



PUBLIC SUMMARY **OF** **WORKSHOP FINDINGS AND RECOMMENDATIONS**

Collaborative Robotics Workshop 2015

Advantages and Challenges for Small Manufacturers

Held October 7, 2015



**MEP • MANUFACTURING
EXTENSION PARTNERSHIP**

EXECUTIVE SUMMARY

The National Institute of Standards and Technology (NIST) Engineering Laboratory (EL) and the NIST Manufacturing Extension Partnership (MEP) partnered during 2015 to conduct the ***Collaborative Robotics Workshop 2015: Advantages and Challenges for Small Manufacturers***. The NIST MEP and NIST EL were supported in the planning and conduct of this workshop by IMC Consulting LLC and 10 MEP Centers from 7 states.

This document summarizes the Workshop, and highlights its findings and results as they are applicable to small U.S. manufacturers, to robotics manufacturers, to systems integrators, to researchers, and to MEP Centers. This document is intended to serve as a publicly available Workshop Report that has been produced by NIST MEP following an internal NIST report of the Workshop proceedings and results that was presented by NIST MEP to NIST EL in 2015.

Held October 7, 2015, at the Howard Community College Charles I. Ecker Business Training Center in Columbia, MD, the ***Collaborative Robotics Workshop 2015*** was an interactive mechanism to allow robotic end users and prospective end users from a broad cross section of small U.S. manufacturers to communicate the challenges and barriers they encounter when integrating and using robotics in their factories. The event was attended by 28 representatives of manufacturing companies and systems integrators located in the states of MD, NY, OH, PA, TX, VA, and WV. Additionally, one representative attended from a not-for-profit manufacturing institute. The Workshop was also attended by 12 representatives from 9 MEP Centers located in 7 different states, as well as 1 representative from IMC, 4 representatives from NIST MEP and 8 representatives from NIST EL.

KEY WORKSHOP FINDINGS

Key findings from the Workshop include the following:

- The small manufacturers that participated in the Workshop are generally positive about the potential implementation of robotics and flexible automation within their manufacturing operations, and they generally believe that the implementation of collaborative robotics and flexible automation can result in increased productivity, throughput, quality, and eventually reduced costs.
 - ✓ Based upon input from participating manufacturers, the implementation of robotics also can address several workforce-related issues, including the ability to apply workers to higher-level tasking and the ability to remove workers from environments with health and safety risks.
- Many factors contribute to small manufacturers not implementing robotics within their operations, including the following:

- ✓ lack of staff education and skilled workforce to operate the robotic systems;
 - ✓ cost of implementation (both perceived and actual);
 - ✓ lack of manufacturing applications and processes that are appropriate for robotic systems implementation;
 - ✓ lack of technical capabilities of robotic systems to meet manufacturer needs;
 - ✓ lack of understanding of the benefits to manufacturers associated with robotics implementations that can produce acceptable returns on investments (ROIs); and
 - ✓ an aggregation of the challenges small manufacturers face within their companies relating to robotics as cultural barriers.
- Manufacturers at the Workshop clearly identified the need for the availability of concise information that they can use to justify the ROI on robotics implementations, including information relating to total cost of ownership for robotic systems.
 - Based upon the presentations that were provided during the Workshop, as well as Q&A discussion with the robotics experts in attendance, many of the challenges and barriers to implementation voiced by the participating small manufacturers may exist due to a general lack of awareness and understanding of the various attributes of the state of robotic systems technology.
 - Many manufacturers are interested in obtaining independent, trustworthy, expert assessments of their business operations to determine the extent to which collaborative robotics and flexible automation can and should apply to their environments.
 - ✓ Informed understanding of manufacturers' current state operations, combined with similar understanding of potential benefits that could be obtained through new implementations – along with what would be involved with such implementations – is a logical approach to:
 1. justifying operational changes and new investments, as well as to reducing risk; and
 2. making strides in overcoming several cultural challenges that stand as barriers to robotics implementations for small manufacturers.
 - Many of the current research and development programs that are focused on collaborative robotics and flexible automation are primarily applicable to the needs and interests of manufacturing companies that produce robotic systems and automation equipment, as well as to systems integrators.
 - ✓ The technical areas that are generally the focus of such programs tend to be oriented toward advancing the technology state of the art and cutting-edge technology.

