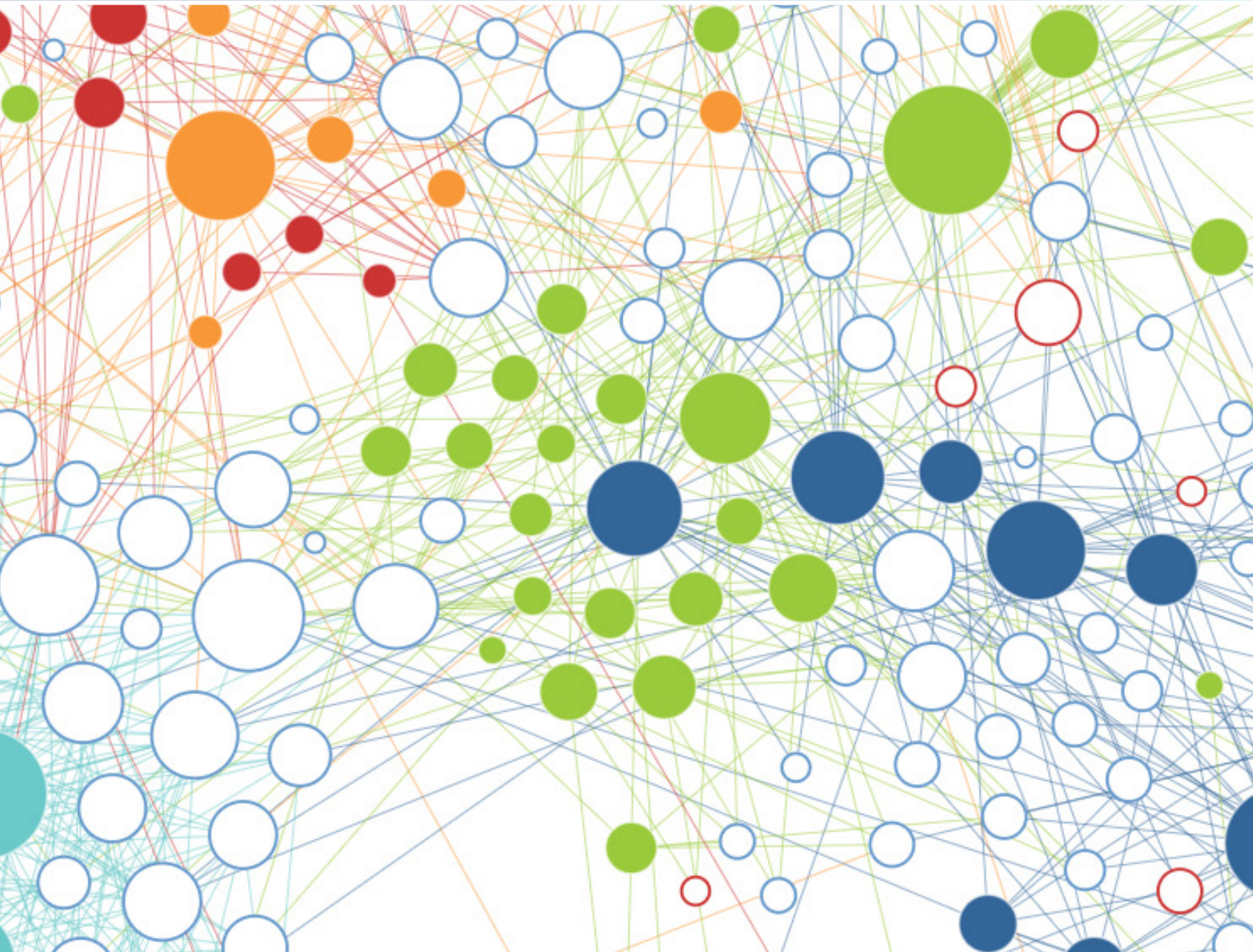
Manufacturing USA®

Manufacturing USA Advanced Manufacturing Occupation and Competency Framework

2026



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2026

Office of Advanced Manufacturing
National Institute of Standards and Technology
U.S. Department of Commerce

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ABOUT

The Manufacturing USA Advanced Manufacturing Occupation and Competency Framework

The **2026 Manufacturing USA Advanced Manufacturing Occupation and Competency Framework** was developed by the Office of Advanced Manufacturing (OAM) at the National Institute of Standards and Technology (NIST) and prepared by staff from OAM, the Nexight Group, and the Manufacturing USA institutes and their sponsoring federal agencies. Notable contributors include Aaron Bell, Brad Conrad, Jeremiah Forshey, Rob Foy, Joseph Long, and Ashley Smith-Schoettker.

This competency framework was developed in direct response to Revitalizing America's Manufacturing Workforce: A Manufacturing USA National Roadmap, which identifies ways for the Manufacturing USA network to work together to develop and scale learning and development opportunities to equip the current, emerging, and future workforce with advanced manufacturing skills. A primary goal of developing the framework is to support NIST OAM's responsibilities for program office coordination of Manufacturing USA's workforce development network activities, which include guiding and coordinating credentialing efforts across the network. The data collected for this framework will facilitate greater reach of network-wide workforce development projects, agency planning efforts, and individual institute workforce programs.

About Manufacturing USA

Manufacturing USA® helps secure U.S. global leadership in advanced manufacturing through large-scale public-private collaboration on technology, supply chain, and advanced manufacturing workforce development. The network includes the U.S. Departments of Commerce, Energy, and Defense, their 17 sponsored manufacturing innovation institutes, and six additional federal agency partners, creating a whole-of-government, national effort to drive innovation in manufacturing.

In 2024, the institutes:

Collectively worked with over

3,100 **member organizations**

to collaborate on **more than 875** applied research and development technology **projects of high priority to industry**

Attracted

$392M from **state, federal,** and **private funds**

In addition to **$133M** in base federal funding

Engaged over

200,000 **people**

in **building workforce knowledge and skills** in advanced manufacturing

Visit **manufacturingusa.com** to learn more and **EWD Connect** to explore Manufacturing USA workforce programs

Contents

Executive Summary

The Manufacturing USA Advanced Manufacturing Occupation and Competency Framework (MFG USA Competency Framework) was developed in response to the need for a more organized set of competencies and skills related to the industries served by the 17 Manufacturing USA institutes. Through a cooperative and iterative process with institute representatives, the sets of **Knowledge, Skills,** and **Abilities** (KSAs) needed by workers in advanced manufacturing were identified and catalogued. The result is a comprehensive set of competencies, sub-competencies, and KSAs interconnected across the Manufacturing USA network. Highlights and collaboration opportunities are presented here.

THE NEED

Advanced manufacturing in the United States is a foundational component of the U.S. economy and a platform for providing good jobs to a resurgent middle class. With domestically developed advances in technology, the U.S. can realize the potential of advanced manufacturing at home while strengthening its role as a manufacturing leader across the globe. However, **to achieve these goals and meet opportunities for reshoring manufacturing, the manufacturing industry must address its ongoing challenge of attracting and retaining workers while also ensuring it has access to a skilled workforce.**

Advanced manufacturing jobs require workers with a broad range of experience levels and skill sets. Reaching potential workers who may either be unaware of these jobs or incorrectly believe they are unqualified for them is vital for growing the workforce pipeline. Aligning workforce programs with industry's evolving needs and collaborating on these programs across industry sectors can support both current and future workers at a variety of points in their career journey across multiple advanced manufacturing fields.

A clear description of common skills and abilities required across multiple industry sectors (and the ways in which those skills can be successfully leveraged in manufacturing careers) is currently not available for the U.S. advanced manufacturing industry. While there has been significant growth within advanced manufacturing around credentialing in the past few years, current efforts remain fragmented, making it difficult for workers to navigate these opportunities and for industry-wide adoption of credentialing programs to occur. Industry and workers in many cases do not have a clear system of certificates, credentials, degrees, and endorsements, which impedes workforce development efforts for both prospective workers and industry-led training providers. This competency framework initiative was undertaken to provide coherent national and scalable support services to promote workforce development activities, including the development of industry credentials. These efforts can accelerate the development of an advanced manufacturing workforce and technologies across the Manufacturing USA network.

