



**Compete.**

Council on  
Competitiveness



A PROGRAM AT UCLA

Energy and  
Manufacturing  
Competitiveness  
Partnership

# Smart Manufacturing

Leveraging the Democratization  
of Innovation

## Smart Manufacturing

This publication may not be reproduced, in whole or in part, in any form beyond copying permitted by sections 107 and 108 of the U.S. copyright law and excerpts by reviewers for the public press, without written consent from the publishers.

**THE COUNCIL ON COMPETITIVENESS** is a nonprofit, 501(c) (3) organization as recognized by the U.S. Internal Revenue Service. The Council's activities are funded by contributions from its members, foundations, and project contributions. To learn more about the Council on Competitiveness, visit our home page at [Compete.org](http://Compete.org).

© 2019 Council on Competitiveness

Printed in the United States of America

# Table of Contents

Letter from the Co-Hosts	2
Executive Summary	3
The Case for Smart Manufacturing as a U.S. Competitiveness Differentiator	6
An Agenda to Drive Action on U.S. Smart Manufacturing	21
Appendices	
Dialogue Agenda	22
Dialogue Participants	26
Dialogue Sponsors	28
About the Council on Competitiveness	29
Council on Competitiveness Members, Fellows and Staff	30

## Letter from the Co-Hosts

On June 4, 2019, the Council on Competitiveness (Council) and UCLA, home to CESMII—The Smart Manufacturing Institute, co-hosted a major dialogue on *Smart Manufacturing: Leveraging the Democratization of Innovation*. The day-long session with more than 50 experts representing industry, academia, national labs and government focused on the democratization of smart manufacturing as a practical necessity for the future of U.S. manufacturing. Topics included creating and maximizing the value of innovation through the easy and secure movement of information; rethinking education, training and entrepreneurship in manufacturing; changing manufacturing infrastructure and the innovation ecosystem; aligning market and policy drivers for data centered enterprises; and addressing the need for new jobs and a new culture of data.

We know that competition is rising around the world. We are witnessing the development and acceleration of some of the greatest advancements in science ever known driven by the vast deployment of sensors, the Internet of Things, artificial intelligence, big data analytics, 3D printing, precision manufacturing and unprecedented data interconnectedness at scale and speed. Each of these areas are disrupting sectors of the economy, but they are also converging and colliding with huge economic and national security implications. Smart manufacturing stands at the center of many of these tectonic shifts.

This report captures key discussion points, including assessments of current challenges and opportunities across the manufacturing sector. With the help and input from expertise cutting across multiple sectors

of the economy, a set of actionable recommendations is outlined for federal and state policymakers, as well as leaders from the private sector.

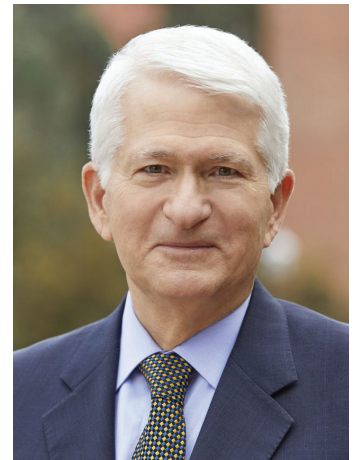
We want to thank the participants who lent their time and knowledge to this important initiative. We also want to acknowledge CESMII, Microsoft, Deloitte and ThinkIQ, who joined the Council and UCLA in sponsoring this dialogue.

Sincerely,



*Deborah L. Wince-Smith*

**The Honorable  
Deborah L. Wince-Smith**  
President & CEO  
Council on Competitiveness



*Gene D. Block*

**Dr. Gene Block**  
Chancellor  
University of California,  
Los Angeles

# Executive Summary

The United States is facing exciting competitiveness, economic and operational opportunities with Smart Manufacturing (SM). These opportunities are the result of a changing manufacturing landscape shaped ultimately by global consumer demands for higher precision, higher value products that are manufactured faster, cheaper and safer, making far better use of materials and energy with less environmental impact. Powering this production revolution and subsequent demand for smart manufacturing is the confluence of:

- Slack in manufacturing productivity, precision and performance that, if made more efficient, could tap significant value from supply chain operations and process operations;
- The digitalization of the manufacturing industry with advanced sensing, controls and modeling technologies and digital infrastructure; and
- The generational re-emergence of advanced and highly productive manufacturing capacity on U.S. soil.

On June 4th, 2019, the Council on Competitiveness (Council), UCLA and CESMII—The Smart Manufacturing Institute, a national Manufacturing USA institute overseen and administered at UCLA, brought together a diverse group of more than 50 stakeholders to focus on the democratization of SM.

In this context, democratization means advanced technology, capability and practice in the hands of all that can add value, as a practical necessity for the future of U.S. manufacturing. While the focus of this dialogue was on SM democratization, the principles of democratization apply generally with advanced technologies in that manufacturers need to work together in enterprise value and supply chains and

can no longer continue to work in silos, and that the United States needs to tap into the full innovation capacity of its entire manufacturing base. SM both requires democratization and facilitates it.

Participants in the day-long dialogue represented a unique collective perspective on SM democratization as an emerging driver of manufacturing competitiveness. Concurrent with the opportunity are persistent challenges with economic viability and protection of intellectual property in a landscape where the business, economic, operational and social drivers are pushing toward digitization, business collaboration and supply chain operational interoperability. To better understand the current landscape and the SM opportunity, the dialogue tackled the following questions:

- Is the United States and its manufacturing base adequately prioritizing SM investment and market priority to keep pace with consumer and global market demand and advanced digital technology, investment and innovation around the globe?
- Will U.S. and global markets move the democratization of SM fast enough, or is proactive government involvement through research and other strategic investments required?
- How can policymakers and industry ensure that digitalization does not outpace security risks in the form of cyber threats from state and unaffiliated actors?
- Is there a need to rethink talent, workforce training and education, and entrepreneurship as elements of an overall cultural shift to a data-driven, innovation-driven economy?



*Participants in the June 4, 2019, Smart Manufacturing Dialogue.*

Looking specifically at current industry practices, the participants worked to identify a common vocabulary and set of priorities for U.S. manufacturing digitalization, SM democratization and advanced manufacturing innovation. Framing this discussion were questions seeking to assess:

- What the current level of knowledge is among industry executives, federal and state governments, and university leaders about SM, the digitalization of manufacturing and the democratization of capability?
- What are the roadblocks, fears and perspectives standing in the way of the SM transformation?
- What are replicable examples of SM best practices?

The importance of this dialogue was underscored by considerable economic, investment and market growth opportunity of SM that can be created for democratization that in turn spurs supply chain productivity, process precision and manufacturing performance. Radically expanded application of data, information and modeling will be a key driver of long-term U.S. competitiveness, with other countries also seizing the opportunity to develop advanced data and modeling capabilities and be “first to market” with new manufacturing capabilities in a global market.

With this “call-to-arms” as backdrop, a consensus emerged around a set of broad goals, which are discussed in greater detail throughout this report.

## Goal No. 1: Inspire the Workforce

There is a very real need to message advanced manufacturing in new ways that are much more attractive and relatable to the next generation workforce. It is time to move from a defensive posture of what advanced manufacturing is “not” (i.e. not dumb, dirty and dangerous) and focus on what advanced manufacturing is: smart, sustainable and surging. The risk is that the United States is not moving nearly fast enough to address the advanced manufacturing workforce shortage problem.

## Goal No. 2: Embrace Technological Innovation

The democratization of innovation, technology and cybersecurity is a cultural change—even a cultural revolution—that manufacturing needs to embrace. To fully understand and embrace this tectonic shift will take sustained commitment and effort, including:

1. Senior management retraining;
2. Reverse mentoring; and
3. Stronger partnerships between industry and education.

## Goal No. 3: Catalyze Collaboration

The federal government and the Manufacturing USA institutes can convene stakeholders to find solutions to SM barriers. Challenges involving intellectual property rights and protections, and the management of real and perceived risks and liabilities associated with data exchange and interoperability, are potential speed bumps on the pathway broader SM utilization.

## Goal No. 4: Explore New Financial Paradigms

Beyond basic scientific research, the U.S. model is one where the market is the better driver for innovation and sustainability than federal investment. However, ongoing financial challenges for companies, especially small and medium-sized enterprises, related to onshore production and scale-up highlight ongoing issues related to access to capital for longer term ventures. Additionally, financial models related to cyber systems, services and shared infrastructure require significantly different approaches than physical/on-premise systems.

