lab
College of Business	Innovation Center
Economic Development	Innovation Labs
Materials Research Institute	Engineering
Montana Nanotechnology Lab	IMS
Techlink	Electrical and Computer Engineering

3c Did the institutional partner provide services to support application of the innovation being transferred (e.g., systems integration; instruction on new equipment/processes; etc.)?

- Yes = 12
- No = 7

3d. What types of services?

Grant support
 Lab, equipment, student, faculty support
 Facility, faculty, student support
 Lab, equipment, faculty support
 Automation/Robotics implementation
 Product design
 Material analysis
 Engineering
 Supply Chain
 Cyber
 Engineering
 Food Expertise
 Supply Chain
 Engineering
 Technical Instruction
 Instruction
 Market Research
 Medical industry expertise

Analysis of snowboard layers for optimized bonding
 material and processing data
 Automation support
 Additive demonstration and support
 Tech Transfer Approach
 Instruction/knowledge transfer
 engineering
 programming
 They helped us develop an adhesive film for a client
 We used the labs to develop a product
 We used their HAAS Labs for training of our CNC Program
 engineering and analysis and testing
 materials and biochemistry
 Curriculum Development

might include technical, marketing, management, I-Corps, and others)

4. Has the Center referred MEP **clients** to other training (not related to a specific transferred technology) from a university, other academic or research institution including federal laboratories? (Examples

- Yes = 14;
- no = 9

4b. What types of training were provide to MEP clients? Please specify:

Automation	CNC
Robotics	Machining
Cyber Physical Security	Advanced Manufacturing
Management development	Company Assessments
Lean startup	Productivity
Food safety	Technology
manufacturing/machining/welding	Workforce
engineering	Environmental
Innovation	iCorp
Supply Chain	Engineering
Food	Additive
	Engineering
	ISO

5. Have other resources and services been provided by a university, other academic or research institution including federal laboratories? (Examples might include laboratories, production facilities, testing and evaluation, workshops, seminars, mentoring, networking, and others.)

- Yes: 14;
- no = 9

What types of resources and services?

Engineering labs	webinars
Training facilities	consultation
Food pilot plant	training
Materials Testing Laboratories	grant management
Licensing and Tech Transfer Advice	consultation
Process Improvement Mentoring	Incubator
Product Performance Validation	Prototyping
Seminars	Training
Workshops	Laboratory Services
Mentoring	Board Membership
Mfg. Site Visits	Inspection

Project collaboration
Testing
evaluation

structural analysis and redesign of equipment
materials analysis of failure of fabric adhesive
dielectric coating of conductor cable

6. Does the MEP interact or participate in other activities with a federal [Manufacturing USA Institute\(s\)](#) or other federal lab? (Examples might include workforce development, equipment use, MEP staff participation in planning, networking, and others.)

- Yes = 11
- No = 12
- Skipped = 1

6.a What institutes or federal labs?

MxD (5)

ARMI (1)

NIIMBL (1)

Institute for Advanced Composites Manufacturing Innovation (IACMI) (3)

Clean Energy Smart Manufacturing Innovation Institute (CESMII) (3)

Rapid Advancement in Process Intensification Deployment (RAPID) Institute (4)

ARM (3)

LIFT (1)

Nextflex (1)

6b. What type of activity?

Cybersecurity

Support - Workshops

WFD

Support - Workshops

WFD

Equipment Use

Networking

Digital Mfg. Training for MEPs

Embed

Mfg. Assessments

Conference

Training

Technology Implementation

Awareness

Assessment

Client visits

outreach

Partner meetings

Digital Manufacturing

3D Manufacturing

embed program, present locally

RAPID meetings

inducing engagement with SMMs

Presented at OMEP Summit

member/meeting attendance

Presented at OMEP Summit

Bring clients to the AFFOA Lab

Partner on projects with the AFFOA Node

Partner on projects with the ARM and AIM nodes

workforce development - apprenticeship program

smart manufacturing

energy conservation

composite technology



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