Framework Definitions

Knowledge, skill, or ability (KSA)

what a person needs to know and be able to do to perform well in a specific job, occupation, or industry[1]

Competency (X.X)

a set of related knowledge, skills, and abilities (KSAs) required to successfully perform "critical work functions" or tasks in a defined work setting[2]

Example: 4.2 Operations Management

Sub-competency (X.X.X)

a specific subset of KSAs in a competency

Example: 4.2.5 Manufacturing Tool and Equipment Management

Competency Model

a collection of multiple competencies that together define successful performance in a defined work setting[3]

Competency Framework

a collection of competency models

Occupation

the kind of work a person does on the job; may encompass multiple roles in a job[4]

KSA/Occupation Connection

one KSA matched to one occupation

THE SOLUTION

The Manufacturing USA network developed the **Manufacturing USA Occupation and Competency Framework** to equip job seekers, employers, and trainers with the common language and understanding they need to successfully meet the advanced manufacturing industry's workforce needs. The MFG USA Competency Framework:

- Outlines the most common entry-level occupations in the advanced manufacturing space as well as the knowledge, skills, and abilities that workers need, both now and in the future, to work with cutting-edge manufacturing technologies
- Provides a common language around occupations, skills, and competencies to improve collaboration among the Manufacturing USA institutes and their industry partners

THE PROCESS

In 2025, all 17 Manufacturing USA institutes identified key entry-level occupations that are important to their industry members and the KSAs essential to at least one of those occupations. This input was cross-referenced with widely accepted competency models—including those published by the Department of Labor (DOL) and the institutes themselves—and was either correlated using those competencies or catalogued under new, cutting-edge competencies.[5] Institute leads refined their own occupation and competency selections through multiple iterations of review and discussion of one another's work. In 2026, the institutes reviewed and provided updates to their initial selections of key entry-level occupations and essential KSAs. The institutes provide a window into the cutting-edge industries actively recruiting workers, and their invaluable input ensures this document is up to date with the skills needed by manufacturers.

1 "About the Competency Models," Competency Model Clearinghouse, accessed July 14, 2025, https://www.careeronestop.org/CompetencyModel/GetStarted/about-models-help.aspx.

2 "About the Competency Models," supra, note 2.

3 "About the Competency Models," supra, note 2.

4 "About Occupation," U.S. Census Bureau, accessed July 14, 2025, https://www.census.gov/topics/employment/industry-occupation/about/occupation.html.

5 "Industry Models," Competency Model Clearinghouse, accessed July 14, 2025, https://www.careeronestop.org/CompetencyModel/Competency-Models/pyramid-home.aspx.

THE RESULT

The **MFG USA Competency Framework** is a first-of-its-kind framework that builds on existing DOL models while spanning the five technology areas covered by the 17 Manufacturing USA institutes.

The MFG USA Competency Framework contains:

421	113	13	79	over 1,700
unique KSAs	**occupations**	**competencies**	**sub-competencies**	**data points ("connections")**

The organization of this data by occupation, competency, and KSA is a key strength of the framework as it facilitates targeting information to various groups, including job seekers, trainers, and employers. The information in the framework enables the Manufacturing USA institutes to understand the skills and occupations that are important to their industries, identify where those skills and occupations overlap with other industries, and leverage their potential connections with other institutes. Using this analysis, training providers can create targeted content in a focused, data-driven manner.

THE TAKEAWAY

This framework provides the key first step to accelerating the recruitment and training of workers across the country: **connecting industry's most important skills, competencies, and occupations in the advanced manufacturing technology fields to existing frameworks, institutes, and workforce development efforts.**

Additionally, institutes now have an aligned set of KSAs that are customized to their specific advanced manufacturing ecosystems. The framework reveals many opportunities for collaboration and information sharing across the Manufacturing USA institutes, some of which are highlighted here. Full access to the KSA data sets by institute and technology area will be made available to the institute members to facilitate such collaborative efforts.

Methodology and Connections to other Frameworks

The MFG USA Competency Framework **builds and expands on pre-existing competency models related to advanced manufacturing.** The U.S. Department of Labor Employment and Training Administration works closely with industry partners to develop competency models that cover economically vital industries and sectors of the U.S. economy through the Competency Model Clearinghouse (CMC).[6] KSAs provided by the institutes were aligned where possible with the Department of Labor's Advanced Manufacturing Competency Model[7] (DOL AMCM), allowing the base of the MFG USA Competency Framework to be structured similarly to the DOL AMCM.

The first three tiers of the DOL AMCM are known as the Foundational Tiers and cover fundamental skills essential for success in all job types.[8] As such, the MFG USA Competency Framework adopts these first three tiers as foundational building blocks for this model, though only at the tier level (See Figure 1).

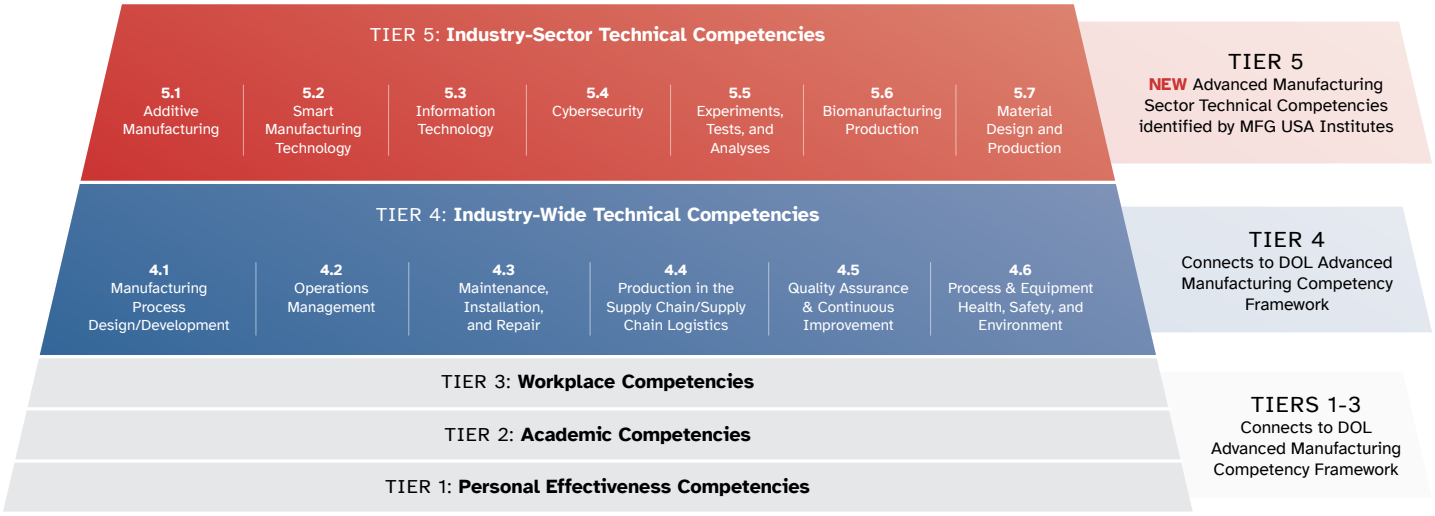


Figure 1: The MFG USA Competency Framework building blocks, including the 13 core competencies, based on the DOL Advanced Manufacturing framework

6 "Industry Models," Competency Model Clearinghouse (CMC), accessed July 14, 2025, https://www.careeronestop.org/CompetencyModel/Competency-Models/pyramid-home.aspx.

7 "Advanced Manufacturing Competency Model," CMC, accessed July 14, 2025 https://www.careeronestop.org/CompetencyModel/competency-models/advanced-manufacturing.aspx.

8 "Building Blocks Model," CMC, accessed July 14, 2025, https://www.careeronestop.org/CompetencyModel/competency-models/building-blocks-model.aspx.

The Tier 4 Industry-Wide Technical Competencies in the DOL AMCM are specifically tailored to the advanced manufacturing industry and serve as the starting point for this framework. **The six major competencies in the DOL AMCM's Tier 4 Industry-Wide Technical Competencies were all identified as essential by at least one institute.**

For more specialized KSAs that did not align with Tier 4 in the DOL AMCM, a fifth tier was created for this framework that references the DOL Bioscience Competency Model (DOL BCM),[9] the DOL Information Technology Competency Model (DOL ITCM),[10] and the NICE Workforce Framework for Cybersecurity (NICE Framework).[11] Seven competencies were created for Tier 5, titled the "Advanced Manufacturing Sector Technical Competencies" (see Figure 1). **The Tier 5 Technical Competencies reflect the leading edge of advanced manufacturing technology.**

89% of essential KSAs identified by the institutes align with one of the four models mentioned above

77% of essential KSAs aligned with the DOL AMCM

- **29%** - Operations Management (4.2) competency
- **22%** - Manufacturing Process Design/ Development (4.1) competency

Tier 4 and Tier 5 in this framework contain a total of 13 competencies, which are referred to collectively as the core competencies. Details of the 13 core competencies and their sub-competencies can be found in Appendix A.