- ✓ Small U.S. manufacturers whose product lines are not robotics equipment have needs that are more oriented toward basic understanding of, and assistance with, robotics implementations.
 - ✓ These small manufacturers tend to need assistance in implementing what is commercially available to them.
 - ✓ These small manufacturers can and should feed information about their manufacturing needs to researchers to inform research agendas relating to collaborative research and flexible automation.
- Voluntary, consensus standards are important to the successful implementation of collaborative robotics by manufacturers, yet small manufacturers generally do not have the wherewithal to directly participate in standards activities.
 - ✓ The small manufacturers that do participate in standards activities tend to be those manufacturers that produce robotics and automation equipment, and/or that operate as systems integrators for these systems.

A CALL TO ACTION: Recommendations and Next Steps

The following recommendations provide potential ways in which research programs focused on collaborative robotics and flexible automation, including such programs operating in the NIST EL, may best apply to small U.S. manufacturers. These recommendations also provide ways in which small U.S. manufacturers can collaborate with these programs. Such collaborations can produce results for the benefit of small manufacturers in general, robotics manufacturers, research programs and organizations, systems integrators, and MEP Centers.

These recommendations are set within a collaboration framework that defines several high level areas in which small manufacturers and researchers, including those in the NIST EL, can collaborate relating to robotics and flexible automation. The collaboration framework focuses on the means by which small U.S. manufacturers can:

1. Be made aware of the technologies, technological approaches, technical methods, technical standards, business cases, use cases, and resources associated with the implementation of collaborative robotics and flexible automation;
2. Be involved in the processes and activities associated with informing the collaborative robotics and flexible automation research agendas being operated by NIST EL and other organizations;
3. Participate in the conduct of collaborative robotics and flexible automation R&D projects with NIST EL and other organizations; and
4. Potentially implement collaborative robotics and flexible automation research results

Included among these recommendations are potential mechanisms that leverage the capabilities, assets, and knowledge of the national network of MEP Centers to help bi-directionally connect the knowledge, resources, testbeds, and research occurring in organizations such as the NIST EL with the needs of small U.S. manufacturers.

Specific recommendations for each of these 4 collaboration framework areas are provided below. The first area focuses on basic awareness and understanding of the many technical and business aspects of robotics and flexible automation technologies, which is where the primary base of small manufacturer needs exists, so this is the area with the most concentrated set of initial recommendations.

1. The means by which small U.S. manufacturers can be made aware of the technologies, technological approaches, technical methods, technical standards, business cases, use cases, and resources associated with the implementation of robotics and flexible automation

- MEP can establish regular communications mechanisms to push technical information to the system of MEP Centers, which can in turn be disseminated by the MEP Centers to thousands of small U.S. manufacturers. These include, but are not limited to:
 - periodic written technical updates focused on robotics from research organizations including the NIST EL, such as blogs, that can be electronically disseminated to MEP Centers
 - periodic webcasts on Robotics and Flexible Automation for MEP Centers and their small manufacturing clients provided by representatives of robotics research programs, including those occurring in the NIST EL
 - participation from robotics research programs, including those occurring in the NIST EL, in regional and national MEP Center meetings to present information about robotics research
 - participation from robotics research programs, including those occurring in the NIST EL, in topical MEP Center events around the country that are designed to inform small manufacturers about different manufacturing technology areas
 - A periodic “standards update” newsletter disseminated by NIST MEP to the system of MEP Centers, with content provided by NIST EL and other researchers, systems integrators, and robotics associations, that can in turn be disseminated to U.S. manufacturers by the MEP Centers