### CESMII—The Smart Manufacturing Institute

CESMII is the United States’ national institute on Smart Manufacturing (SM), driving cultural and technological transformation and industrial cybersecurity leadership as national imperatives. By enabling frictionless movement of information—raw and contextualized data—between real-time operations and the people and systems that create value in and across manufacturing organizations, CESMII is ensuring the power of information and innovation is at the fingertips of everyone who touches manufacturing.

Headquartered in Los Angeles, CA, CESMII brings more than \$140 million in committed public-private investment and more than 100 partners from leading manufacturers and universities across 30+ states. CESMII is accelerating SM adoption through the integration of advanced sensors, data analytics, platforms and controls to radically improve productivity, precision, performance and energy consumption. CESMII’s program and administrative home is with the University of California, Los Angeles (UCLA), in partnership with the U.S. Department of Energy’s Advanced Manufacturing Office.

For more information, visit the CESMII website at: [www.cesmii.org](http://www.cesmii.org).

# The Case for Smart Manufacturing as a U.S. Competitiveness Differentiator

To focus the dialogue and seek actionable recommendations, the day was broken up into discreet, but overlapping segments focused on different aspects of the smart manufacturing ecosystem. Discussants were tasked with addressing specific questions, though not limited by the topics raised. Taken as a whole, these segments presented a picture of the tremendous economic potential of smart manufacturing dependent upon proactive and strategic investments in education, skills enhancement, research and technology, coupled with an updated regulatory and cyber infrastructure that will incent and secure a more high-value, efficient and productive manufacturing sector.

## Building the Talent and Workforce for a Digitized Future

A democratization-of-innovation viewpoint makes the right workforce with the right skills and capabilities at the right time a high priority. Recognizing the primacy of this issue, the dialogue led with a discussion of workforce focusing on the awareness, skills and training associated with the emergence and acceleration of SM.

There has been, and continues to be, considerable national discussion on talent, workforce training and education for advanced manufacturing technologies, including several prior Council ([www.compete.org/programs/compete-energy-manufacturing/emcp](http://www.compete.org/programs/compete-energy-manufacturing/emcp)) dialogues on issues as diverse as biosciences to aerospace. The workforce opportunity in SM is real and growing, and the process of manufacturing digitalization, requires much more than a narrow workforce trained in data technologies. For example, CESMII is chartered to lead SM's education and

workforce development (EWD) on a national scale, with a focus on technology and cultural/leadership education and on leveraging regional programs as best practices wherever possible. The question is, are the current approaches for upskilling the workforce and building the workforce pipeline fast enough?

The stark magnitude of the gap between the supply of human capital and the demand for skilled workers is perhaps the most significant challenge facing the manufacturing industry today. According to a study completed by Deloitte, by 2028, 2.4 million skilled manufacturing jobs will go unfilled in the United States.<sup>1</sup>

Several reasons for the gap between supply of and demand for talent in the manufacturing sector have been discussed over the years, but they remain unaddressed and continue to exacerbate the challenge. At the micro level, digitalization, the implementation of advanced sensing and modeling for much greater precision, automation and robotics and the introduction of physical bots are fundamentally shifting the skills required to work in factories. At the macro supply chain level, skills are needed to work closely with and across operations with higher levels of insight, prediction and process self-awareness. Automation is not about cutting workforce, but about utilizing advanced technology to meet increasing acceleration of product precision and value-add demands. Companies and workers are beginning to understand the depths of how technological advancements now require a workforce with a specific set of skills to learn an entirely new skill set, including new expectations, approaches, structures and methods in advanced manufacturing.

1 <https://www2.deloitte.com/us/en/pages/manufacturing/articles/future-of-manufacturing-skills-gap-study.html>.





*Dr. Kiran Sheth, Distinguished Engineering Associate, ExxonMobil Research and Engineering; Dr. Jim Davis Vice Provost IT & Chief Academic Technology Officer, UCLA; Mr. John Dyck, CEO, Clean Energy Smart Manufacturing Innovation Institute; Dr. Gene Block, Chancellor, UCLA; Mr. William Bates, Executive Vice President, Council on Competitiveness; and Dr. Steven F. Ashby, Laboratory Director, Pacific Northwest National Laboratory.*



*Mr. Chad Evans, Executive Vice President, Council on Competitiveness.*

While the best path forward might be to retrain and fundamentally reskill workers, the manufacturing workforce is older and often lack the interest in or are intimidated by working in these new, data- and technology-intensive roles. When it comes to younger generations, companies struggle to make a compelling value proposition for manufacturing, because of a persistent stigma surrounding the industry and because they just do not have the vocabulary or communicate the opportunities well. Millennials, who make up 35 percent of the workforce according to a recent study completed by the PEW Research Center,<sup>2</sup> still tend to view manufacturing as “dumb, dangerous and dirty,” even though the reality is far different.

To attract the younger generation, it is not sufficient to simply articulate that manufacturing is not dumb, dangerous and dirty, there is a need to shift the entire public perception with new and positive vocabulary that manufacturing is becoming smart, safe and sustainable. Companies must strengthen commitments to engage with students and workers early in their studies and careers, but must equally commit to changing a culture of a stale vocabulary.

Colleges and universities are trying to respond, in no small measure because of increasing pressure from policymakers, parents and students to demonstrate the value of a college degree. Cultivating a strong, versatile workforce remains a focus of universities

<sup>2</sup> <https://www.pewresearch.org/fact-tank/2018/04/11/millennials-largest-generation-us-labor-force/>.

through programs such as a five-year masters or extension programs that fuse STEM and liberal arts disciplines. However, there is a struggle to create excitement among students about the manufacturing field—particularly as other information technology (IT) industries, e.g. gaming, social media, consumer, entertainment within and outside Silicon Valley continue to draw the best and brightest through financial and lifestyle perks. As a consequence, traditional manufacturers often find it challenging to compete for the limited pool of computer engineers, data scientists and IT skilled students at the graduate and post-graduate levels.

At the same time, a persistent and cultural “college for all” mentality has led students and families to take on high levels of debt to pursue a level of schooling that may not be necessary for a wide variety of manufacturing job opportunities. Coupled with a state and federal policymaker emphasis on STEM to the detriment of critically important liberal arts skills such as communications, ethics and problem solving, students are not necessarily getting the education that best prepares them for the digitalized world and that meets the needs of industry.

Addressing the workforce gap will require concurrent efforts to immediately reskill the existing workforce and develop the longer-term pipeline. Through partnerships with local high schools, companies can not only begin to destigmatize and demystify the manufacturing field, but can paint a new resonant perspective of what manufacturing is and can be, while simultaneously preparing students to enter the manufacturing workforce through hands-on training opportunities.



*The Honorable Patricia Falcone, Deputy Director for Science and Technology, Lawrence Livermore National Laboratory; Mr. Richard Heisey, Director of Product Engineering, CNH Industrial; and Ms. Gail Johnson-Roth, Principal Director, Enterprise Systems Engineering, Corporate Chief Engineer's Office, The Aerospace Corporation.*

Students must have the opportunity to learn early on about the merits of a career in manufacturing. Students at the K-12 level can gain a fundamental understanding of skilled labor positions within the industry through hands-on training and internship opportunities, but industry needs to change the model and make clear the potential for a long-term career path through programs such as multi-year, part-time training. A four-year degree is not a prerequisite to success. For example, with the promise of full-time employment after completion of a relevant two-year degree, companies can begin to build a strong talent pipeline early on.

Two-year degree, community college and technical training programs can also help bring returning veterans—who are often unable to wait four years after returning to obtain a college degree—into the workforce. Adding in a reverse-mentoring concept,



*Mr. Doug Lawson, Chief Executive Officer, ThinkIQ.*

through which millennials and older generations of workers can transfer their skills and knowledge and better engage younger workers, will help contribute to a virtuous cycle of multi-generational knowledge-sharing while creating a sense of purpose for millennial workers.

At the high school level, there is ongoing concern that vocational-type schools and classes aimed at preparing students to enter the manufacturing sector are on the decline, with students earning fewer course credits in technical education. From 1990 to 2009, the average number of career and technical education (CTE) credits earned by students dropped from 4.2 to 3.6. Occupational coursework, such as business and agriculture, dropped from 2.7 to 2.5 credits. General technical education coursework dropped from 1.5 to 1.1 credits. Inversely, the average

number of credits students obtained in core academic subjects (i.e. English, mathematics, science and social studies) rose between 1990 and 2009.<sup>3</sup>

## The Federal Role

Developing the SM workforce requires federal investment, as well. When it comes to public sector investment in manufacturing, funding is typically allocated to research and to cultivating doctorate-level students. Unfortunately, research does not often trickle down to the factory floor, where there are very few Ph.D.-level employees managing operations and product lines.

