National Institute of Standards and Technology
Request for Information
National Network for Manufacturing Innovation (NNMI)
Due: October 25, 2012

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This response to the RFI provides recommendations for the establishment of a Manufacturing Innovation Institute uniquely focused on "engineering approaches" to supply chain management and breakthroughs in the application of engineering disciplines to develop the next generation of Supply Chain Automation (SCA) technologies.

In addition to Institutes that focus on broad technologies for 1) new product innovation such as additive manufacturing or 2) broad technologies for new production process innovation such as smart manufacturing, a third leg of the NNMI strategy should focus on 3) broad technologies for supply chain innovation such as SCA. Compared to the first two types of innovation, an institute focused on supply chain innovation and automation breakthroughs could have equal and potentially even greater impact on the nation's economic growth as well as the global competitiveness of the U.S. manufacturing sector.

The 2012 World Economic Forum Report, titled The Future of Manufacture: *Opportunities To Drive Economic Growth,* momentously states that "the globalization of the manufacturing ecosystem has driven more change and impacted the prosperity of more companies, nations and people than at any time since the dawn of the Industrial Age." However, even more important, this comprehensive report suggests "the dominant factors that shaped the disaggregated supply chains we find today will not be the same as those that carry us through the next several decades… Powerful new competitors, complex macroeconomic and geopolitical challenges will profoundly reshape manufacturing supply chains over the coming several decades."

"All these factors are driving more localized supply chains," the World Economic Forum Report concludes.

An SCA-focused Supply Chain Institute unlike any centers of excellence that exist today is essential to research and develop the next generation of manufacturing ecosystems and infrastructures necessary for the nation's industrial sector to successfully take advantage of these dramatic looming industrial sector dynamics and prosper.

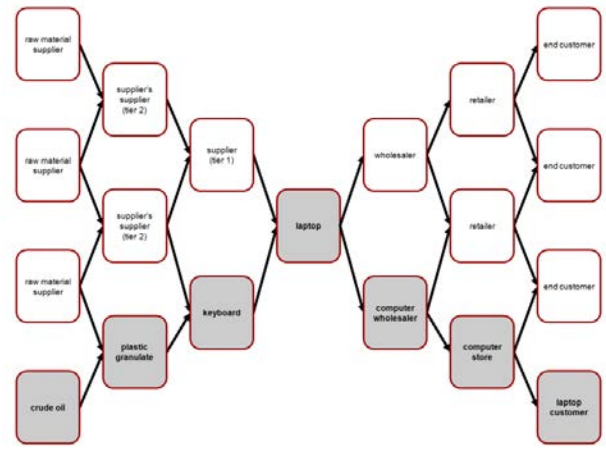
- Technologies With Broad Impact
  - What criteria should be used to select technology focus areas?
  - What technology focus areas that meet these criteria would you be willing to co-invest in?
  - What measures could demonstrate that Institute technology activities assist U.S. manufacturing?
  - What measures could assess the performance and impact of Institutes?

If Congress only approves funding for three Institutes, the NNMI selection strategy should fund one institute in each of the three broad technology areas for 1) new product innovation such as using additive manufacturing, 2) new production process innovation such as smart manufacturing, and 3) supply chain innovation such as SCA. As outlined in the 2012 World Economic Forum report, the bottom line criteria for determining which technology has the broadest impact should be economic. Every proposal should be required to provide an independent analysis of the Institute's potential economic impact to the nation's GDP. Although other factors such as improved national security, environmental sustainability and contributions towards the overall welfare of society should also be considered, the ability of an institute to improve our nation's overall financial strength must be the top priority.

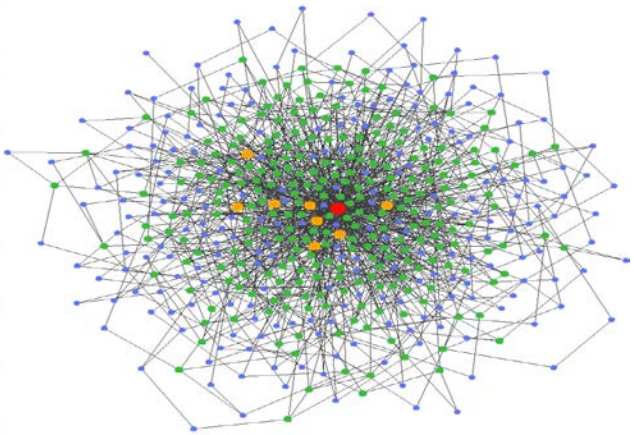
The annals of our nation's history provide sage advice about how Secretary of State Thomas Jefferson decided to support a young inventor named Eli Whitney. Catching word of Whitney's patent application for an ingeniously simple cotton gin, Jefferson instantly saw the huge economic potential for the nation. He personally quizzed Whitney for details. Jefferson saw right away that the cotton gin could be a key to the monetary muscle he knew America would need to stay independent and pay off our significant Revolutionary War debts, according to historian Stephen Yafa in his book "Big Cotton." Comfortable cotton clothing was the craze in America and Europe. Before Whitney's innovation in 1794, America only shipped less than one quarter million pounds of cotton. By 1800, the U.S. produced 35 million pounds of cotton and "practically overnight spurred a languishing Southern agrarian economy into becoming one of the wealthiest the world has ever know," according to Yafa. Like Jefferson's criteria, NNMI program managers should wisely choose technologies that have the broadest economic impact for the nation.

