**The Department of Defense Supports Advanced Manufacturing Education and Workforce Opportunities to Strengthen Our National Security and Economy**

With an acute skilled-labor gap facing U.S. industry, the Department of Defense (DoD) is moving aggressively to help build an educated, technology-enabled workforce that can support the development of a world-leading manufacturing sector. In particular, the Department is mobilizing its Manufacturing Engineering Education Program (MEEP) and Manufacturing Innovation Institutes (MII) to create and maintain collaborative partnerships with industry, academia, and Government to provide education and training—including virtual learning opportunities—for the current and future workforce.

"Historically, the Nation's peerless manufacturing base has allowed the United States to build the most complex and capable weapons systems in the world," said Dr. Jagadeesh Pamulapati, Director of the Laboratories and Personnel Office in the Office of the Under Secretary of Defense for Research and Engineering (OUSD(R&E)). "Programs like MEEP and MII are vital to nurturing the next generation of manufacturing talent and growing the manufacturing capacity to maintain our Nation's technological advantage."

Advanced manufacturers and workers form the vanguard of the U.S. economy. As the growth of new technologies causes job elimination, the manufacturing industry is creating additional new job opportunities by adopting these new technologies. The challenge today is that U.S. manufacturing companies of all sizes and across industry sectors are hard-pressed to fill these available positions with digitally skilled workers. According to Deloitte's "2018 Skills Gap in Manufacturing Study," the shortage of skilled workers is expanding in the advanced manufacturing industry and may leave as many as 2.4 million manufacturing positions (53 out of every 100 jobs) unfilled through 2028. If this skills shortage persists, Deloitte predicts that the United States could lose $2.5 trillion in economic output over the next decade.

"The Nation's manufacturing industrial base must not be caught flat-footed, lagging in the capacity needed to meet the challenges of a transforming economy. Much as we did at the onset of World War II, it's time again to bring focus to our Nation's needs and build the advanced manufacturing capacity of the future," said Robert Gold, Director, Technology and Manufacturing Industrial Base, OUSD(R&E).

Advanced manufacturing harnesses computing and information capabilities to produce both new and existing products. It depends on the use and coordination of new and innovative technologies, including information, automation, computation, software, sensing, and networking. These new smart manufacturing technologies, collectively referred to as Industry 4.0, are continuously evolving and require an increased knowledge base and new skillsets in the workforce. Research suggests that through 2030, workers in the United States can expect tasks requiring competence with new manufacturing technologies to increase by 50 percent. However, as demand for workers with these skills rapidly increases, the United States is not keeping pace with its global competitors. According to the 2018 Automation Readiness Index from the Economist Intelligence Unit, the United States ranks ninth in the world in workforce readiness to adapt to increased automation.

To increase workforce readiness, MEEP and MII focus heavily on the key skills required for careers in advanced manufacturing. These include a blend of technical skills (e.g., programming for robots and automation, digital and computer skills, and materials science expertise) and professional skills (e.g., problem solving, critical thinking and analysis, creativity, originality, and adaptability). Department-sponsored career programs are available to students pursuing traditional four-year degree programs, students pursuing technical training, and workers trying to maximize their relevance in a future-focused industry.

"MEEP and MII play important roles in developing and maintaining the advanced manufacturing workforce our Nation needs to maintain our technological superiority for years to come," said Dr. JihFen Lei, Director of Defense Research and Engineering for Research and Technology in OUSD(R&E). "These programs expand opportunities in cutting-edge manufacturing techniques such as additive manufacturing and robotics, and strengthen important shop floor skills like welding and machining."

The Department's advanced manufacturing educational and workforce initiatives provide opportunities for students and educators of all ages, as well as for the current workforce. These resources range from workshops, interactive courses, training, continuing education, curricula, ecosystem networking, apprenticeships, and more, and are made available through the Department's MEEP and MII initiatives. A list of the most recently added advanced manufacturing education and workforce programs are highlighted below.

"We are particularly pleased with the breadth and depth of this year's offerings, which include programs ranging from middle school up to workforce retraining—including programs focused on military veterans—and span the country from coast to coast," said Lei. "But, we're not resting on our laurels. As the need for skilled workers continues to climb, we're committed to spreading the word that the doors are open—physically and virtually—so that those who would most benefit from Industry 4.0 education and training do, in fact, get that education and training."

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List of MII Advanced Manufacturing Online Educational and Workforce Opportunities:

- The **Advanced Functional Fabrics of America (AFFOA)** institute, in partnership with Massachusetts Institute of Technology (MIT) and the Fashion Institute of Technology (FIT), created an innovative textiles workshop for students called **MITANDFIT (MITxFIT).** The program connects the worlds of design and engineering for products made of advanced functional fibers, yarns, and textiles. These fabrics aren't the traditional materials of yesterday. Recent breakthroughs in fiber material and fabric processing allow for the design and production of fibers and fabrics that can perform a wide range of functions (i.e., see, hear, sense, communicate, store and convert energy, regulate temperature, monitor health, change color, etc.). The MITxFIT program provides lessons in this very exciting new world of functional fabrics. To learn more, please go to: https://mitxfit.info/videos-and-resources/

- The **American Institute for Manufacturing Integrated Photonics (AIM Photonics)** leads the AIM Photonics Academy. The Academy offers resources to both students and teachers for learning about the optical circuits that process and transmit signals of light. These photonic integrated circuits will eventually replace the routing of electrical signals in a traditional computer microchip, opening the door to higher speed and performance and revolutionizing the very basis of computing technology. The AIM Photonics Academy educates participants in designing, building, maintaining, and repairing this technology. To learn more, please go to: https://aimphotonics.academy/education/student-resources/online-courses