There is, however, a growing number of federally funded programs in place intended to close the manufacturing skills gap. The National Science Foundation (NSF) has several initiatives, including: Advanced Technological Education (ATE), Programs for Non-Academic Internships as Supplements to Existing NSF Research Awards, Engineering for U.S. All (E4USA) and Production Engineering Education and Research.

- The **ATE program** educates students with the skills necessary to succeed in high-technology fields that drive the U.S. economy. This highly competitive grant encourages collaboration between employers and secondary and university educators, giving students the transferable skills they need to succeed once they graduate. To allow students to make contributions outside academia, the NSF provides supplemental funding to qualified graduate students to explore other sectors of the workforce.

<sup>3</sup> <https://nces.ed.gov/fastfacts/display.asp?id=43>.

- **E4USA** builds the foundation for an engineering career by providing a one-year high school course through which students and their teachers can gain the skills to think and practice engineering and design principles. E4USA allows students to gain the competencies needed to excel in an engineering field, while simultaneously gaining college credit.
- A specific example of a public-private partnership to build the future workforce in the manufacturing sector is the work of the NSF and The Boeing Company to spearhead a new initiative aimed at accelerating training in critical skills necessary for the advanced manufacturing and engineering

workforce. The program will better-prepare those in the U.S. STEM workforce to excel in their fields through the design, development, implementation and analysis of online courses in model-based engineering, model-based systems engineering, mechatronics, robotics, data science and sensor analytics, program management, and artificial intelligence.

In sum, talent continues to be the No. 1 challenge facing the manufacturing industry today. Yet, at the same time, the United States is on the precipice of incredible opportunity, if industry and academia can come together to systemically address this challenge. By combatting some of the perception issues

## Deloitte and the Manufacturing Institute Skills Gap and Future of Work Study

According to a study completed by Deloitte and the Manufacturing Institute in 2018, the skills gap may leave an estimated 2.4 positions unfilled between 2018 and 2028. On average, these jobs take roughly 100 days to fill, a 30-day increase from 2015. The talent shortage appears to be intensified by two factors. The first is that the United States is seeing one of the longest periods of economic expansion in history, with the manufacturing industry playing a major role. The second is a demographic challenge, as 4.6 million manufacturing jobs are expected to open—from both retirement and from natural growth—while only 2.2 million are likely to be filled. These jobs will remain unfilled as required skill sets shift due to the introduction of advanced technologies, misperceptions of manufacturing jobs and the retirement of the Baby Boomers. The skills shortage alone has the potential to put over \$454 million in United

States manufacturing GDP at risk, significantly impacting the U.S. economy. With this persistent skills shortage, the U.S. is at risk of losing over \$2.5 trillion in economic output in the next decade. The search for skilled talent continues to be the number one driver of U.S. competitiveness, and over 89 percent of U.S. executives agree that there is a talent shortage in the manufacturing sector. The study identified a number of strategic approaches manufactures could take to influence a more positive employment future, including: public-private partnerships, bolstering apprenticeship programs, developing in-house training and taking advantage of the emerging workforce ecosystem.<sup>4</sup>

<sup>4</sup> 2018 Deloitte and The Manufacturing Institute skills gap and future of work study. <https://documents.deloitte.com/insights/2018DeloitteSkillsGapFoWManufacturing>.

facing the manufacturing sector and cultivating the talent pipeline in the earliest stages of education, industry and academia can work together to ensure the current 2.4 million manufacturing jobs projected to go unfilled represent an opportunity rather than a crisis.

## Smart Manufacturing Challenges and Best Practices

Catalytic innovation throughout all of manufacturing provides the foundation for smart manufacturing in the United States. Catalytic innovation in the SM sense refers to creating data and modeling applications that improve operational productivity, precision and performance throughout the supply chain with new insights, automation, control, optimization, monitoring, diagnosis, prediction and self-analyzed asset and process health. Application innovation is spurred by new infrastructure technologies that are disrupting the sector, but results in an intertwining of legacy and new systems and significant pressure on how vendors generate value. Some of the most disruptive technologies are:

- **Cloud:** Cloud-based systems are globally available and have nearly unlimited compute resources. Data can be accessed remotely and without capital expenditures, making it ideal for small to medium-sized firms. Cloud provides unprecedented opportunity to aggregate and harness the value of data, if data can be secured and IP protected. However, the current proliferation of vendor and product specific cloud platforms is trapping data and adding complexity.
- **Internet of Things (IoT):** IoT is about increased networked sensing and devices providing data and operational opportunity wherever the data are needed. Cloud provides the means to aggregate, manage and harnesses signals from sensors and devices. The benefits of networked sensors and actuators is becoming evident, but the challenges are significantly increased by the proliferation of connected devices combined with the increased need for trusted data that is not under direct control.
- **Edge:** Edge allows the user local flexibility and manageability of local data, management, contextualization and computation, providing a layer of capability between the factory operation and the cloud. Internal IoT device data can be processed, and external IoT data can be managed with edge computing, formerly known as embedded development. Edge capability has allowed for intelligence to be offloaded from the cloud to IoT devices. By doing so, workloads can be accessed on mobile devices or through central data centers.
- **Artificial Intelligence (AI):** AI addresses actionable knowledge and insights in the form of algorithms that can be strengthened with contextualized data, and the use of contextualized data to validate and update other forms of models. There are breakthrough capabilities with the ability to aggregate and process large quantities of data with edge/cloud capabilities. The challenge is that the data needs to be carefully contextualized and the models need to be carefully maintained. It is easy to build a model, but it is difficult to build and maintain a model with operational understanding, validation and verification.

- **5G and Connectivity:** 5G, with its high bandwidth and high connection density, allows users to increase network device, sensor and instrumentation local density and splice them together for high regional densities, running multiple workloads on distributed parts of the network. 5G is expected to proliferate data and actuator capability, but also to amplify the data and modeling challenges above. Edge is turbocharged by 5G.

These catalytic digital capabilities connect and enable unprecedented sources and amounts of data for use in a digital feedback loop at the scale of supply chains, connecting businesses to their operations, materials, products, customers and employees. The digital loop captures data from different key contributors—operations, suppliers, integrators, vendors, materials, employees, products and customers—and then allows it to be connected, synthesized, and modeled for productivity, precision, performance, consumer impact, customer relations, safety and environmental impact. Building digital insights and feedback is not a one-time activity—it is a journey of continuous improvement. Companies that can synthesize this information and connect these insights are growing in comparison to those that cannot. However, an ongoing challenge is the wide gulf in resources available to small and medium-sized firms relative to large global corporations.

While these catalytic innovations offer huge new data capabilities and the potential of significantly increased competitiveness and economic growth combined with better use of resources, they pose a unique set of challenges for the manufacturing

industry. There is hesitancy regarding the sharing of operational data and IP across supply chains, despite clear efficiency and other benefits. Enterprise sharing must be based on a partnership requiring agreements by the business and the operations management. There is a huge gap in enabling or even acknowledging innovation external to a manufacturer or vendor. Data and testing are critical.

Collecting data is easy. Contextualizing data is difficult. Applications can be solution silos that act as red tape, slowing down or blocking the discovery process with data. Businesses invariably must navigate multiple ways of connecting and collecting data, different kinds of data sets and the data models needed to gain insight into the problems and solutions of interest. As data is distributed, there are questions about who owns the data, who manages the data and whether it can be trusted. Security, brownfield equipment, gaps in IT and OT capabilities and their collective contributions to impeding interoperability are also challenges facing the manufacturing industry. Another of CESMII's areas of focus is leading the effort to drive a defacto industry standard for the collection, ingestion, contextualization and orchestration of data from real-time manufacturing systems, with significant emphasis on better ways to achieve interoperability. Interoperability and consistent infrastructure are essential to the democratization of SM, which also requires dramatically reducing the cost and complexity of these systems.

When it comes to digital and data security, the U.S. manufacturing sector has largely moved beyond the notion that data in the cloud is not secure. However, manufacturers, especially small and medium-sized

## Bühler + Microsoft

Through a partnership with Microsoft, Bühler is combining advanced data analysis with machine learning to tackle key problems in the global food chain. Keeping highly carcinogenic toxins out of grain is a key concern for growers, harvesters and processors. Using cloud-based data analysis coupled with UV lighting technology, Bühler enabled technology to detect contamination in the grain.