In the belief that supply chain innovations can have such a broad economic impact for our nation, a collaborative group including Rockwell Automation, UW-Madison Center for Quick Response Manufacturing, UW-Milwaukee Supply Chain Institute, the Milwaukee Institute for high performance computing, the Wisconsin State Economic Development Corporation and other organizations are establishing a Wisconsin Institute for Manufacturing Innovation (WIMI) group. WIMI expects to provide its customers with advanced infrastructures that allow manufacturers to align (plug & play), synchronize and scale their industrial relationships to achieve quantum improvements in productivity and profitability by optimizing supply chain efficiencies and responsiveness.

Rockwell Automation and the defense contractor Rockwell Collins already expressed their willingness to invest in these concepts through a comprehensive and innovative DARPA proposal submitted in 2011 for the agency's grand manufacturing challenge which was deemed by reviewers to have "technical merit." This pioneering "Service System for the Real-time Command and Control of Supply Chains for Advanced Manufacturing Enterprises," proposal combines innovative elements from military C2 theory, high fidelity supply chain modeling and simulation, advanced supplier network process automation and optimization, and secure private cloud-mediated management services.



20th Century Supply Chain



21st Century Industrial Ecosystem

Information technology (IT) revolutions are enabling the biggest structural shift in the way we make products since Henry Ford invented the assembly line powered by the first "all electric-motor driven" factories in the 1920's. As the first "all IT-driven" production processes are just now becoming a reality, the growing consensus among academic, industry and government leaders is that the greatest transformational changes will not occur inside the four walls of factories - but instead between enterprises in the exponentially exploding and evolving global industrial ecosystems.

20th century vertically integrated factories, with their relatively rigid mass production processes and supply chains, are morphing into complex 21st century multi-tiered supplier networks. Rather than the current business systems approach (open loop) to supply chain management, an engineered approach (closed loop) can enable tighter, more agile and responsive controls, mimicking the complexity afforded natural systems through their DNA. Like first cracking the genetic code, manufacturers will increasingly need high performance computing arrays to discover and manage every end-to-end sequence in these complex supplier networks. To improve operational efficiencies, truly automated supply chain infrastructures are increasingly essential today. Unlike current business "transactional systems" (e.g, SAP or Oracle), production automation requires time-critical and fault-managed control systems linking supply nodes with the same speed and sophistication as if they were discrete functions or processes on the factory floor. This engineered approach enables quantum reductions in costly "buffer inventories" that nearly every manufacturer maintains today because of business system approach limitations. Defense Logistics Agencies estimate the embedded DOD supplier costs escalate 14 percent annually due to similar limitations.

This Wisconsin Institute for Manufacturing Innovation will apply advanced information, automation and industrial control theories to innovative developments of highly-available, time-critical, fault tolerant and scalable supply chain management infrastructures and applications.

- Institute Structure and Governance
  - What business models would be effective for the Institutes to manage business decisions?
  - What governance models would be effective for the Institutes to manage governance decisions?
  - What membership and participation structure would be effective for the Institutes, such as financial and intellectual property obligations, access, and licensing?
  - How should a network of Institutes optimally operate?
  - What measures could assess effectiveness of Network structure and governance?

Institutes should be private-public partnerships. Although most policy and program leaders talk about public-private partnerships, institutes should be try to emulate a private enterprise business model more than a public sector government or university model. One of the most successful examples of a private-public partnership is NorTech, a regional nonprofit technology-based economic development organization serving 21 counties in Northeast Ohio. By starting with an economic development mission first, it is in a better position to then support collaborative R&D initiatives. We know about the success of this business model because a Rockwell Automation senior executive is a board member. Rockwell Automation's chief technology officer has been involved in a very similar organization called WERC, the Wisconsin Energy Research Coalition. But it has a more traditional public-private partnership model with a major University Chancellor chairing the board of directors. By putting the R&D mission ahead of the economic development mission, WERC has not achieved anywhere near the same level of success and results compared to NorTech (www.nortech.org).