Table 1: *A list of the working definitions for the Tier-5 Technical Competencies used for this analysis*

Tier 5	(Sub-) Competencies	Definitions
5.1	**Additive Manufacturing**	Design and manufacture products using layer-by-layer fabrication by understanding and applying additive manufacturing principles.
5.2	**Smart Manufacturing Technology**	Implement fully-integrated, collaborative manufacturing systems that respond to changing factory operations in real-time.
5.3	**Information Technology**	Advanced knowledge and application of Information Technologies to manufacturing systems.
5.4	**NICE Framework/Cybersecurity**	Advanced knowledge and application of cybersecurity fundamentals in manufacturing operations.
5.5	**Experiments, Tests, and Analyses**	Implement specific scientific techniques to synthesize, assess, and maintain manufactured products derived from biological system processes.
5.6	**Biomanufacturing Production**	Implement advanced processes for the manufacture of bioscience products.
5.7	**Material Design and Production**	Implement advanced material design and production methods to manufacturing systems.

9 "Bioscience Competency Model," CMC, accessed July 14, 2025 https://www.careeronestop.org/CompetencyModel/competency-models/bioscience.aspx.

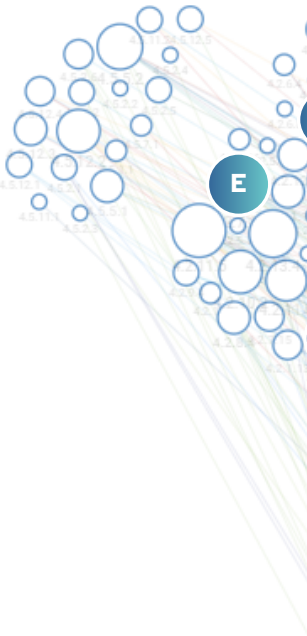
10 "Information Technology Competency Model," CMC, accessed on July 14, 2025 https://www.careeronestop.org/CompetencyModel/competency-models/information-technology.aspx.

11 "NICE Framework for Cybersecurity," National Initiative for Cybersecurity Careers and Studies, accessed July 14, 2025 https://niccs.cisa.gov/tools/nice-framework.

Network Insights

Analysis of the MFG USA Competency Framework revealed the following:

- **Over 1,700 KSA/Occupation connections link the entire Manufacturing USA network**
- **32% of essential KSAs cross technology area lines**
- **33% of essential KSAs are shared by 3 or more institutes**
- **15% of essential KSAs align with 8+ occupations**



113 occupations were provided by the institutes. Of those occupation selections, 65% (72 occupations) were specific to a single institute while the remaining 35% (39 occupations) were selected by more than one institute. The most frequently identified occupations were:

- **Process Engineers (9 institutes)**
- **Mechanical Engineers (6 institutes)**
- **Electrical Engineers (5 institutes)**
- **Design Engineers (5 institutes)**

The combination of institute-specific and more common occupations in the framework indicates that, similarly to the essential KSAs they identified, there is considerable opportunity for collaboration on occupation-based programs across the network and there are specific, cutting-edge roles that the Manufacturing USA institutes can play in training the workforce in their industries. KSAs tied to Artificial Intelligence tools are likely to increase significantly in future iterations of this report.

The connections between essential KSAs, occupations, institutes, technology areas, and sponsoring agencies are shown in Figure 2.

Most Commonly Selected Essential KSAs Across the Manufacturing USA Network:

A. Knowledge and use of computer-aided design (CAD)/computer-aided manufacturing (CAM) software (4.1.2)

B. Data collection and analysis (4.1.7)

C. Machine and equipment operations (4.2.5)

D. Use computers, computer-interfaced equipment, robotics or high-technology industrial applications to perform work duties (4.2.6 and 4.2.9)

E. Review instructions to determine operational methods or sequences (4.2.7)

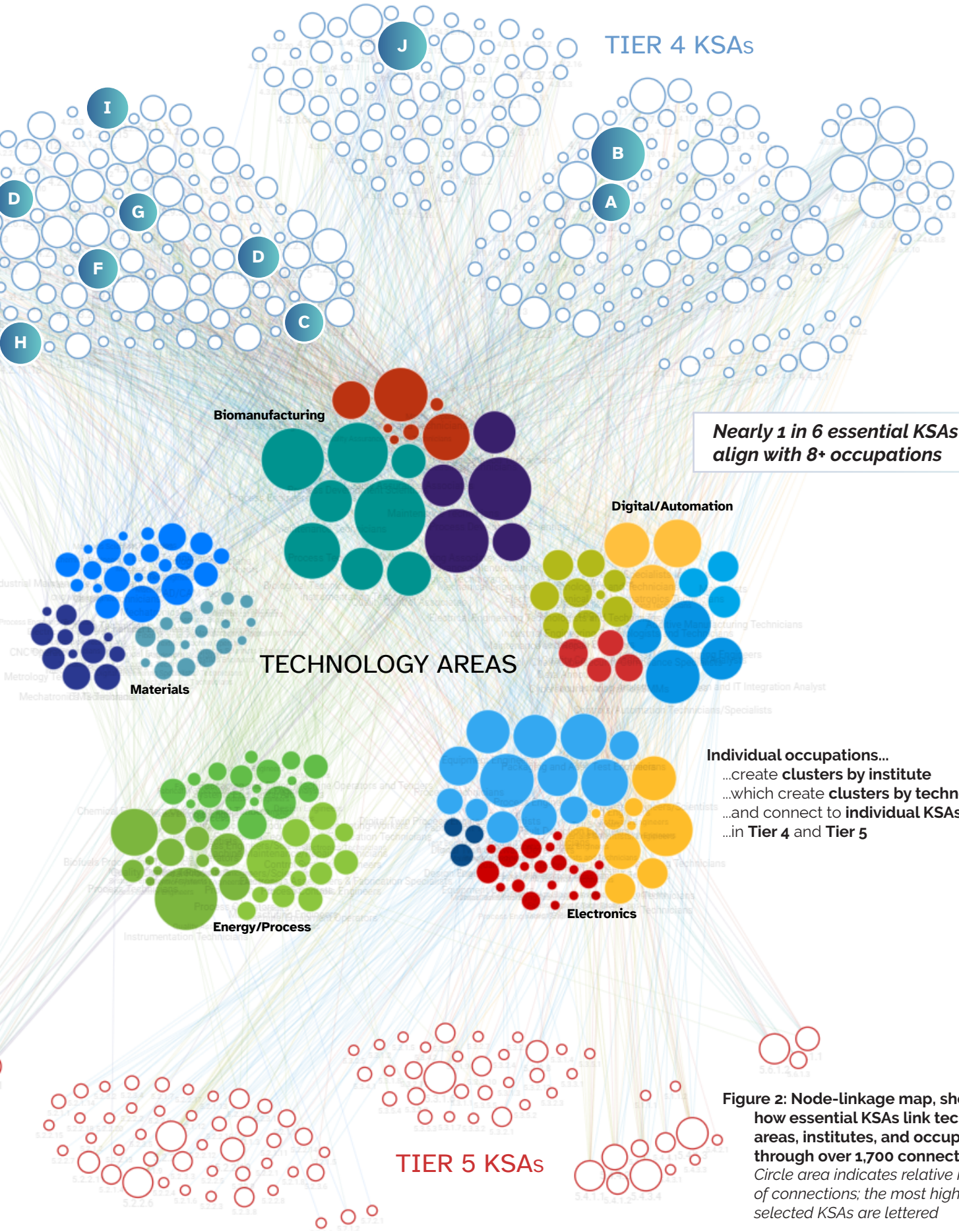
F. Operation and control of manufacturing machinery (4.2.9)

G. Documenting and reporting information and data (4.2.11)

H. Understand and execute test and measurement assays (4.2.11)

I. Production/process troubleshooting (4.2.11)

J. Use basic hand tools in a safe and efficient manner to shape and form simple components (4.3.2)



Nearly 1 in 6 essential KSAs align with 8+ occupations

Individual occupations...
...create **clusters by institute**
...which create **clusters by technology area**
...and connect to **individual KSAs**
...in **Tier 4** and **Tier 5**

Figure 2: Node-linkage map, showing how essential KSAs link technology areas, institutes, and occupations through over 1,700 connections. *Circle area indicates relative number of connections; the most highly selected KSAs are lettered*

Technology Area Highlights

Opportunities exist for collaboration between technology areas, which benefits the network.