Common grain carcinogens affect roughly 2 in every 10,000 grains. An inherent difficulty in detecting these contaminated grains poses significant health risks in countries without strict food regulation and economic risks in heavily regulated countries. By combining 70 years of grain sorting expertise with Microsoft's cloud, data analytic software and advances in camera and UV lighting technology, Bühler produced LumoVision. By taking pictures of individual kernels, they are able to remove the contaminated grain, ensuring it is safe for food and feed.

Through an exploratory analysis of the hyperspectral data in Azure Machine Learning Studio, the most optical parameters and wavelengths for classifying contaminated grain were established.

These insights enabled the Bühler team to develop an effective and cost-effective camera with high-throughput grain sorting, capable of detecting the carcinogenic toxins in the grain. Once these grains are detected, they are removed with high precision air injectors, allowing the rest of the grain to be sold. The technology has the capability to sort more than 15 tons of grain an hour, equivalent to an entire truck load of maize.

In addition to their dedication to keeping highly carcinogenic toxins out of grain, Bühler is taking steps to ensure transparency throughout the food value chain. Using technology such as Block Chain, companies can track quality and location, ensuring transparency for their customers, who can gain early intelligence in the event of a food safety outbreak. Through this technology, companies will be able to locate the cause of the contamination and will be able to prevent illness, lost food production and damaged brand reputation.

manufacturers (SMMs) often do not have the know-how or financial means to create a secure, reliable networks for facilities. Brownfield equipment and the legacy data and software management capabilities pose security challenges for all manufacturers, but especially SMMs. As manufacturers install new equip-

ment and software—often in a piecemeal fashion—and integrate it with older equipment, interoperability, network stability and security become serious risks. SMMs, which have potentially the most to gain with SM, face some of the largest obstacles, even for relatively small steps into digitalization.

While the arguments are strong for SM, the economics to deploy these technologies requires different considerations about capital and service investments that are still not fully appreciated or even understood. Questions remain about how manufacturers account for and address variable costs for cloud services in which access and transactions carry charges. For example, will current variable cost accounting drive the industry in the best direction, or will it prohibit access to the data that companies are working so hard to gather and curate? What is certain, however, is that the greatest value that can be extracted from IoT and machine learning comes from addressing solvable problems. If used effectively, these technologies will allow industries to find significant economic value by removing supply chain inefficiencies, operating more effectively and securing their data.

One important path toward addressing concerns with interoperability and collaboration is to utilize consortia that already exist to help drive standardization. Even so, these agenda-based approaches often move far too slowly relative to the pace of digitalization. There is a need to accelerate on the basis on value, proceed to accept and expose multiple methods, and let the market value drive toward what is standardized and what is not. This is not a winner-take-all situation, but instead a place for partnerships—partnerships that can transform the entire global manufacturing supply chain.

At the end of the day, an Open Manufacturing Platform is needed to create industry standard schemas (defacto standards) to enable data sharing between all the vendors participating in SM. Standards development approaches do not achieve necessary goals. There are huge advances in optimization to be made in the manufacturing process in the United States.



*Dr. Mark Johnson, Director, Center for Advanced Manufacturing, Clemson University; and Mr. Glen Lewis, Principal & Operations, Energy & Supply Chain Management Advisor, Glen Lewis Group, LLC and University of California Davis.*

As competitors such as China and Europe invest in this space, the United States must move much more quickly to take advantage of these opportunities before it finds itself falling behind these and other rising global leaders in the SM space.

### **Further Aligning Interests and Opportunities**

Open platforms, trusted data exchange and shared infrastructure are critical to business collaboration, operational interoperability and the democratization of capability and innovation with and across small, medium-sized and large companies. There is a critical need for a platform that provides key shared digital, data and software infrastructure that scales nationally and globally. The value of such an open platform derives from the collaboration, interoperability and democratization it facilitates, but depends on significant shifts in long-held mindsets about market-





*Dr. Steven F. Ashby, Laboratory Director, Pacific Northwest National Laboratory; Mr. Chad Evans, Executive Vice President, Council on Competitiveness; and Mr. John Chisholm, CEO, Chisholm Ventures.*

drivers, infrastructure value, isolationism with data and intellectual property, siloed operations and the risk/value in collaboration involving business exchange of information.

From a technical standpoint, an “open platform” is far from an established term and still means many things to many people. Vendors, practitioners, integrators, university researchers and government personnel all emphasize openness differently, because business interests and agendas vary dramatically. From the point of view of democratization, however, openness needs to include access for all to technologies, data and tools for operational and development use, while at the same time individual data and IP are appropriately protected, yet can be selectively used by business or service level agreements. Operational use needs to be defined in terms of agreed upon readiness and with agreed upon service levels. Additionally, an open platform as shared infrastructure has a significant capability with

aggregating data across products, manufacturers, users, etc. Aggregated data can be valuable as a shared resource, but problematic because of individual sources. What data are collected, in what form and how it is used require governance and significant attention to security, privacy and protection of intellectual property. There needs to be a very high degree of trust, security and governance for an open platform of this nature to be used, even if the arguments for usefulness are very strong.

In today's environment, the sensitive nature of building trust and credibility relative to risk with an open platform leads to slow, incremental progress. Yet, to remain competitive, the United States must accelerate the rate and efficiency of operational data, modeling and control innovation across the economy. At present, the pace at which new data and modeling operational innovations from research and academic institutions, and other companies—vendors and manufacturers alike—are implemented has remained exceptionally slow and exceptionally slanted in favor of large manufacturers that have the resources.

While the long-term value of the market to drive change is recognized, the question is whether market-driven change is fast enough relative to the pace necessary to sustain competitiveness. With federal funding allocated to research flat, increasing the development and deployment of new products by democratizing the capability for innovation is of great interest to policymakers and other stakeholders.

Public-private partnerships offer the best structure for addressing challenges and accelerating the pace of innovation, which largely depend on collaboration, trust and governance, because no single entity can take on an overall role for industry. By advocating for open platforms as defined—the technological wherewithal

to use data and models extensively, and the access to tools, methods and practices that support win-win business collaborations—public private partnerships can build capability, share risk, build critical mass and facilitate governance for a shift toward open platforms held together by practical standards. Open platforms must be part of the solution, or democratization fails. Yet, just funding partnerships with federal dollars alone is not a long-term solution.

CESMII has demonstrated that access to contextualized plant information is a decades-old problem still plaguing manufacturing. The massive amount of raw data collected is overwhelming to most companies. Without good, validated and contextualized data, manufacturing will lack the fuel to drive the vision of a digital (and more competitive) enterprise. Additionally, technological developments that include cloud computing that can dramatically facilitate ways to do data exchange offer IT pathways to accelerate innovation. Nevertheless, organizational and cultural change remain challenging. Changing the mindsets and the ways systems are architected continues to be a barrier for building repeatable and reusable solutions that are not locked into a specific platform. Building models that support many applications in order to avoid fragmentation must be part of the solution.

Cultural complexities, the complexity of systems and global complexity all present additional challenges to interoperability and business collaboration. The global nature and opportunity of the manufacturing sector means that isolationism and siloing will eventually result in economic loss as other companies and countries move forward. Silos within organizations make it difficult to work toward a common goal. The tendency of organizations is to take information offline, which is the opposite of what needs to happen.



*Dr. Todd Steyer, Sr. Manager, Materials & Manufacturing Technology, The Boeing Company; Dr. Suresh Sunderrajan, Interim Associate Laboratory Director, Argonne National Laboratory; and Mr. Gregg Profozich, Director, Advanced Manufacturing Technologies, CMTC.*

The challenges with the market, cost, time, risk and resource intensive innovation have roots in generating reusable contextualized data, the lack of widespread industry access to capability and the increasing complexity with IoT and cloud. These all combine to make change difficult, slow and risky. Deployment of information systems, the key to taking advantage of the innovations with IoT, extensive use of data, modeling, machine learning, AI and other transformation technologies, is moving way too slow. There remain large challenges with the inability to build on applications and systems engineering efforts and make them reusable, scalable and shareable.

Current approaches are not working and certainly not fast enough. There needs to be an alternative that can be truly driven by the market that moves at the speed of business. Manufacturers, the public sector and academia must all be engaged, and democratization should be a driving principle since it is fundamentally about access—to data, technology and the ability and capability to innovate.