- NIST EL and NIST MEP can convene additional Collaborative Robotics Workshops on a recurring basis, and/or in different regions of the country, and/or in national settings facilitated by NIST MEP, such as MEP Update Meetings.
- NIST EL and NIST MEP can work together, and also with third party partners as well to include systems integrators and robotics associations, to jointly create a Robotics and Flexible Automation Training program for MEP Center staff. This program could train manufacturing specialist field personnel from MEP Centers to intelligently engage with small manufacturers about robotics and flexible automation. This would enable MEP Centers to provide technical assistance to small manufacturers to meet their needs, or to direct them to the appropriate resources that can assist them if the Centers cannot. Such a training program could include:
 - Outreach and Education Webcasts – for MEP Center Staff and for small U.S. manufacturers
 - Robotics and Flexible Automation Assessments
 - Initial / quick Right and Ready assessments (that can be administered by MEP field staff during client engagements, or perhaps via online manufacturer completion)
 - Deeper Dive technical assessments in detailed facets of manufacturer operations relating to robotics and flexible automation
 - Leading to the development of a Robotics and Flexible Automation Roadmap for a manufacturer, followed by implementation of that Roadmap
 - Train the Trainer Program
 - Jointly developed approach for MEP Centers to engage manufacturers in robotics and flexible automation, starting with initial engagement (Right and Ready Assessment) and continuing through implementation of the manufacturer’s Robotics and Flexible Automation Roadmap – with the approach created by researchers from the NIST EL and NIST MEP
- NIST EL can host visiting personnel from MEP Centers and the manufacturing companies they serve in the NIST EL robotics lab facilities in Gaithersburg, MD, to provide first hand exposure to cutting-edge and state-of-the-art robotics technologies. Such hosting can similarly occur with other robotics research programs and systems integrators.

- NIST EL and NIST MEP can compile resource lists for different aspects associated with robotics and flexible automation and communicate these lists to MEP Centers and small U.S. manufacturers. These can also be included in the training program mentioned above.
 - Such lists could include systems integrators operating in different regions of the country (with disclaimers to not give the appearance of any endorsement by NIST), university labs that can be accessed, community college training programs or centers that can be accessed, and known vendors of different types of robotic systems, among others.

2. The means by which small U.S. manufacturers can be involved in the processes and activities associated with informing the nation's robotics and flexible automation research agenda

- Robotics researchers, including those from the NIST EL, can produce listings of specific technical areas where there are questions relating to small manufacturer needs and issues and communicate those listings to NIST MEP, who can in turn disseminate it to its system of Centers using NIST MEP's different communications mechanisms, who in turn can disseminate it out to the manufacturers operating in their various regions. Specific instructions would need to be included about mechanics of how manufacturers can and should provide input to the technical areas.
- NIST MEP and the nationwide network of MEP Centers can publicize and if appropriate host relevant informational sessions, technical meetings, and other forums where robotics research and development personnel can participate and can receive input from industry.
- NIST MEP and MEP Centers can identify small U.S. manufacturers who are interested in implementing robotics and flexible automation within their manufacturing operations and host site visits to those manufacturers by teams of researchers, including from NIST EL, to expose the researchers firsthand to the real-world applications resident in the manufacturing plants of these companies.

3. The means by which small U.S. manufacturers can participate in the conduct of robotics and flexible automation R&D projects

- Robotics researchers, including from NIST EL, can inventory those technical areas where use cases are sought from industry to pilot test within laboratories, and NIST MEP can disseminate the inventory to MEP Centers, who can in turn disseminate it to the small manufacturers operating in their service regions. Specific instructions

would need to be included about mechanics of how manufacturers can and should provide input to the need areas.

- NIST MEP and MEP Centers can publicize any relevant SBIR topic areas relating to robotics and flexible automation research.