Each Manufacturing USA institute works in a specific industry with a focus on an advanced manufacturing technology or collection of technologies. Some institutes work on subjects more closely related than others; to help facilitate collaboration and navigate the network, the Manufacturing USA institutes are organized into five general technology areas for this analysis, as shown in Table 2.

Table 2: *Institute Associations with Technology Areas for this Analysis*

BIOMANUFACTURING	DIGITAL/AUTOMATION	ELECTRONICS	ENERGY/PROCESS	MATERIALS
BioFabUSA	America Makes	AIM Photonics	EPIXC	AFFOA
BioMADE	ARM Institute	NextFlex	RAPID	IACMI
NIIMBL	CESMII	PowerAmerica	REMADE	LIFT
	CyManII			
	MxD			

Collaboration within a technology area is an important method for advancing network and institute education and workforce development goals. Each institute has opportunities to collaborate with technology area peers, although the extent of this varies by technology area. Additionally, many technology areas share KSAs, occupations, and connections (as mentioned above and seen in Figure 3).

The next section highlights key statistics for each technology area, identifies the KSAs with the most impact potential, and addresses collaboration opportunities within and across technology areas.

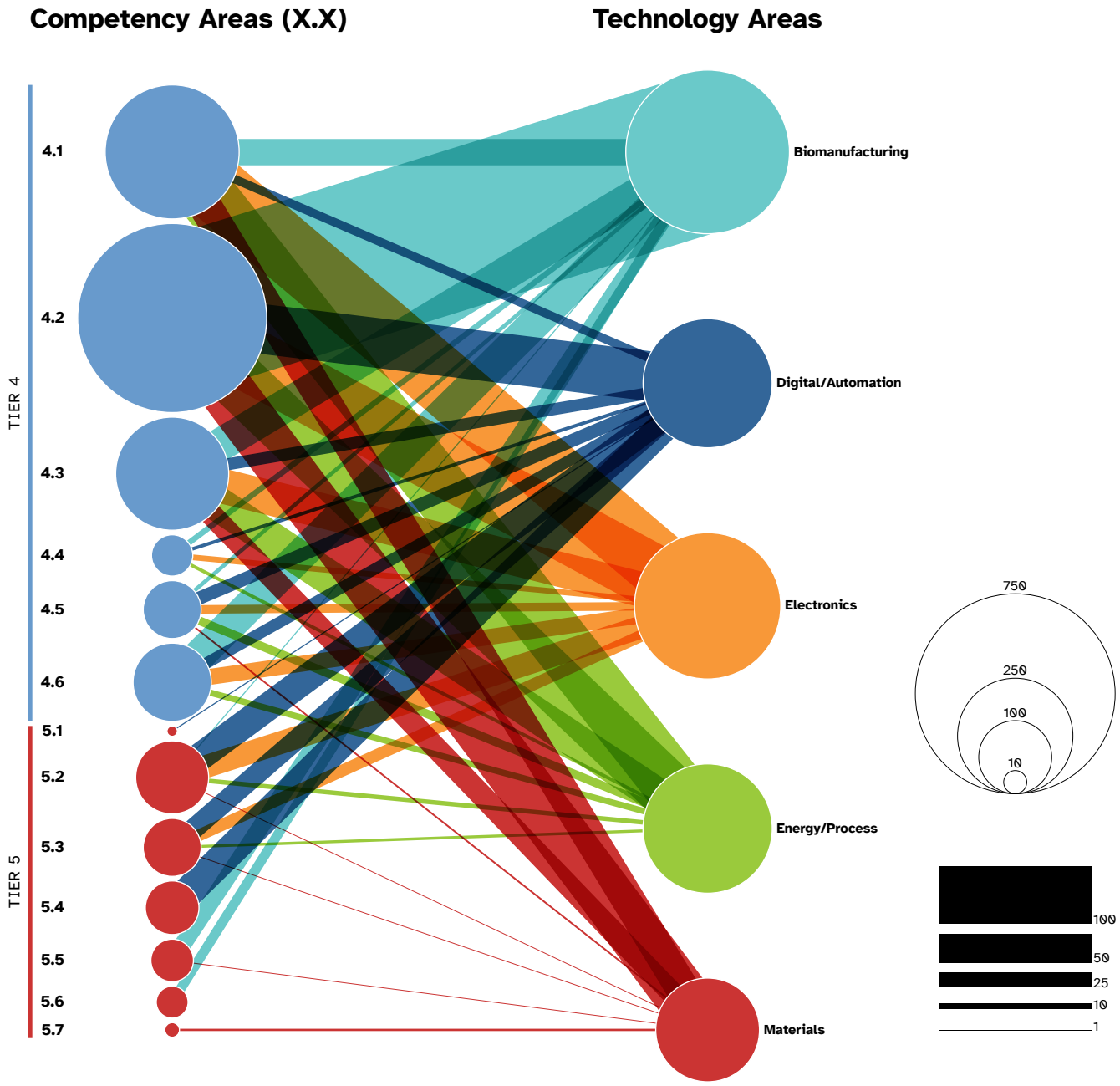


Figure 3: Relationships between the 13 core competencies and the 5 technology areas.
Line thickness and circle area indicates relative number of connections

BIOMANUFACTURING

Biomanufacturing technology uses systems and processes to create biological products for commercial use, including in industries such as agriculture, energy, chemicals, materials, and pharmaceuticals. The biomanufacturing institutes—**BioFabUSA, BioMADE, and NIIMBL**— identified 66 KSAs as essential for at least one occupation.

- **57 of the 66 KSAs (86%)** selected by the biomanufacturing institutes are shared with their technology areas peers, with 46 of the 66 KSAs (70%) selected by all three institutes and another 11 selected by two
- **10 of the 66 KSAs (15%)** are specific to the biomanufacturing technology area

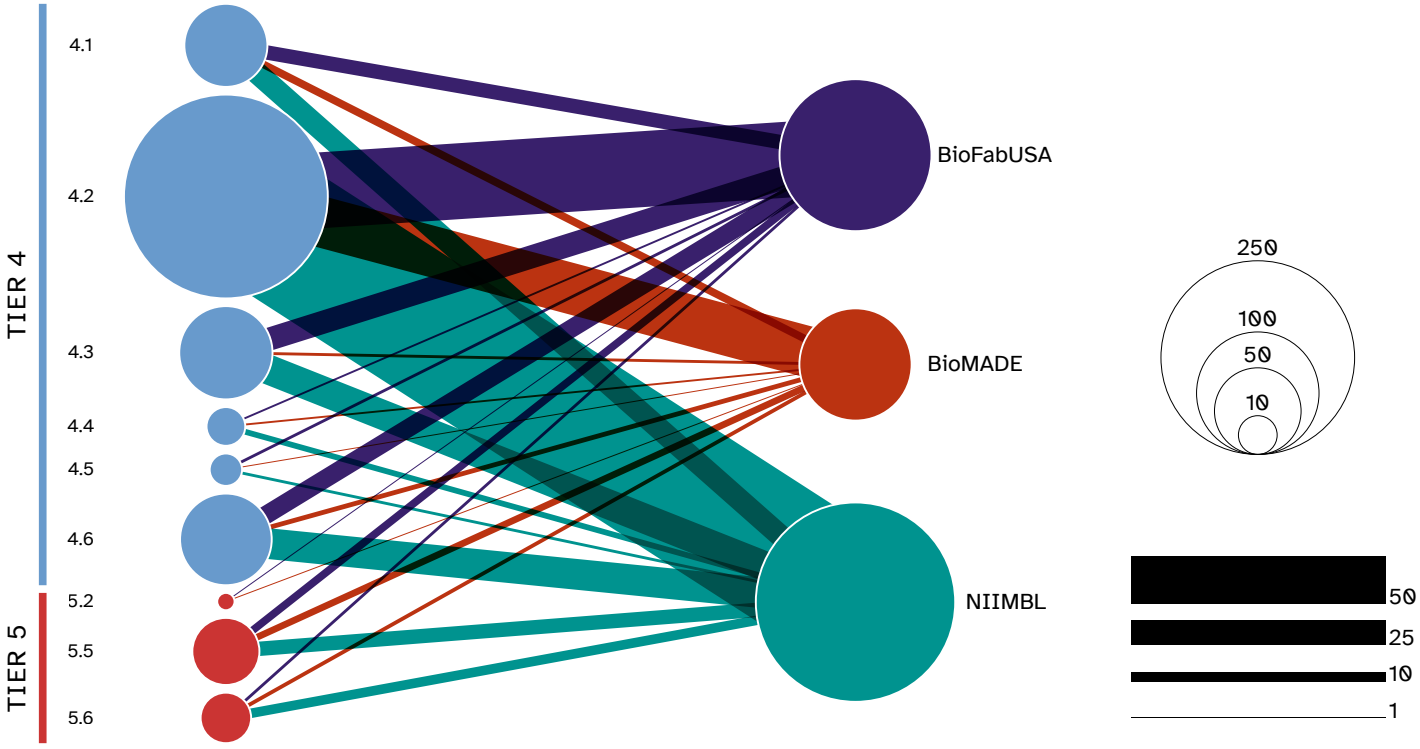


Figure 4: Institute occupation competency mapping for the biomanufacturing technology area.
Line thickness and circle area indicates relative number of connections