One example of a public sector effort to advance America's innovation enterprise is ICORE, a program headed by the National Science Foundation. ICORE provides training and education for those who want to start a company. Through a seven-week boot camp, participants can interview potential customers to see if there is a market for their product. If nobody buys in, they can return to the lab with a new perspective. Through this program, researchers who are interested in starting their own company have an opportunity to lower risks and are thus more willing to take larger risks. Programs like these must be made more scalable and accessible—and transcend agency boundaries—for the nation to capitalize on the democratization of innovation.

## Strategic Investments in Smart Manufacturing

The United States must make the necessary investments to raise the domestic potential of and counter global competition in SM. The United States relies heavily on market forces when it comes to making federal investment decisions. This differentiates the nation from many of its competitors, creating both opportunities and challenges related to sustainability and necessitating public-private partnerships. While one analog are the federally funded Fraunhofer Institutes in Germany, it is not clear that the model Germany is pursuing is the right model for the United States.

When looking at innovation infrastructures across the globe, the Fraunhofer Society—a German research organization with 72 institutes spread

throughout Germany, each focusing on different fields of applied science—is a relevant example. About 30 percent of the funding for the Fraunhofer institutes comes from the government, with the rest generated through both private and public sector contracts. Other countries are investing federal dollars in greater amounts and in more directed ways. Clearly there are benefits to stable, predictable public funding to overcome short-term sustainability concerns, but relying too much on public funding and not focusing on scalable, market-driven solutions is a detriment.

Beyond the traditional federal role as the prime funder of basic scientific research, recent investments in large public-private manufacturing hubs, known as the Manufacturing USA institutes, have been the signature federal initiative in the manufacturing space. When it comes to cross-sector collaboration, those companies that are aware of the Manufacturing USA institutes look to them as examples of the type of public-private partnerships that provide several distinct functionalities: collaboration with partners from academia and industry; the ability to come together in a public forum that does not cross through anti-trust constraints; the neutrality and openness to address non-proprietary, pre-competitive challenges; and a place to manage proprietary consideration with neutral infrastructure. Yet, the pace at which the institutes are progressing on activities vis-à-vis public sector solutions remains a challenge, as does substantive collaboration among the institutes and their sustainability as fixed-term funded institutes. There is no question that CESMII and other institutes have a tremendous opportunity to drive value if properly supported for the amount of time.

When it comes to the individual sustainability of the Manufacturing USA institutes past their federally funded life expectancy, it is important to consider each Institute's unique value to America's manufacturing enterprise and whether the value add is sufficient to drive the corporate funding needed to sustain it. The National Academy of Sciences, think tanks and other organizations have all published reports on the challenges related to the sustainability of the funding. However, if funded and sustained for a enough time to have impact, these institutes can successfully focus on the mid- to long-term developments and the infrastructure development that are so difficult, if not impossible, for manufactures to do alone.

One example of a working model is the Commonwealth of Massachusetts, which is linking state funding with the Manufacturing USA institutes to foster development in geographical areas where manufacturing used to thrive. This kind of partnership more strongly emphasizes economic development and the desire to spark innovation and collaboration. Similarly, a 2017 study completed by Deloitte noted that Manufacturing USA has successfully created public-private partnerships that bring together members of academia, industry and government.<sup>5</sup> It can be argued that the Manufacturing USA institutes, such as CESMII, are addressing a significant market failure in the United States and, as a result, the public sector should maintain support for the institutes—in partnership with state-level and private sector partners—to ensure America's innovation ecosystem can accelerate and thrive.



*Mr. Jim Watson, CEO, California Manufacturing Technology Consulting, Inc.; Ms. Laurie ten Hope, Deputy Director, R&D Division, California Energy Commission; and Mr. Jimmy Asher, Senior Manager, Supply Chain and Network Operations Practice, Deloitte Consulting LLP.*

While current nonfederal funding matches federal funding at a 2-1 ratio, exceeding the original 1-1 goal and demonstrating the value of the network to industry, academia and the states,<sup>6</sup> federal and private sector funding will need to extend further to ensure the sustainability of the institutes. However, the president's budget continues to question the value of the Manufacturing USA institutes and to propose cutting the funding for these programs by as much as 70 percent, signaling that federal support for these programs may be waning.

5 <https://www2.deloitte.com/content/dam/Deloitte/us/Documents/manufacturing/us-mfg-manufacturing-USA-program-and-process.pdf>.

6 <https://www.nist.gov/fy-2019-presidential-budget-request-summary/industrial-technology-services/manufacturing-usa>.



*Mr. Sam George, Corporate Vice President of Azure IoT, Microsoft.*

Looking to the future, it is not a question of how valuable public-private partnerships are to U.S. manufacturing and overall competitiveness, but specifically:

1. Are the institutes addressing those aspects of manufacturing competitiveness that no one company can address;
2. Are they as effective as they can be with a business model framework in which each institute has its own membership model, its own operating model; and
3. Do the bureaucracy management requirements sufficiently outweigh the investment and time to effort to deal with institute operations?

## Smart (and Secure) Manufacturing

The economic advantages of the internet, increasing functionality of commodity networking and information technology and the diversification of supply chains that include many small businesses has led to new cybersecurity risks that now affect the safety and availability of the services provided by critical infrastructures. These risks have been well documented by the Council's work in this space and by the work of MForesight,<sup>7</sup> which included significant SM involvement.

Digitalization, IoT, AI/modeling and interoperability—all of which carry the promise and potential to transform the manufacturing sector—also increase vulnerability to sophisticated cyber-attacks. In order to combat this threat, the United States must proceed thoughtfully when it comes to implementing SM technologies—not just across industry, but across academia, the military, the electric grid and all the nation's interconnected systems. The military, which increasingly relies on the nation's technological superiority to maintain its military superiority, faces cyber threats to some of the most sophisticated weapons platforms. And the threat to the electric grid has been laid bare in places such as Ukraine, with sobering consequences several winters in a row.

The Stuxnet attack in 2010 exemplifies the potential severity of a cyber-attack. With only 500 kilobytes of code (the size of a small JPEG photo), nearly 1,000 of Iran's uranium-enriching centrifuges were impacted by infecting Siemens software. This attack set the Iranian Nuclear Weapons Program back significantly. Similar programmable logic controllers

<sup>7</sup> MForesight: Alliance for Manufacturing Foresight is an independent, nonprofit, expert-driven organization focused on the future of technology, policy and the workforce.

(PLCs) in centrifuges are used in most industrial equipment, and it would take just a thumb drive to cause a similar attack on U.S. manufacturing capability. As a result, the United States must consider cybersecurity through a proactive lens rather than solely in response to cyber sabotage.

In February, the U.S. Department of Energy Office of Energy Efficiency and Renewable Energy (EERE) announced the intent to fund a new manufacturing institute, the Cybersecurity Institute for Energy Efficient Manufacturing. The institute is intended to ensure all U.S. energy technologies across the board are best equipped to handle cyber threats. By engaging academia, industry, government and national labs, the institute will aim to:

- Understand the evolving cybersecurity threat to greater energy efficiency in manufacturing industries;
- Develop new cybersecurity technologies and methods; and
- Share the information and expertise with the broader community of U.S. manufacturers.



*Dr. Luke Monck, Senior Manager, Industrial Products and Construction Practice, Deloitte Consulting LLP; and Ms. Michelle Pastel, Manager of Technology and Engineering Development, Corning Glass.*

While cybersecurity is largely considered a necessity, it comes at a price. To motivate companies to take the steps necessary to combat a cyber-attack, they must first understand the value of their data. To small and medium-sized firms, cybersecurity remains a huge challenge. These firms have problems with their internal infrastructure and skills sets, and thus are struggling to create secure cyber networks. Smaller firms are often running to keep up with current technology trends. Paying for a secure cyber infrastructure continues to be a challenge, as the money is often not currently in corporate budgets. Because of this, these smaller firms are waiting until there is a cyber-attack to build up their cyber infrastructure—otherwise, it is often viewed as not worth the cost to them until it is too late. Ultimately, cybersecurity requires a proactive approach, given the potential impacts of a cyber-attack on business, national security, economic security and livelihoods.

# An Agenda to Drive Action on U.S. Smart Manufacturing

## The Private Sector Should:

1. Explore partnerships between companies and K-12 schools to help demystify and destigmatize the manufacturing field. Internships, hands-on training and pathways to careers are all important steps that can be taken to better prepare students and meet companies' future employment needs.
2. Encourage reverse mentoring arrangements to engage millennials with older generation workers to create a virtuous cycle of multi-generational knowledge transfer and greater sense of purpose for both new and "near retirement" workers.
3. Seek to strengthen lifetime linkages to college and university graduates, enabling easier access to lifelong learning opportunities and mid-career upskilling.
4. Proactively work to break down data and solution silos internally to enable data analytics to identify resource, talent and production efficiencies.
5. Encourage partnerships, consortia and general interoperability through agreed upon standards to allow vendors and other stakeholders in the SM ecosystem to be able to collaborate and communicate.
6. Encourage greater uptake and use of cybersecurity standards to ensure the stability and security of SM.

