US National Academies report recommends research funding to enhance smart manufacturing

https://nap.nationalacademies.org/catalog/27260

A national effort is needed to advance smart manufacturing in the United States, says a new report from the National Academies of Sciences, Engineering, and Medicine. The report, *Options for a National Plan for Smart Manufacturing,* recommends the US Department of Energy (DOE) and other government agencies support the development of smart manufacturing workforce training, a "cyber interstate" for real-time data sharing, and investments in critical technologies such as artificial intelligence.

Smart manufacturing utilizes a range of advanced sensing and computing technologies to improve factories and supply chains, encompassing prototypes and production line operations while being attentive to cybersecurity and industrial decarbonization. Smart manufacturing can include connecting supply chain networks digitally, optimizing the design of products and the energy and material efficiency of their production, and automating manufacturing equipment.

"The US is at a critical juncture right now, faced with a significant opportunity to rejuvenate, reinvigorate, and disrupt global manufacturing in favor of more local efforts—and smart manufacturing is a key element of this revolution," says Thomas Kurfess, HUSCO/Ramirez Distinguished Chair in Fluid Power and Motion Control and professor of mechanical engineering at the Georgia Institute of Technology, and chair of the committee that wrote the report. "And though the focus is often on technologies, none of this can be done if we don't ensure that the country has a robust and skilled workforce, and that advances are leveraged for the benefit of the entire manufacturing ecosystem, from small- and medium-sized enterprises to large corporations."

Facilitating high-demand technologies

Enabling the growth of smart manufacturing will require technologies that cover nearly all disciplines of science, engineering, and social sciences, the report says. DOE and other federal agencies should fund programs and consortia to work at the intersections of these fields. It identifies six interdisciplinary technologies that are in high demand and recommends associated funding opportunities:

- *Human–machine co-piloting:* Establish programs that investigate how humans can maintain situational awareness in complex smart manufacturing deployments, make informed decisions, and efficiently interact with machines and other co-workers.
- *Sensing:* Promote research to ensure consistency between digital models and their physical counterparts; explore additive manufacturing to improve adaptivity and accessibility of sensors for high-fidelity data acquisition; and encourage the development of robust, reliable, and cost-effective sensors.
- *Artificial intelligence and machine learning (AI/ML):* Fund R&D that can reduce computational costs using advanced AI/ML methods and create AI/ML diagnostic tools validated by data; and fund research in generative AI to facilitate smart manufacturing workflow.
- *Platforms:* Support continued investment and research in operational technology and information technology integration through platforms and general-purpose tools.
- *Digital twins:* Fund programs that develop the modules for digital twins using DOE-coordinated manufacturing data banks; and employ manufacturing research institutes in the United States to point manufacturers to cases where digital twins have been successfully used to increase productivity and efficiency.
- *Uncertainty quantification:* Fund research that develops methods to incorporate uncertainty quantification into data curation and modeling processes.

Connecting and protecting industry data

The smart manufacturing sector lacks the technical infrastructure to securely exchange analytics, share valuable experience and data, and communicate best practices across the industry, the report says. This hampers progress and makes it difficult for smaller companies to adopt cutting-edge technologies. A secure, digital, national data infrastructure is necessary to maximize innovation and competitiveness.

The report says DOE's smart manufacturing plan should support the creation of a "cyber interstate" to serve as a conduit connecting the wider smart manufacturing community—including US government agencies, companies, academia, and other stakeholders—allowing it to securely share data in real time and at scale. Facilitating this

would require the adoption of some new business structures and cybersecurity practices, to allow companies to take advantage of being networked and interconnected, while mitigating cyber risks.

Manufacturers need better assurance that their data will be protected when they are shared and aggregated. The report says that DOE, in partnership with the National Institute of Standards and Technology, the US Department of Defense, and manufacturing institutes, should establish new, secure-by-design data architectures and protocols, incorporating AI-enabled threat detection and response mechanisms and other advanced technologies.

Advancing sustainability

Smart manufacturing is a key enabler of environmental sustainability, says the report. Most notably, if smart manufacturing solutions are scaled industrywide and made interoperable, they could provide the end-to-end life-cycle measurements, monitoring, and management needed to sustain a circular economy—a system of production and consumption that seeks to maximize reuse of materials and minimize waste. This includes, for example, measuring material consumption and the energy and carbon footprints of products, optimizing recycling, monitoring waste generation, and manufacturing with increased productivity, precision, and performance. The report recommends DOE develop a framework to better understand the sustainability benefits of smart manufacturing, and the government should take steps to ensure any benefits or costs are distributed equitably.

The study—undertaken by the Committee on Options for a National Plan for Smart Manufacturing—was sponsored by the US Department of Energy.

Sources: US National Academy of Sciences