Figure 5: KSAs shared by the biomanufacturing technology area and the other Manufacturing USA technology areas

Frequently selected biomanufacturing-specific KSAs:

Sub-Competency (X.X.X), KSA	
4.2.5	**Manufacturing Tool and Equipment Operation** Set up, adjust, calibrate, clean, maintain, and troubleshoot laboratory and field equipment
4.2.8	**Industrial Processes** Provide support and services for scientists and engineers working in fields such as agriculture, environmental science, resource management, biology, and health sciences
4.6.8	**Safety Procedures** Understand and execute safety and cleaning procedures
5.5.3	**Protein Techniques** Protein purification analysis

Frequently selected network-wide KSAs :

Sub-Competency (X.X.X), KSA	
4.1.7	**Testing/Troubleshooting** Data collection and analysis
4.2.5	**Industrial Productions** Use computers, computer-aided interfaced equipment, robotics or high-technology industrial applications to perform work duties
4.2.11	**Production/Process Monitoring** Understand and execute test and measurement assays
4.3.2	**Maintenance, Installation, and Repair-Critical Skills** Use basic hand tools in a safe and efficient manner to shape and form simple components

As the majority of KSAs selected by the three biomanufacturing institutes are shared by at least one of their biomanufacturing peers, there is considerable potential for the biomanufacturing institutes to engage in **beneficial collaboration on training programs around shared KSAs.** Additionally, they should look to connect with the **energy/process institutes** as they share many KSA connections with that technology area.

DIGITAL/AUTOMATION

Digital control and automation technologies use cutting-edge computer technology to optimize operational and information technology convergence in cyber-physical systems, improving the flexibility, efficiency, and productivity of the manufacturing industry. The digital/automation institutes—**America Makes, ARM Institute, CESMII, CyManII, and MxD**—identified 106 KSAs as essential for at least one occupation.

- **49 of the 106 KSAs (46%) are specific** to the digital/automation technology area
- **23 of those 49 unique KSAs (47%)** were selected by more than one digital/automation institute
- **32 of those 49 unique KSAs (65%)** fall within the Advanced Manufacturing Sector Technical Competencies (Tier 5), which represent the leading edge of technological advancements

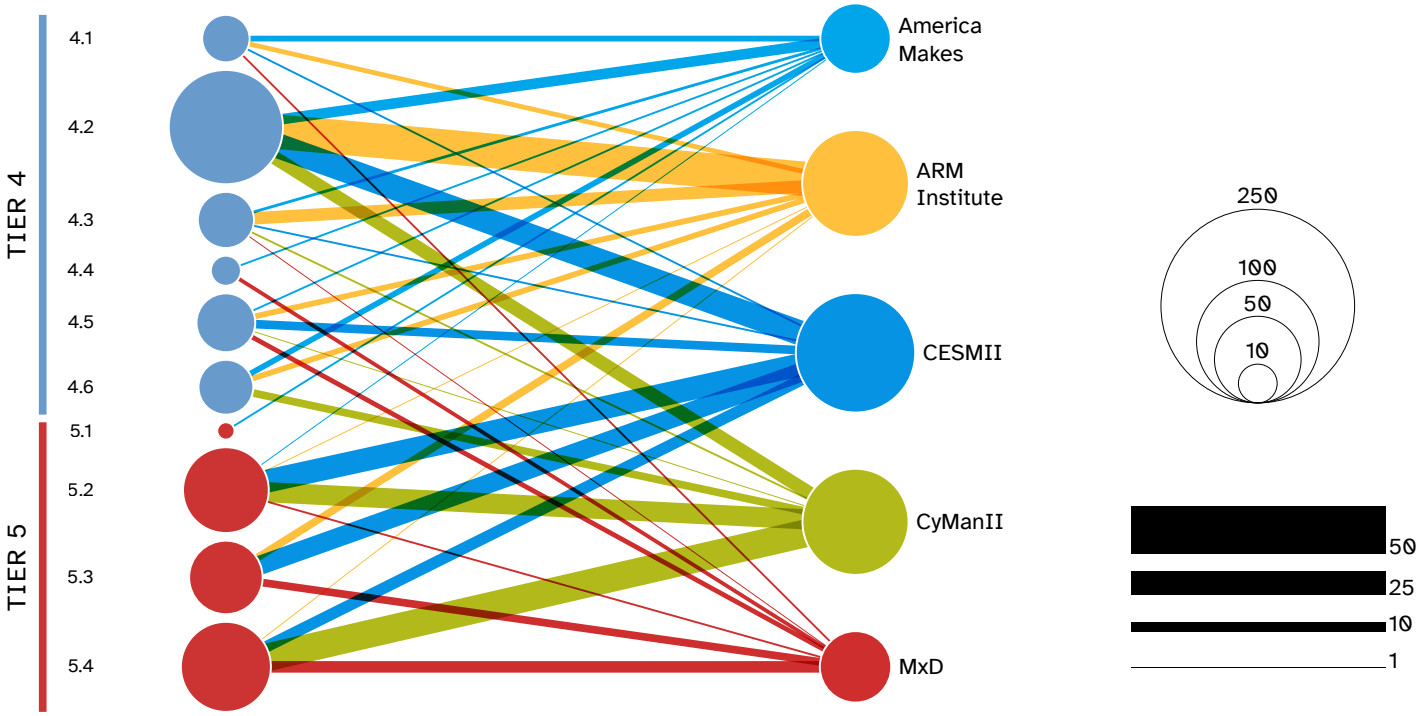


Figure 6: Institute occupation competency mapping for the digital/automation technology area.
Line thickness and circle area indicates relative number of connections

Figure 7: KSAs shared by the digital/automation technology area and the other Manufacturing USA technology areas

Frequently selected digital/ automation-specific KSAs:

Sub-Competency (X.X.X), KSA	
4.2.11	**Production/Process Monitoring** Operational Technology (OT)
5.2.2	**Information Technology (IT)/ Operational Technology (OT) Integration** Industrial Internet of Things devices Cyber-Physical Systems (CPS)
5.4.1	**Cybersecurity Fundamentals** Understand and use cybersecurity fundamentals
5.4.3	**Cyber-Resiliency** Resilient cybersecurity response, administrative tools, and program implementation

Frequently selected network-wide KSAs :

Sub-Competency (X.X.X), KSA	
4.1.2	**Technical Drawings and Schematics** Knowledge and use of computer-aided design (CAD)/computer-aided manufacturing (CAM) software
4.1.7	**Testing/Troubleshooting** Data collection and analysis
4.2.5	**Manufacturing Tool and Equipment Operations** Machine and equipment operations Monitor manufacturing operations
4.2.11	**Production/Process Monitoring** Production/process troubleshooting

The breadth of KSAs that are unique to the digital/automation technology area indicates that **this emerging technology will require a concerted training effort to fully prepare the workforce.**

ELECTRONICS

The electronics industry develops the semiconductors, integrated photonics devices, and hybrid integrated circuits critical to the functioning of advanced electronic devices, while also using emerging technologies like digital twins to improve electronics manufacturing processes. The electronics institutes—including **AIM Photonics, NextFlex,** and **PowerAmerica**— identified 221 KSAs as essential for at least one occupation.[12]