## The Government (Federal, State and Local) Should:

1. Integrate more technical training into K-12 curricula, including encouraging more engineering credits.
2. Reduce state and local barriers to allow industry practitioners in the classroom to help inspire the next generation of SM workers.
3. Increase funding for research across all federal agencies at a consistent and predictable growth rate, with a goal of 1 percent of GDP.
4. Develop a mechanism for long-term sustainable funding for the Manufacturing USA institutes.
5. Build on existing efforts to incentivize technology transfer and partnerships between national laboratories, universities and businesses by streamlining IP agreements and making industry collaboration part of promotion and tenure decisions.
6. Create a federal verification system for crowdsourced data to enhance the validity and usefulness of knowledge databases across sectors.
7. Sustain funding for the Manufacturing Extension Partnership<sup>8</sup> network and expand resources available for cybersecurity tools and training for small and medium-sized businesses.
8. Expand existing programs to additional states to provide veterans with access to manufacturing and cybersecurity training opportunities and resources to re-enter the workforce.

<sup>8</sup> Manufacturing Extension Partnership (MEP) is a public-private partnership with centers in all 50 states and Puerto Rico dedicated to serving small and medium-sized manufacturers.

## APPENDIX A

# Dialogue Agenda

## MORNING

### 8:30 Registration and Light Breakfast

### 9:00 Welcome and Opening Remarks

**Gene Block**

Chancellor  
UCLA

**William Bates**

Executive Vice President  
Council on Competitiveness

### 9:15 The Council and the Goals of Today's Dialogue

The United States is facing a promising frontier with Smart Manufacturing (SM), shaped by the opportunity of digitalization, the emergence of advanced operation and information technologies and the resulting generational re-emergence of advanced and highly productive manufacturing capacity on U.S. soil. This dialogue will focus on the democratization of SM as a practical necessity for the future of U.S. manufacturing—the result of demand for higher precision, higher value products and the faster, cheaper, safer and far better use of materials and energy with less environmental impact. Realization of the considerable economic, investment and market growth opportunity created by supply chain productivity, process precision and manufacturing performance with radically expanded application of data, information and modeling will be a key driver of U.S. competitiveness.

**William Bates**

Executive Vice President  
Council on Competitiveness

**Chad Evans**

Executive Vice President  
Council on Competitiveness

**Jim Davis**

Vice Provost IT & Chief Academic Technology  
Officer, Principal Investigator CESMII  
UCLA



### 9:30 Building the Talent and Workforce for the Future

There has been, and continues to be, considerable national discussion on talent, workforce training and education for advanced manufacturing technologies. SM, and the process of manufacturing digitalization, requires much more than a workforce trained in data technologies. There is a growing need—and ability—to build and tap into a new culture of data consumers and data innovators and entrepreneurs. There is also a need to capitalize on an evolving culture of public and private partnerships to address complex, grand challenge level problems. Innovation, solutions and security can be spurred by an army of people with levels of expertise and proficiency in data partnerships and innovation and who know how to tap into and put into action an infinite array of possibilities created through access and exchange of data.

#### Key Questions

- Is there a need to rethink workforce training and education as part of a cultural shift to a data, innovation and partnership-driven economy?
- How can industry and academia work together to build and tap into this new cohort of data consumers but also data innovators and entrepreneurs?

#### Lead Discussants

##### Gene Block

Chancellor  
UCLA

##### Jimmy Asher

Senior Manager, Supply Chain and Network  
Operations Practice  
Deloitte Consulting LLP

##### Luke Monck

Senior Manager, Industrial Products and  
Construction Practice  
Deloitte Consulting LLP

### 10:30 Networking Break

### 10:45 Challenges and Best Practices

There is much discussion that U.S. manufacturing needs to spur democratization of technology, knowledge, and innovation. This is particularly acute for SM, where success depends on extensively scaled data exchange and interoperability agreements and partnerships. Democratization can occur through shared infrastructure that facilitates openness and interoperability in manufacturing and reduces the complexity of data and information use. What are today's SM digitalization transformation challenges and best practices for U.S. manufacturing?

#### Key Questions

- What is the SM scorecard today? What is working and what the roadblocks standing in the way of transformation?
- What are some examples of replicable transformation best practices in manufacturing?

#### Lead Discussant

##### Sam George

Corporate Vice President of Azure IoT  
Microsoft

### 11:45 The National Commission on Innovation and Competitiveness Frontiers

In 2019, the Council launched a new initiative, the National Commission on Innovation and Competitiveness Frontiers (Commission). The Exploring the Future of Production, Sustainable Consumption and Work Working Group of the Commission aims to map out the forces driving innovation and motivations shaping the future economy.

#### Chad Evans

Executive Vice President  
Council on Competitiveness

### AFTERNOON

#### 12:00 Lunch

#### 12:30 Guest Presentation

#### John Dyck

CEO  
CESMII, the Smart Manufacturing Institute

### 1:00 Aligning Interests and Opportunities

Openness, “open” platforms, interoperability, and shared infrastructure are not at all straightforward. For example, vendor, practitioner, integrator, university and government “business” interests can vary dramatically. Aligning interests and opportunities across multiple stakeholders is essential to the competitiveness of the manufacturing sector in the United States.

#### Key Questions

- What do industry executives, federal and state governments, and university leaders need to know today about SM?
- How can policymakers and users ensure that digitalization and democratization do not outpace security in the form of cyber threats from state and unaffiliated actors?
- How are the voices of small, medium and large practitioners, providers, integrators, universities and government aligned to address risk and opportunity?

#### Lead Discussants

#### Michelle Pastel

Manager of Technology and Engineering  
Development  
Corning Glass

#### Doug Lawson

CEO  
ThinkIQ

## 2:00 U.S. Private and Public Investment in Enabling Smart Manufacturing

The United States places a high reliance on market forces relative to government policy and investment compared to other countries for both initial change and sustainability. Are U.S. manufacturing industry, the Manufacturing USA institutes, the national labs, agency research and development programs, and state programs adequately prioritizing these to keep pace with consumer and global market demand and technology, investment and innovation around the globe? Does the United States have the right balance to achieve SM at a good pace and sustain it?

### Key Questions

- Is the U.S. adequately prioritizing policy and investment to keep pace with consumer and global market demand that SM and related advanced digital technology, investment, and innovation around the globe?
- What is the balance between market forces and investment for manufacturing cybersecurity?
- Is the U.S. manufacturing base on track to compete in the global marketplace when it comes to digital technology?

### Lead Discussants

#### Mark Johnson

Director, Center Advanced Manufacturing, Clemson & Former Director, DOE Advanced Manufacturing Office

#### Kiran Sheth

Distinguished Engineering Associate  
ExxonMobil Research & Engineering

## 3:00 Smart Manufacturing and a National Agenda for Cybersecurity

Specialized, closed-circuit cyber-physical systems have been in place in large industrial and manufacturing facilities for years. However, the economic advantages of the internet, increasing functionality of commodity networking and information technology, and the diversification of supply chains that include many small businesses has led to new cybersecurity risks that now affect the safety and availability of the services provided by critical infrastructures.

#### Steven F. Ashby

Laboratory Director  
Pacific Northwest National Laboratory

## 3:15 Smart Manufacturing and the Larger Council Agenda

The SM discussion will inform the work of the Commission, and the Production, Consumption and Work working group as it looks to prepare the United States for the coming, and constantly evolving, shifts in how Americans create, use and otherwise contribute to society.