4. The means by which small U.S. manufacturers can potentially implement robotics and flexible automation research results

- Robotics researchers, including those from the NIST EL, along with other research and robotics associations, as well as systems integrators, can develop a handbook for robotics implementations for use by small manufacturers.
 - Such a handbook could provide step-by-step guidance for small manufacturers regarding which types of robotic systems apply to different manufacturing processes and operations.
 - Such a handbook could also be implemented by MEP Center staff in conjunction with the MEP Train the Trainer program included in Recommendation #1 herein.
- Through a commitment to communicate made between research programs, including those of NIST EL, and NIST MEP, ensure that NIST MEP and MEP Centers are made aware of commercially implementable research results when they become available – in whatever form they may take – so NIST MEP and MEP Centers can make small U.S. manufacturers aware of these results.

APPENDIX: WORKSHOP AND COLLABORATION BACKGROUND

The NIST EL – NIST MEP collaboration is developing and operating to provide mutual value to NIST EL and MEP, as well as and perhaps most importantly, to the U.S. manufacturers that are being, or could be, served by these two organizations.

The NIST EL promotes U.S. innovation and industrial competitiveness in areas of critical national priority by anticipating and meeting the measurement science and standards needs for technology-intensive manufacturing, construction, and cyber-physical systems, including the Smart Grid Program Office, in ways that enhance economic prosperity and improve the quality of life.

The NIST EL executes a Smart Manufacturing Goal, comprised of 4 Programs, which is aimed at enabling the next generation of innovative and competitive manufacturing through advances in measurement science. With an emphasis on smart, NIST EL Smart Manufacturing research projects aim to speed development, adoption, and integration of leading-edge intelligent technologies to advance U.S. manufacturing. Through research that stretches the limits of measurement science and pushes the envelope of current measurement and test capabilities, the NIST EL Smart Manufacturing Programs will:

- Safely increase the versatility, autonomy, and rapid re-tasking of intelligent robots and automation technologies for smart manufacturing and cyber-physical systems applications;
- Enable real-time monitoring, control, and performance optimization of smart manufacturing systems in the factories of small, medium, and large companies;
- Enable rapid, agile, and cost-effective production of complex, first-to-market products through advanced manufacturing processes and equipment; and
- Facilitate straightforward integration of engineering information systems used in complex manufacturing and construction networks to improve product and process performance.

As part of its Robotic Systems for Smart Manufacturing Program, NIST EL will provide the measurement science needed to enable all manufacturers, including small and medium ones, to characterize and understand the performance of robotics systems within their enterprises. Measurement science establishes a common language for expressing performance requirements and provides means of verifying that systems meet those requirements. Concrete performance targets also direct innovations towards addressing existing capability gaps in robotic systems. NIST will deliver performance metrics, information models, test methods and protocols to assess and assure the key attributes of robotic systems necessary to enable this new dynamic production vision.

A critical aspect of this work focuses on integration and interoperation and will address the obstacles to easily integrating robotic assembly systems within manufacturing facilities. Models

of the underlying information required to automate the composition and integration of complex robotic assembly systems, along with a suite of tools to foster interoperability will address the existing incompatibility between robots and the next generation of perception, mobility, and manipulation technologies needed to achieve automated assembly.

Complementing the above efforts is one that tackles the technically challenging procedures that hinder adoption of robotic systems by small and medium enterprises. Specifically, the calibrations of robot arms, sensors, and end-of-arm tooling are essential procedures when installing new systems and must be executed periodically thereafter to maintain correct performance. A tool suite that automates the creation of the complex models and parameters necessary to achieve correct robotic system performance will enable easier installation and greater robustness during the life of the robotic system.

Enter NIST MEP.

NIST operates the MEP Program, which strengthens U.S. manufacturing, by providing direct hands-on technical assistance to U.S. manufacturers. Through its services and partnerships, MEP has a profound impact on the growth of well-paying jobs, the development of dynamic manufacturing communities, and the enhancement of American innovation and global competitiveness.