- **34 of the 221 KSAs (15%) were identified as essential** by more than one electronics institute
- **158 of the 221 KSAs (72%)** are specific to the electronics technology area
- **43 of the 158 unique KSAs (27%)** fall within the Advanced Manufacturing Sector Technical Competencies (Tier 5), which represent the leading edge of technological advancements

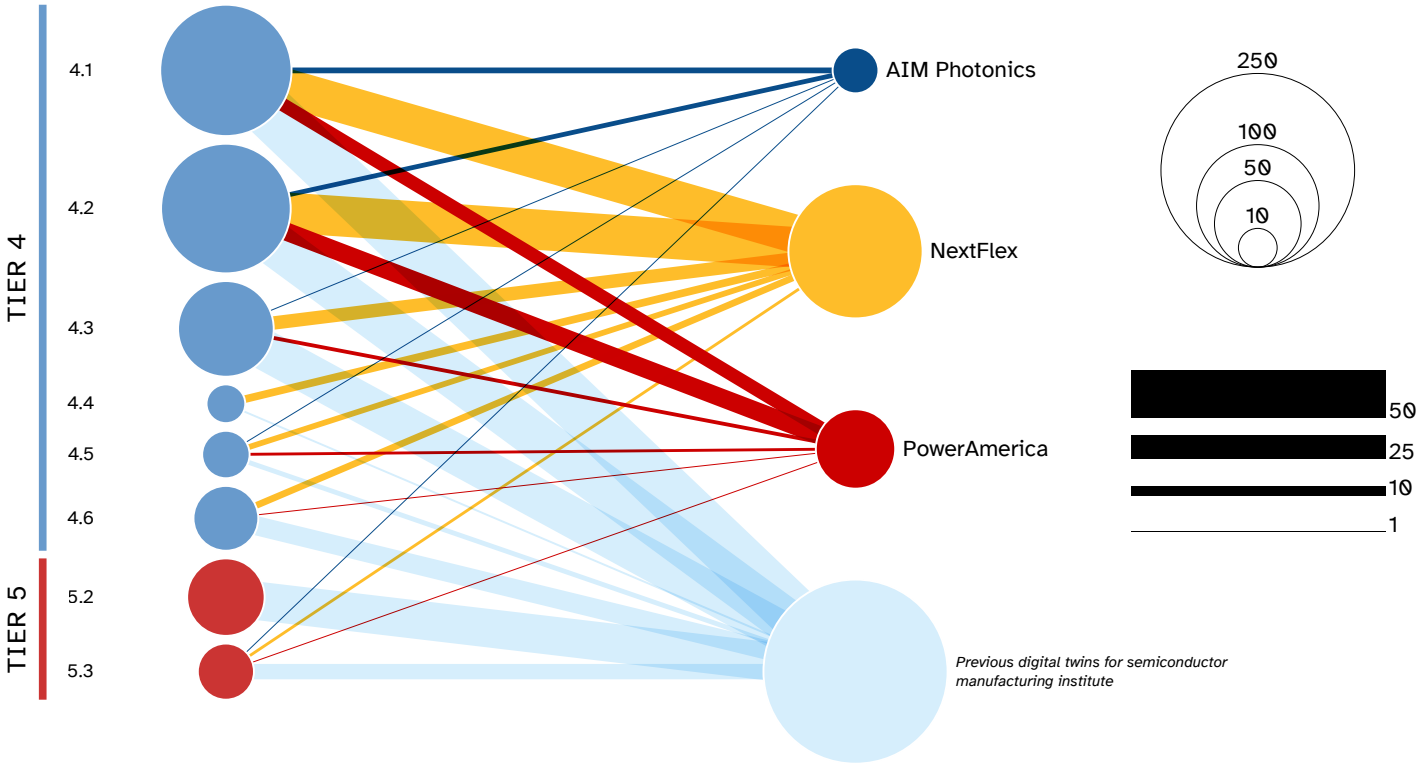


Figure 8: Institute occupation competency mapping for the electronics technology area.
Line thickness and circle area indicates relative number of connections

12 Data provided by the previous ditigal twins for semiconductor manufacturing institute at the end of 2025.

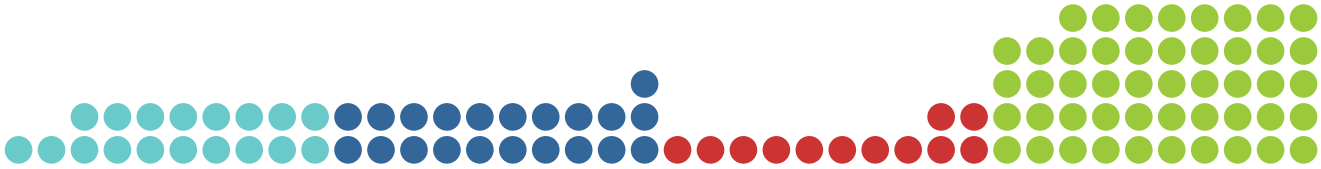


Figure 9: KSAs shared by the electronics technology area and the other Manufacturing USA technology areas

Frequently selected electronics-specific KSAs:

Sub-Competency (X.X.X), KSA	
4.2.7	**Manufacturing Process Applications and Operations** Assembly and packaging
4.3.29	**Electromechanical Systems** Electrical and mechanical system operation familiarity
4.3.33	**Reliability and Maintainability** Failure analysis
4.6.1	**Process and Equipment Health, Safety, and Environment—Critical Work Functions** Health and safety compliance

Frequently selected network-wide KSAs :

Sub-Competency (X.X.X), KSA	
4.1.7	**Testing/Troubleshooting** Data collection and reporting
4.2.5	**Manufacturing Tool and Equipment Operations** Machine and equipment operation
4.2.9	**Industrial Productions** Use computers, computer-interfaced equipment, robotics, or high-technology industrial applications to perform work duties
4.2.11	**Production/Process Monitoring** Understand and execute test and measurement assays
	Production/process troubleshooting

The frequently selected electronics-specific KSAs can act as starting points for collaborations that will benefit all four electronics institutes. Additionally, they should look to connect with the **energy/process institutes** as they share many KSA connections with that technology area.

ENERGY/PROCESS

Energy and industrial process technologies increase efficiency in manufacturing processes and reduce manufacturing costs across a variety of industries. The energy/process institutes—**EPIXC, RAPID, and REMADE**—identified 144 KSAs as essential for at least one occupation.

- **29 of the 144 KSAs (20%)** are specific to the energy/process technology area
- **32 KSAs (22%)** were selected by at least two of the three energy/process institutes
- **9 KSAs (6%)** were selected by all three energy/process institutes, five of which fall under the Manufacturing Process Design/Development competency and two of which are specific to the technology area