Thus, the ideal Institute governance structure is more similar to a private enterprise like NorTech's business model. A CEO guides the organization. Financial, intellectual property and other decisions are made by the board of directors. But the bottom line measure regarding effectiveness comes from an Institute's economic impact on members as well as the geographic region that it serves.

Specific to the proposed SCA-focused Supply Chain Institute, its organization structure would also uniquely foster inter-disciplinary collaboration between manufacturing engineers and business operations professionals. Today, almost every supply chain management educational and research program is located in the Business Schools at U.S. colleges and universities. Similarly, in almost every manufacturing firm, supply chain management leaders and practitioners use these same best practices developed from this business systems approach to the profession. Thus, supply chain management technologies have been an extension of ERP systems developed to manage transactional relationships with suppliers. The term "Supply Chain Automation" defines a financial software system that manages batches of contractual relationships. It is an ERP-to-ERP system interconnection today, not a direct interconnection of production system to production system between federated factories envisioned by next-gen SCA.

Over the past three to four decades, manufacturing engineers have been using an increasingly sophisticated evolution of much different methodologies to manage relationships -- first between dynamic components in a single machine; next between multiple machines or stages in a cell; and then between multiple cells synchronized in a production line or process. Finally today, the state-of-the-art is complete plant-wide optimization of big data across an entire factory floor or processing plant. This Institute would pursue the next level in that evolution – innovative engineering approaches to supply chain automation that synchronize each supplier with the same precision "as if" each one were just another node or cell inside the factory or plant.

Supply Chain Automation using an engineering approach requires that each supply node be synchronized using highly available, time critical and fault tolerant and scalable technologies. This would be achieved by fostering inter-disciplinary collaboration between those doing "transactional" supply chain automation today at business schools, purchasing & logistics depts., or ERP technology vendors… with those who want to do "real-time" supply chain automation from engineering schools, production depts., or automation technology vendors.

- Strategies for Sustainable Institute Operations
  - How should initial funding co-investments of the Federal government and others be organized by types and proportions?
  - What arrangements for co-investment proportions and types could help an Institute become self-sustaining?
  - What measures could assess progress of an Institute towards being self-sustaining?
  - What actions or conditions could improve how Institute operations support domestic manufacturing facilities while maintaining consistency with our international obligations?
  - How should Institutes engage other manufacturing related programs and networks?
  - How should Institutes interact with state and local economic development authorities?
  - What measures could assess Institute contributions to long term national security and competitiveness?

Initially, in year one, an SCA-focused Supply Chain Institute would need significant start-up funding from the federal government. During the first five years, a 50-50 private-public match of industry and federal funding would establish the long-term sustainability which could then be phased out at that point with on-going sustainability expected in a business model similar to NorTech or perhaps the original SemaTech organization. By adopting the above business model, long-term sustainability would occur because the organization's success is being driven and measured by economic impact, first and foremost. This financial model will ensure that Institute operations support the needs of members who invest in its on-going R&D initiatives because there is a measurable return on their investment as well as a return on the investment by public entities measured by broader economic impact.

President Obama called for "creating a *smart manufacturing* infrastructure and approaches that lets operators make real-time use of "big data" flows from fully-instrumented plants in order to improve productivity, optimize supply chains, and improve energy, water, and materials use" in his initial announcement of the National Network for Manufacturing Innovation Institutes program (March, 2012). Thus, the WIMI group is actively collaborating with the Smart Manufacturing Leadership Coalition and expects to engage in the development of their