#### William Bates

Executive Vice President and Chief of Staff  
Council on Competitiveness

## 3:45 Closing Remarks from UCLA and the Council on Competitiveness

## APPENDIX B

## Dialogue Participants

**Jose Anaya**

Director  
El Camino Community College

**Steven F. Ashby**

Laboratory Director  
Pacific Northwest National Laboratory

**Jimmy Asher**

Senior Manager, Supply Chain and Network  
Operations Practice  
Deloitte Consulting LLP

**William Bates**

Executive Vice President  
Council on Competitiveness

**Gene Block**

Chancellor  
UCLA

**John Chisolm**

CEO  
Chisholm Ventures

**Jim Davis**

Vice Provost IT & Chief Academic Technology  
Officer  
Principal Investigator CESMII  
UCLA

**Kelly Dodds**

Advanced Manufacturing Technical Director  
Raytheon

**John Dyck**

CEO  
CESMII

**Chad Evans**

Executive Vice President  
Council on Competitiveness

**Patricia Falcone**

Deputy Director for Science and Technology  
Lawrence Livermore National Laboratory

**Sam George**

Corporate Vice President of Azure IoT  
Microsoft

**Richard Heisey**

Director of Product Engineering  
CNH Industrial

**Scott Hibbard**

Vice President  
Bosch

**John Hopkins**

Chief Executive Officer  
IACMI

**Pam Hurt**

Director, Business Capture, Brand, Membership  
National Center for Manufacturing Sciences

**Leszek Izdebski**

Group Vice President, Digital Transformation  
ABB

**Mark Johnson**

Director, Center for Advanced Manufacturing  
Clemson University

**Gail Johnson-Roth**

Principal Director, Enterprise Systems Engineering  
Corporate Chief Engineer's Office  
The Aerospace Corporation

**Pramod Khargonekar**

Vice Chancellor of Research  
University of California, Irvine

**Dominik Knoll**

CEO  
AVA Ventures

**Bruce Kramer**

Director Civil, Mechanical and Manufacturing  
Innovation  
National Science Foundation

**Dimitris Lagoudas**

Associate Vice Chancellor for Engineering  
Research  
Texas A&M University

**Doug Lawson**

CEO  
ThinkIQ

**Glen Lewis**

Principal & Operations, Energy & Supply Chain  
Management Advisor  
Glen Lewis Group, LLC & University of California  
Davis

**Haresh Malkani**

Chief Technology Officer  
CESMII

**Rob Massoudi**

Vice President, Digital Transformation  
ABB

**Larry Megan**

R&D Director  
Praxair

**Luke Monck**

Senior Manager, Industrial Products and  
Construction Practice  
Deloitte Consulting LLP

**James Nokes**

Principal Director of the Space Materials  
Laboratory  
The Aerospace Corp

**John Orth**

EVP Operations  
Ryerson

**Michelle Pastel**

Manager of Technology and Engineering  
Development  
Corning Glass

**Jennifer Pilat**

Vice President, Engagement  
DMDII

**Dave Pritts**

Vice President Business Development and  
Marketing  
ThinkIQ

**Gregg Profozich**

Director, Advanced Manufacturing Technologies  
CMTC

**Steve Prusha**

Program Manager, Strategic  
JPL

**Sudarsan Rachuri**

Program Manager CESMII  
DOE

**Jon Riley**

Senior Vice President  
National Center for Manufacturing Sciences

**Katie Sarro**

Senior Policy Director  
Council on Competitiveness

**Rob Schoenthaler**

CEO  
Atollogy

**Kiran Sheth**

Distinguished Engineering Associate  
ExxonMobil Research and Engineering

**Todd Steyer**

Senior Manager, Materials & Manufacturing  
Technology  
The Boeing Company

**Marcus Sturm**

Director, Global Manufacturing IT  
PepsiCo

**Suresh Sunderrajan**

Interim Associate Laboratory Director  
Argonne National Laboratory

**Laurie ten Hope**

Deputy Director, R&D Division  
California Energy Commission

**Dawn Tilbury**

Assistant Director for Engineering  
National Science Foundation

**Rick Van Dyke**

Supply Chain Engineering Director  
PepsiCo Americas Foods

**Roger Wakimoto**

Vice Chancellor of Research  
UCLA

**Jim Watson**

CEO  
CMTC

APPENDIX C

# Dialogue Sponsors

The logo for Deloitte, featuring the word "Deloitte" in a bold, black, sans-serif font, followed by a small green dot.The Microsoft logo, consisting of four colored squares (red, green, blue, yellow) arranged in a 2x2 grid, followed by the word "Microsoft" in a grey, sans-serif font.The ThinkIQ logo, featuring a stylized orange and blue gear-like icon on the left, followed by the word "ThinkIQ" in a blue and orange sans-serif font.The UCLA logo, consisting of the letters "UCLA" in white, bold, sans-serif font, centered within a solid blue rectangular background.The CESMII logo, featuring a green gear icon on the left, followed by the letters "CESMII" in a large, blue, bold, sans-serif font, and the text "THE SMART MANUFACTURING INSTITUTE" in a smaller, blue, sans-serif font below it.

# About the Council on Competitiveness

For more than three decades, the Council on Competitiveness (Council) has championed a competitiveness agenda for the United States to attract investment and talent, and spur the commercialization of new ideas.

While the players may have changed since its founding in 1986, the mission remains as vital as ever—to enhance U.S. productivity and raise the standard of living for all Americans.

The members of the Council—CEOs, university presidents, labor leaders and national lab directors—represent a powerful, nonpartisan voice that sets aside politics and seeks results. By providing real-world perspective to Washington policymakers, the Council's private sector network makes an impact on decision-making across a broad spectrum of issues from the cutting-edge of science and technology, to the democratization of innovation, to the shift from energy weakness to strength that supports the growing renaissance in U.S. manufacturing.

The Council's leadership group firmly believes that with the right policies, the strengths and potential of the U.S. economy far outweigh the current challenges the nation faces on the path to higher growth and greater opportunity for all Americans.

## **Council on Competitiveness**

900 17th Street, NW  
Suite 700  
Washington, D.C. 20006  
+1 (202) 682-4292  
Compete.org

# Council on Competitiveness Members, Fellows and Staff

## BOARD

### Chairman

**Dr. Mehmood Khan**  
Chief Executive Officer  
Life Biosciences, Inc.

### Industry Vice-chair

**Mr. Brian T. Moynihan**  
Chairman and Chief Executive Officer  
Bank of America

### University Vice-chair

**Dr. Michael M. Crow**  
President  
Arizona State University

### Labor Vice-chair

**Mr. Lonnie Stephenson**  
International President  
IBEW

### Chairman Emeritus

**Mr. Samuel R. Allen**  
Chairman and Chief Executive Officer  
Deere & Company

### President & CEO

**The Honorable Deborah L. Wince-Smith**  
Council on Competitiveness

## EXECUTIVE COMMITTEE

**Mr. Jim Balsillie**  
Co-founder  
Institute for New Economic Thinking

**Mr. Thomas R. Baruch**  
Managing Director  
Baruch Future Ventures

**Dr. Gene D. Block**  
Chancellor  
University of California, Los Angeles

**Mr. William H. Bohnett**  
President  
Whitecap Investments, LLC

**Dr. James P. Clements**  
President  
Clemson University

**Mr. Jim Clifton**  
Chairman and CEO  
Gallup

**Dr. John J. DeGioia**  
President  
Georgetown University

**Mr. George Fischer**

Senior Vice President and President, Global Enterprise  
Verizon Business Group

**Ms. Janet Foutty**

Chair of the Board  
Deloitte LLP

**Dr. William H. Goldstein**

Director  
Lawrence Livermore National Laboratory

**Mr. James S. Hagedorn**

Chairman and CEO  
The Scotts Miracle-Gro Company

**Dr. Sheryl Handler**

President and CEO  
Ab Initio

**Mr. Charles O. Holliday, Jr.**

Chairman  
Royal Dutch Shell, plc

**The Honorable Shirley Ann Jackson**

President  
Rensselaer Polytechnic Institute

**Dr. Farnam Jahanian**

President  
Carnegie Mellon University

**Dr. Pradeep K. Khosla**

Chancellor  
University of California, San Diego

**Mr. James B. Milliken**

Chancellor  
The University of Texas System

**Gen. Richard B. Myers**

President  
Kansas State University

**The Honorable Janet Napolitano**

President  
The University of California System –Regents

**Mr. Nicholas T. Pinchuk**

Chairman and CEO  
Snap-on Incorporated

**Professor Michael E. Porter**

Bishop William Lawrence University Professor  
Harvard Business School

**Mr. Robert L. Reynolds**

President and CEO  
Putnam Investments

**Dr. Mark S. Schlissel**

President  
University of Michigan

**Mr. Steve Stevanovich**

Chairman and Chief Executive Officer  
SGS Global Holdings

**Mr. Larry Weber**

Chairman and Chief Executive Officer  
Racpoint Global

**Ms. Randi Weingarten**

President  
American Federation of Teachers, AFL-CIO

**Dr. W. Randolph Woodson**

Chancellor  
North Carolina State University

**Mr. Paul A. Yarossi**

President  
HNTB Holdings Ltd.