MEP's strength is in its partnerships. Through its collaborations at the federal, state and local level, MEP puts manufacturers in position to develop new products and customers, expand into global markets, adopt new technology, re-shore production, and more. And because of its direct contact with manufacturers, MEP serves as a valuable bridge to other organizations that share a passion for enhancing the manufacturing community.

MEP's strategic objective is to create value for all U.S. manufacturers, and the Program has a particular focus on small and mid-sized U.S. manufacturers (hereinafter referred to as small manufacturers). Small manufacturers represent nearly 99% of manufacturing firms in the U.S. and form the essential fabric of the U.S. manufacturing infrastructure. MEP is able to provide this support to individual manufacturers through its [nationwide network of local centers](#) that are made up of teams of manufacturing experts and business professionals. There is an MEP Center in every U.S. state, plus Puerto Rico, and MEP served over 29,100 U.S. manufacturers during 2015.

The collaboration between the NIST EL and NIST MEP provides NIST EL with access to and useful perspectives of small manufacturers to contribute to ongoing NIST EL robotics research and development (R&D), set within the NIST EL Smart Manufacturing R&D Program. For NIST EL, the collaboration serves to provide researchers with direct access to small manufacturers and MEP Centers around the nation as a means of gaining insight to the technical, operational, and business needs, challenges, and motivators of their production environments. The collaboration leverages the nationwide network of MEP Centers to understand how to best gain access to and work with small domestic manufacturers relating to NIST EL robotics research, including the standards development aspects of that research.

For NIST MEP, the collaboration serves to provide the MEP Program's nationwide network of MEP Centers and the small U.S. manufacturers they serve with direct access to world class robotics expertise, knowledge, and facilities as resources to help small manufacturers accelerate technology adoption in their products and processes. The collaboration also provides small manufacturers with opportunities to provide direct input to the technical standards development processes that can directly impact their ability to implement robotics and flexible automation within their manufacturing operations.

A major initial focus of the NIST EL – NIST MEP collaboration during 2015 was the planning and conduct of the ***Collaborative Robotics Workshop 2015***. The primary purpose of the Workshop was to leverage the broad and deep reach of a collection of MEP Centers – primarily, but not limited to MEP Centers operating in the Mid-Atlantic states – to provide an interactive forum by which NIST EL could engage with small domestic manufacturers that have experience with or are considering implementing collaborative robotics and flexible automation within their production operations.

The ***Collaborative Robotics Workshop 2015*** was designed to be an interactive mechanism to allow robotic end users and prospective end users from a broad cross section of small U.S. manufacturers to communicate the challenges and barriers they encounter when integrating and using robotics in their factories. One of the objectives of the NIST EL R&D is to reduce the barriers that small U.S. manufacturers encounter in the adoption of robots and robotic tools that advance flexible automation within their manufacturing facilities. Robots have the ability to help small manufacturers decrease part cycle times, improve part quality, improve workflow, as well as to perform dangerous and other tasks unfit for human workers.

The ***Collaborative Robotics Workshop 2015*** was structured to allow the small manufacturers who participated to:

- Have the opportunity to influence NIST research by ensuring that their company's technical interests are considered
- Contribute to the development of performance requirements, robotics standards and authoritative technical guidelines that impact robotic implementations within manufacturing operations
- Gain insights from recognized experts into trends, cutting edge tools, and emerging robot technologies
- Learn how other small manufacturers have been able to address and overcome the challenges of integrating robots into manufacturing processes
- Engage in follow on meetings and interactions with NIST representatives to explore potential long-term collaboration opportunities
- Potentially gain future access to NIST's robotics testbeds which deploy state-of-the-art technologies, advanced sensor systems, and cutting edge manufacturing application research.
- Tour state-of-the-art NIST robotics research facilities.