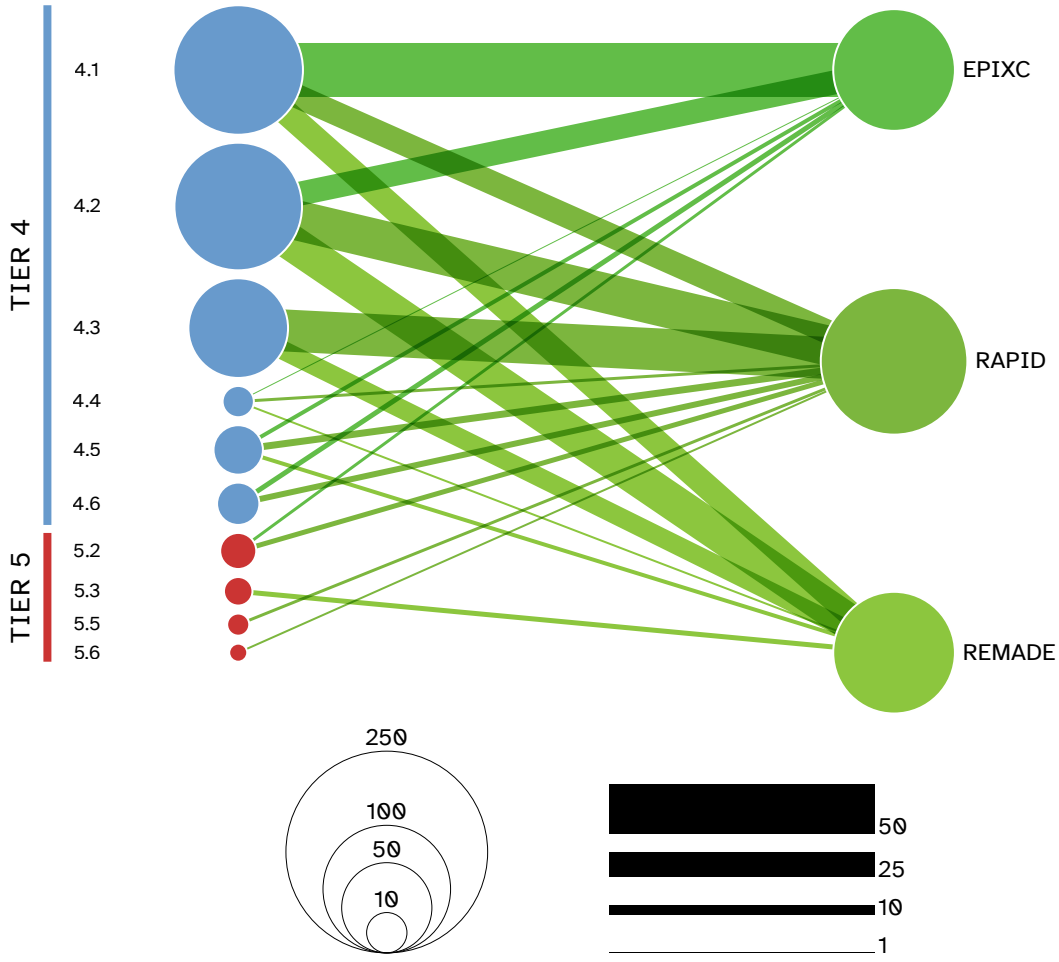
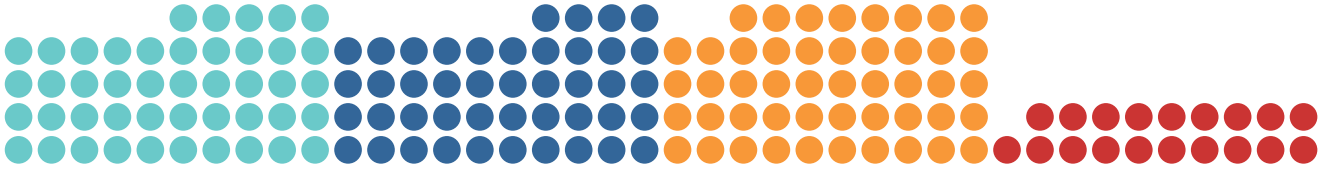


Figure 10: Institute occupation competency mapping for the energy/process technology area.
Line thickness and circle area indicates relative number of connections



Biomanufacturing
45 KSAs

Digital/Automation
44 KSAs

Electronics
48 KSAs

Materials
19 KSAs

Figure 11: KSAs shared by the energy/process technology area and the other Manufacturing USA technology areas

Frequently selected energy/process-specific KSAs:

Sub-Competency (X.X.X), KSA	
4.1.2	**Technical Drawings and Schematics**
	Process flow diagram/piping and instrumentation diagram drawing
	Technology design/system design
4.1.5	**Design Lifecycles and Concepts**
	Life Cycle Analysis (LCA)
4.3.2	**Maintenance, Installation, and Repair - General Skills**
	Disassembly/assembly skills
	Equipment/system/defect management
4.3.4	**Electrical Systems Maintenance, Installation, and Repair**
	Repair and calibrate electrical systems

Frequently selected network-wide KSAs :

Sub-Competency (X.X.X), KSA	
4.1.7	**Testing/Troubleshooting**
	Data collection/analysis
4.2.9	**Industrial Productions**
	Use computers, computer-interfaced equipment, robotics, or high-technology industrial applications to perform work duties
	Operation and control of manufacturing machinery
4.2.11	**Production/Process Monitoring**
	Production/process troubleshooting
	Understand and execute test and measurement assays

The frequently selected **energy/process-specific KSAs can act as starting points for collaboration** that will benefit all three energy/process institutes, but the **energy/process institutes should also look to peers across the network for collaborators** as each technology area's KSAs overlap the most with those of the energy/process technology area.

MATERIALS

Advanced materials are used in fields such as textiles, composites, and metals. The materials technology area focuses on developing these advanced materials and the technology used to produce them. The materials institutes—**AFFOA, IACMI, and LIFT**—identified 66 KSAs as essential for at least one occupation.

- **31 KSAs (47%)** were selected by two or more materials institutes
- **14 of those 31 KSAs** were specific to the materials technology area
- **13 KSAs (20%)** were selected by all three materials institutes

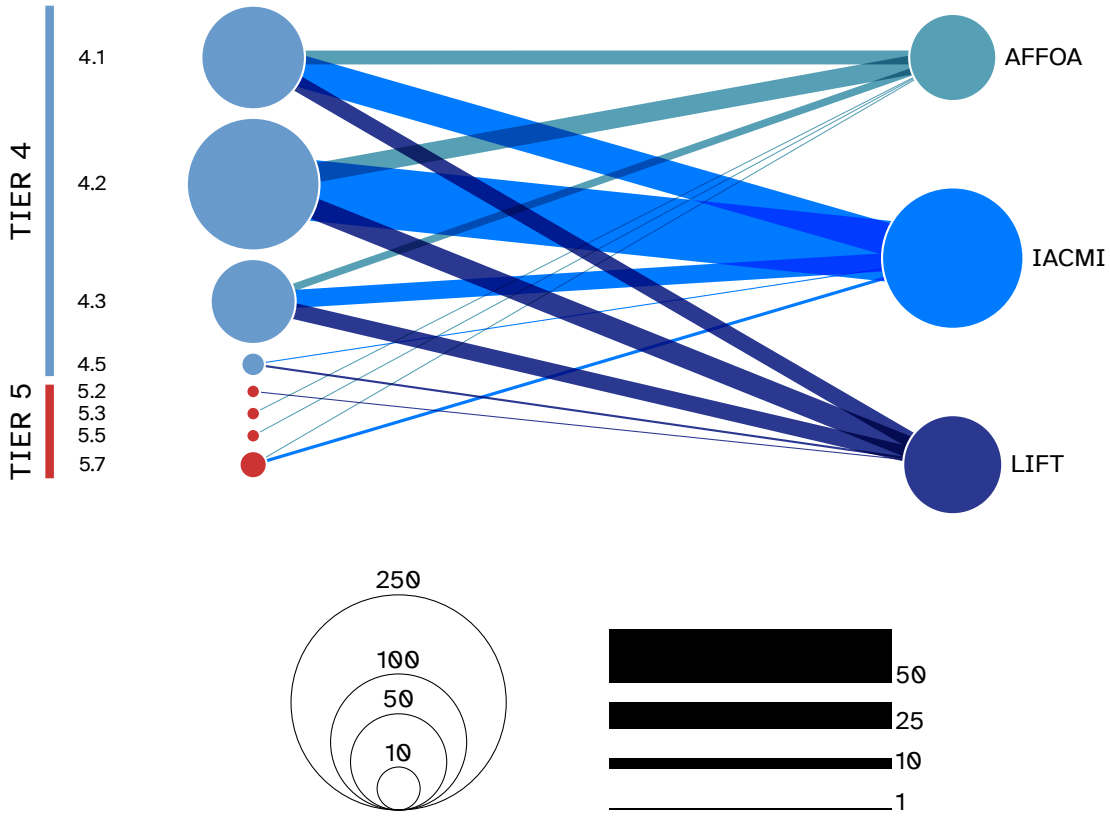


Figure 12: Institute occupation competency mapping for the materials technology area.
Line thickness and circle area indicates relative number of connections

Biomanufacturing
10 KSAs

Digital/Automation
12 KSAs

Electronics
12 KSAs

Energy/Processes
19 KSAs

Figure 13: KSAs shared by the materials technology area and the other Manufacturing USA technology areas

Frequently selected materials-specific KSAs:

Sub-Competency (X.X.X), KSA	
4.1.9	**Workflow Assessment** Oversee the manufacturing process of devices
4.2.9	**Industrial Productions** Quality control analysis
4.2.13	**Project Management and Execution** Work with project managers on production efforts to ensure that projects are completed satisfactorily, on time, and within budget

Frequently selected network-wide KSAs :

Sub-Competency (X.X.X), KSA	
4.1.7	**Testing/Troubleshooting** Data collection and analysis
4.2.9	**Industrial Productions** Operation and control of manufacturing machinery
4.2.11	**Production/Process Monitoring** Understand and execute test and measurement assays
4.3.2	**General Skills** Use basic hand tools in a safe and efficient manner to shape and form simple components

The materials institutes would benefit greatly from collaboration with each other as there is **close alignment in the KSAs needed by the materials institutes' industries.** Additionally, they should look to **connect with energy/process institutes** as they share many KSA connections with that technology area.