**Dr. Robert J. Zimmer**

President  
The University of Chicago

## GENERAL MEMBERS

**Mr. Jonathan R. Alger**  
President  
James Madison University

**Dr. Joseph E. Aoun**  
President  
Northeastern University

**Dr. Aziz Asphahani**  
Chief Executive Officer  
QuesTek Innovations, LLC

**Dr. Dennis Assanis**  
President  
University of Delaware

**Dr. Eric Barron**  
President  
The Pennsylvania State University

**The Honorable Sandy K. Baruah**  
President and Chief Executive Officer  
Detroit Regional Chamber

**Dr. Mark P. Becker**  
President  
Georgia State University

**Dr. Richard Benson**  
President  
The University of Texas at Dallas



**The Honorable Rebecca M. Blank**  
Chancellor  
University of Wisconsin—Madison

**Dr. Lee C. Bollinger**  
President  
Columbia University

**Dr. Robert A. Brown**  
President  
Boston University

**Mr. Al Bunshaft**  
Senior Vice President, Global Affairs  
Dassault Systèmes Americas

**The Honorable Sylvia M. Burwell**  
President  
American University

**Mr. Bill Cave**  
CEO  
Prediction Systems

**Mr. John Chachas**  
Managing Partner  
Methuselah Advisors

**Mr. John Chisholm**  
Chief Executive Officer  
John Chisholm Ventures

**The Honorable Mitchell E. Daniels, Jr.**  
President  
Purdue University

**Mr. Ernest J. Dianastasis**  
CEO  
The Precisionists, Inc.

**Dr. Michael V. Drake**  
President  
The Ohio State University

**Dr. Taylor Eighmy**  
President  
The University of Texas at San Antonio

**Mr. Robert Ford**  
President and Chief Operating Officer  
Abbott

**Mr. Kenneth C. Frazier**  
Chairman and Chief Executive Officer  
Merck & Co., Inc.

**Dr. Wayne A. I. Frederick**  
President  
Howard University

**Dr. Julio Frenk**  
President  
University of Miami

**Dr. W. Kent Fuchs**  
President  
University of Florida

**The Honorable Patrick D. Gallagher**  
Chancellor  
University of Pittsburgh

**Dr. E. Gordon Gee**  
President  
West Virginia University

**Dr. Amy Gutmann**  
President  
University of Pennsylvania

**Ms. Marilyn A. Hewson**  
Chairman, President and CEO  
Lockheed Martin

**Mr. G. Michael Hoover**  
Chief Executive Officer  
Sundt Construction

**The Honorable Steven J. Isakowitz**  
President and Chief Executive Officer  
The Aerospace Corporation

**Rev. John I. Jenkins**  
President  
University of Notre Dame

**Dr. James R. Johnsen**  
System President  
University of Alaska

**Dr. Paul Johnson**  
President  
Colorado School of Mines

**Dr. Robert E. Johnson**  
Chancellor  
University of Massachusetts Dartmouth

**Mr. Edward Jung**  
Founder and CEO  
Xinova, LLC

**The Honorable Alexander A. Karsner**  
Managing Partner  
Emerson Collective

**Dr. Timothy L. Killeen**  
President  
University of Illinois System

**Dr. Laurie A. Leshin**  
President  
Worcester Polytechnic Institute

**Dr. Michael R. Lovell**  
President  
Marquette University

**Dr. Larry R. Marshall**  
Chief Executive  
CSIRO

**Dr. Gary S. May**  
Chancellor  
University of California, Davis

**Mr. Sean McGarvey**  
President  
North America's Building Trades Unions

**Dr. Jonathan McIntyre**  
Chief Executive Officer  
Motif FoodWorks, Inc.

**Brig. Gen. John Michel**  
Director, Executive Committee  
Skyworks Global

**Mr. Jere W. Morehead**  
President  
University of Georgia

**Mr. Christopher Musselman**  
Head, U.S. Commercial Business  
Palantir Technologies, Inc.

**Mr. Eloy Ortiz Oakley**  
Chancellor  
California Community Colleges

**Dr. Christina Hull Paxson**  
President  
Brown University

**Dr. Neville Pinto**  
President  
University of Cincinnati

**Mr. John Pyrovolakis**  
CEO  
Innovation Accelerator Foundation

**Dr. Edward Ray**  
President  
Oregon State University

**Dr. L. Rafael Reif**  
President  
Massachusetts Institute of Technology

**Mr. Rory Riggs**  
Managing Member  
Balfour, LLC

**Mr. John Rogers**  
President and CEO  
Local Motors

**Dr. Rodney Rogers**  
President  
Bowling Green State University

**Mr. Clayton Rose**

President  
Bowdoin College

**Mr. Douglas Rothwell**

President and Chief Executive Officer  
Business Leaders for Michigan

**Dr. David Rudd**

President  
University of Memphis

**Vice Admiral John R. Ryan**

President and Chief Executive Officer  
Center for Creative Leadership

**Dr. Cathy Sandeen**

Chancellor  
University of Alaska Anchorage

**Dr. Timothy D. Sands**

President  
Virginia Polytechnic Institute and State University

**Dr. Kirk Schulz**

President  
Washington State University

**Mr. John Sharp**

Chancellor  
The Texas A&M University System

**Mr. Frederick W. Smith**

Chairman and Chief Executive Officer  
FedEx

**Dr. Samuel L. Stanley**

President  
Michigan State University

**Dr. Joseph E. Steinmetz**

Chancellor  
University of Arkansas

**Dr. Elisa Stephens**

President  
Academy of Art University

**Dr. Claire Sterk**

President  
Emory University

**Dr. Elizabeth Stroble**

President  
Webster University

**Dr. Kumble R. Subbaswamy**

Chancellor  
University of Massachusetts Amherst

**Dr. Satish K. Tripathi**

President  
University at Buffalo

**Dr. Marty Vanderploeg**

Chief Executive Officer and President  
Workiva

**Dr. Ruth Watkins**

President  
University of Utah

**Dr. Adam S. Weinberg**

President  
Denison University

**Dr. Kim A. Wilcox**

Chancellor  
University of California, Riverside

**Dr. Wendy Wintersteen**

President  
Iowa State University

**NATIONAL LABORATORY PARTNERS****Dr. Steven F. Ashby**

Laboratory Director  
Pacific Northwest National Laboratory

**Dr. Paul Kearns**

Director  
Argonne National Laboratory

**Dr. Martin Keller**

Director  
National Renewable Energy Laboratory

**Dr. Thomas Mason**

Director  
Los Alamos National Laboratory

**Dr. Mark Peters**

Director  
Idaho National Laboratory

**Dr. Michael Witherell**

Director  
Lawrence Berkeley National Laboratory

**Dr. Thomas Zacharia**

Director  
Oak Ridge National Laboratory

**CORPORATE PARTNERS****Intel Corporation****PepsiCo, Inc****Shell Oil Company****SparkCognition, Inc.****UNIVERSITY PARTNERS**

University of California, Irvine

**NATIONAL AFFILIATES****Dr. Dean Bartles**

President & CEO  
National Center for Defense Manufacturing and Machining

**Mr. Jeffrey Finkle**

President and CEO  
International Economic Development Council

**Ms. Sherry Lundeen**

President  
ARCS Foundation Inc.

**Dr. Anthony Margida**

Chief Executive Officer  
TechGrit AMX2 LLC

**Dr. David W. Oxtoby**

President  
American Academy of Arts and Sciences

**Mrs. Sandra Robinson**

President  
IEEE-USA

**STAFF****Mr. William Bates**

Executive Vice President

**Mr. Chad Evans**

Executive Vice President

**Ms. Marcy Jones**

Special Assistant to the President & CEO and Office Manager

**Ms. Patricia Hennig**

Vice President for Finance

**Ms. Kathy Trimble**

Vice President

**Mr. Gourang Wakade**

Vice President

**Mr. Michael Bernstein**

Senior Policy Director

**Ms. Ta Tanisha Scott Baker**

Director for Information Technology and Services

**Mr. Joshua Oswald**

Policy Analyst

**Mr. Timothy Planert**

Policy Analyst





**Council on Competitiveness**  
900 17th Street, NW, Suite 700, Washington, D.C. 20006, T 202 682 4292

**Compete.**

**Council on  
Competitiveness**

### Join the Conversation

 @CompeteNow

 /USCouncilonCompetitiveness

 /company/council-on-competitiveness/

 CompeteTV

 Compete.org