- The **Manufacturing x Digital (MxD)** institute, in partnership with University of Maryland–Baltimore County, is developing a series of courses on rapid adaptable cybersecurity. These courses integrate instruction about manufacturing-focused job roles, career pathways, and success profiles for cybersecurity in manufacturing. Cybersecurity, as a vocation, will be critical to the long-term success of manufacturers whose differentiating and proprietary knowledge, processes, and designs are stored on computers and cloud-based networks. To learn more, please go to: https://www.umbctraining.com/training-centers/for-individuals/cybersecurity/

- **America Makes** is the Nation's leading and collaborative partner in additive manufacturing and 3D printing technology research, discovery, creation, and innovation. America Makes has over 14 courses live on Tooling U-SME, an online training repository of easy-to-use, interactive courses that reinforce learning and keep students focused. Additive manufacturing uses computer-aided-design software or 3D object scanners to direct hardware to deposit material, layer upon layer, in precise geometric shapes, as opposed to traditional processes of removing material through milling, machining, carving, shaping, and other means. To learn more, please go to: https://www.toolingu.com/catalog

List of 2019-2020 MEEP Awardees and Projects:

- **Institute for Advanced Composites Manufacturing Innovation (IACMI), Knoxville, TN**: IACMI and collaborators will establish a national learning network, based on the best-in-class program at Davis Technical College (Kaysville, UT), to develop a skilled composites manufacturing workforce.

- **Lightweight Innovations for Tomorrow (LIFT), Detroit, MI**: This venture will expand Operation Next, a manufacturing-focused training and credentialing program for soldiers in their last six months of active duty, to nine new locations nationwide.

- **Lorain County Community College, Elyria, OH**: This consortium of educational institutions and companies will address near- and long-term needs for production and technician workers at Ohio companies serving the defense industry.

- **Massachusetts Institute of Technology, Cambridge, MA**: The initiative will develop a Virtual Manufacturing Lab that offers guided or autonomous online learning for three advanced manufacturing audiences: design engineers, fabrication engineers, and technicians.

- **Monroe Community College (MCC), Rochester, NY**: MCC will enhance the Nation's optics workforce via improved curricula, apprenticeships, and high school recruitment and outreach.

- **NextFlex, San Jose, CA**: NextFlex and its partners will expand FlexFactor, a proven middle and high school outreach program for growing the talent pool in manufacturing engineering, to 30 labor markets nationwide.

- **Society of Manufacturing Engineers (SME), Cleveland, OH**: SME will develop an online, broad-based advanced manufacturing curriculum, delivered through augmented and virtual reality, that aligns with industry-recognized credentials.

- **University of Texas, Rio Grande Valley, Edinburg, TX**: A consortium of partners will cultivate an educational ecosystem to draw young talent to additive manufacturing, smart manufacturing, and innovations in lightweight materials, structures, and systems.

- **Virginia Polytechnic Institute and State University, Blacksburg, VA**: The school will create university and continuing education curricula to develop engineering talent for advanced manufacturing of structures and integration with lightweight composites for electromagnetic applications critical to U.S. military superiority.

List of 2018 MEEP Awardees and Projects:

- **Battelle Education, Columbus, OH:** is leveraging public-private partnerships to strengthen manufacturing engineering education at the high school level. During the summer of 2019, 22 educators across 9 sites participated in the first educator cohort, which included problem-based learning, training, and externship experiences. These problem-based learning modules developed by educators will be made publically available. The program will be expanded to 15 sites in Ohio and will double the cohort size in Tennessee in the summer of 2021.

- **Clemson University, Clemson, SC**: Clemson University is developing immersive and personalized instruction to strengthen learning and retention for high school through graduate school students. As of summer 2020, 80 percent of the curriculum has been developed, including 11 courses and 33 modules for 4 academic tracks, including 1) the high school track focusing on introduction to robotics in manufacturing; 2) the associate degree track focusing on fundamentals of robotics-enabled systems; 3) the baccalaureate degree track focusing on advanced manufacturing; and 4) the master's degree track focusing on the advanced science component. This program is also developing a robust curriculum integration with the Educate Workforce online learning platform, which will broaden the audience that can access the material. A majority of the courses and modules feature virtual reality simulation.

- **Massachusetts Institute of Technology, Cambridge, MA**: The Massachusetts Institute of Technology will develop a comprehensive 15-month apprenticeship training program in support of a highly skilled manufacturing workforce. This program will teach general and specific manufacturing competencies, including introductory quantum mechanics, electrical technology, and design principles that demonstrate the interrelation of various manufacturing sectors. Accomplishments to date include: 1) the Photonics Technician Certificate Program at Stonehill College and Bridgewater State University, where 15

students, diverse in age, race, education, and work experience, enrolled in the program and 12 students have successfully completed the first online course and 2) the Robotics Technician Certificate Program at Westmoreland County Community College, where 11 students enrolled in this inaugural program and successfully adapted to a hybrid model with online lectures and a lab on site. There is a plan to continue use of the hybrid model for the second cohort of students.

- **National Center for Defense Manufacturing and Machining, Blairsville, PA**: The National Center for Defense Manufacturing and Machining will develop and launch a series of new virtual courses, including courses on additive manufacturing and related technologies, to broaden and extend the scope of the Society of Manufacturing Engineers' long-standing certificate programs. As of summer 2020, the program has identified seven regional focus areas, based on critical demands and needs from underserved and underrepresented communities. Potential virtual events are scheduled throughout2020, and 14:35 classes are now live for public access and have been assigned over 15,000 times. Nine instructor-led training classes are in development.