Conclusions

The analysis conducted as part of the MFG USA Competency Framework project identifies key areas for institute collaboration, both network-wide and within specific technology areas.

Across the technologies that are covered by the Manufacturing USA network, pre-existing training content could be used to more immediately target KSAs needed by the institutes' industry members. However, because the context of these trainings and their implications for specific technologies vary substantially, industry engagement will be critical to ensuring their use. The institutes have provided a clear window into the technologies that are critical to the industries they support, but continuous engagement is important for the validation and implementation of this framework. Therefore, an essential role of the institutes within workforce development should be the application of this existing content to new and emerging technologies, as well as the development of new content focused on the Tier 5 Advanced Manufacturing Sector Technical Competencies, for which the most specialized content will be needed by emerging industries.

NEXT STEPS

This analysis emphasizes forward-looking, transferable skills from across the technical areas of Manufacturing USA and highlights connections between different career pathways in advanced manufacturing and potential augmentations to other workforce frameworks. As technology evolves, so too will the needs of the advanced manufacturing industry, including the KSAs needed by the emerging and future workforce. For example, the 2026 data showcases a marked increase in the need for AI-related skills across many technology areas. It is expected that this trend in AI skills will increase as AI tools continue to permeate the manufacturing space, including the KSAs that entry-level workers will need. Therefore, to ensure the relevancy of the framework, this in-depth analysis benefits from regular institute-led industry validation.

This report serves as a potential guide for workforce professionals, training providers in the advanced manufacturing sectors, and other workforce frameworks. The analysis outlines actionable data to align curricula, training, and career pathways with the needs of the advanced manufacturing industry. This data can be used to show workers and potential workers the variety of skills needed in today's manufacturing jobs, making it more effective and efficient for people to pursue careers in advanced manufacturing. Through this analysis, individual institutes can identify credentialing efforts that would most benefit their members and areas where collaboration or coordination among the network members would benefit industry, the institute's approach to credentialing, and U.S. advanced manufacturing.

Appendix A

Table A1: *Tier 4 Competencies and Sub-Competencies in the MFG USA Competency Framework*

	Competency (4.X) Sub-competency (4.X.X)	Number of Essential KSAs
	4.1 Manufacturing Process Design/Development	
4.1.1	Critical Work Functions	**6**
4.1.2	Technical Drawings and Schematics	**27**
4.1.3	Engineering Concepts	**13**
4.1.5	Design Lifecycle and Concepts	**14**
4.1.7	Testing/Troubleshooting	**15**
4.1.8	Research and Development	**3**
4.1.9	Workflow Assessment	**13**
	4.2 Operations Management	
4.2.1	Critical Work Functions	**16**
4.2.2	Systems	**4**
4.2.3	Production Materials – Sources and Types	**2**
4.2.4	Precision Measurement	**9**
4.25	Manufacturing Tool and Equipment Operations	**20**
4.2.6	Automated Systems and Control Operations	**15**
4.2.7	Manufacturing Process Applications and Operations	**21**
4.2.8	Industrial Process	**4**
4.2.9	Industrial Productions	**6**
4.2.10	Manufacturing Types	**2**
4.2.11	Production/Process Monitoring	**18**
4.2.13	Project Management and Execution	**4**
	4.3 Maintenance, Installation, and Repairs	
4.3.1	Critical Work Functions	**9**
4.3.2	General Skills	**19**
4.3.3	Machining Skills	**1**
4.3.4	Electrical Systems Maintenance, Installation, and Repair	**6**
4.3.5	Electronic Systems Maintenance, Installation, and Repair	**3**
4.3.6	Hydraulic Systems Maintenance, Installation, and Repair	**1**
4.3.7	Pneumatic Systems Maintenance, Installation, and Repair	**1**
4.3.8	Mechanical Systems Maintenance, Installation, and Repair	**1**
4.3.9	Mechanical Power Transmission Systems Maintenance	**1**
4.3.10	Piping Operations Maintenance, Installation, and Repair	**1**

	Competency (4.X) Sub-competency (4.X.X)	Number of Essential KSAs
4.3.12	Programmable/Configurable Systems Maintenance, Installation, and Repair	**1**
4.3.20	Process Controls Maintenance, Installation, and Repair	**1**
4.3.21	Pump Systems Maintenance, Installation, and Repair	**1**
4.3.23	Refrigeration Systems Maintenance, Installation, and Repair	**1**
4.3.24	Separation/Heat Exchange Systems Maintenance, Installation, and Repair	**1**
4.3.26	High Voltage/Utility Systems Maintenance, Installation, and Repair	**1**
4.3.27	Programmable Logic Controlled Industrial Equipment Maintenance, Installation, and Repair	**2**
4.3.29	Electromechanical Systems	**3**
4.3.31	Chemical Processing Systems Maintenance, Installation, and Repair	**1**
4.3.32	Chemical and Gas Delivery and Disposal System Maintenance, Installation, and Repair	**1**
4.3.33	Reliability and Maintainability	**5**
4.3.34	Clean Room Protocol for Maintenance	**1**
	4.4 Production in the Supply Chain/Supply Chain Logistics	
4.4.1	Critical Work Functions	**2**
4.4.4	Detailed Scheduling and Planning	**1**
4.4.5	Executing Operations	**2**
4.4.6	Managing Inventory	**2**
4.4.7	Packaging and Distributing Product	**2**
4.4.8	Production Systems	**1**
4.4.10	Supply Chain Management	**2**
4.4.11	Workflow	**2**
	4.5 Quality Assurance and Continuous Improvement	
4.5.1	Critical Work Functions	**2**
4.5.2	Quality Assurance	**6**
4.5.5	Quality Inspection	**2**
4.5.7	Quality Assurance Audits	**1**
4.5.11	Probability and Statistics/Statistical Process Control Methods	**2**
4.5.12	Data Analysis and Presentation	**5**
	4.6 Process and Equipment Health, Safety, and Environment	
4.6.1	Critical Work Functions	**3**
4.6.3	Environmental Protection/Waste Management	**1**
4.6.5	Preventive Health, Safety, or Environment Inspections	**1**
4.6.6	Regulations	**1**
4.6.8	Safety Procedures	**11**

Table A2: *Tier 5 Advanced Manufacturing Sector Technical Competencies and Sub-Competencies*

	Competency or Sub-competency Name	Number of Essential KSAs	Deriving Framework/Model
5.1 Additive Manufacturing		**2**	
5.2 Smart Manufacturing Technology			
5.2.1	Tools and Technologies	**14**	
5.2.2	IT/OT Integration	**20**	
5.2.3	Efficiency and Process Improvements	**9**	
5.3 Information Technology			**DOL ITCM**
5.3.1	Programming	**9**	DOL ITCM **4.4.2**
5.3.2	Databases and Applications	**12**	DOL ITCM **4.2**
5.3.3	Networking and Communications	**2**	DOL ITCM **4.3.1**
5.3.4	Virtualization and Cloud Computing	**2**	DOL ITCM **4.3.4**
5.3.5	Software Acquisition, Management, and Maintenance	**5**	DOL ITCM **4.4.3**
5.4 NICE Framework/Cybersecurity			**NICE Framework**
5.4.1	Cybersecurity Fundamentals	**3**	NICE Framework ID: **NF-COM-008**
5.4.2	Access Control	**1**	NICE Framework ID: **NF-COM-001**
5.4.3	Cyber Resiliency	**4**	NICE Framework ID: **NF-COM-007**
5.4.4	Operating Technology (OT) Security	**2**	NICE Framework ID: **NF-COM-010**
5.5 Experiments, Tests, and Analyses			**DOL BCM 4.2.9**
5.5.1	Microbiology Techniques	**1**	DOL BCM **4.2.9.2**
5.5.2	Cell Biology Techniques	**1**	DOL BCM **4.2.9.3**
5.5.3	Protein Techniques	**2**	DOL BCM **4.2.9.4**
5.5.4	Biochemical Techniques	**1**	DOL BCM **4.2.9.5**
5.6 Biomanufacturing Production			**DOL BCM 4.3**
5.6.1	Production Process	**3**	DOL BCM **4.3.10**
5.7 Material Design and Production			
5.7.1	Coating Preparation and Application	**2**	
5.7.2	Advanced Materials Maintenance and Repair	**1**	