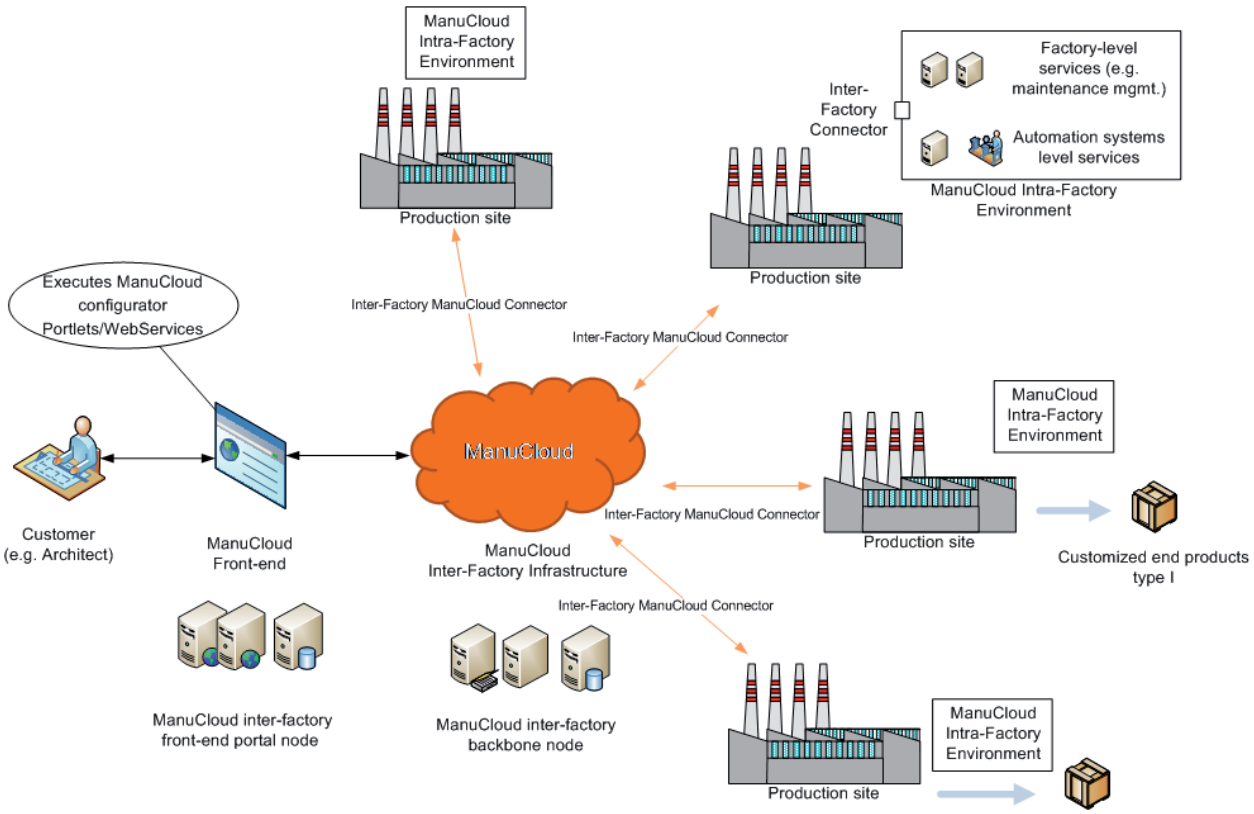
Smart Manufacturing platform. Lastly, an SCA-focused Supply Chain Institute would be sustainable because it provides on-going vital value in response to the profound manufacturing ecosystem changes that the World Economic Forum expects to continue for several decades.

WIMI, centered in the U.S. manufacturing heartland, will establish affordable, open, distributed supply chain governance applications and infrastructures. These innovative technologies will provide decision support services, expanding on the current state of existing supply chains, developing and adapting plans that effectively respond to changes in supply chain ecosystems, and efficiently executing these plans seamlessly throughout the supply network. WIMI recognizes the fact that in increasingly complex supply chains, only about 5% of order fulfillment time is value-added time spent in actual machining and/or assembly (minutes or hours). Roughly 95% of the order fulfillment time is non-value added, being spent in delays (weeks and months) at several levels of the supply chain. These delays add to significant costs (expediting; rectifying quality errors, overtime production, obsolescence, managing order changes and scope creep, storing excess inventory for contingencies, etc.), while material and labor costs in a product are often below 20%. WIMI will exploit leading research in agility, quick response manufacturing, high fidelity supply chain modeling and optimization, and recent developments in secure private cloud-mediated management services to enable manufacturers realize quantum improvements in lead times, costs and delivery reliability across its supply chain. These methodologies being manually applied by the University of Wisconsin Center for Quick Response Manufacturing already help numerous manufacturers optimize their supply chains to reduce lead times by 90%, cut costs by more than 30%, and achieve over 50% improvements in delivery reliability and quality.

Responsiveness innovations from dynamic Smart *Manufacturing* Ecosystems: Once automated supply network infrastructures are in place, a new era of 21st century scale-free industrial ecosystems will encourage new business management and industrial engineering disciplines to emerge, enabling applications that drive sales and profitable growth by increasingly-responding to individual customer desires. Innovations in automated supply chain infrastructures will be complemented by a longer-term second stream of innovations enabling manufacturers to deliver individualized products and services that are more responsive to customer demands and desires. This promises to evolve the manufacturing function from being a traditional cost center at companies into profit centers where the best and brightest business leaders focus their attention in developing innovative new ways to deliver value and derive higher profits through the long-envisioned advent of mass customization. *The two streams of innovation present two sides of the same coin – the benefits of one cannot be realized without the other*.

Given the trend towards more localized or regional supply chains, the Wisconsin Economic Development Corporation is actively interested in also financially supporting the Wisconsin Institute for Manufacturing Innovation. An initial test bed being considered would be for the food industry to develop "farm to fork" tracking and tracing. The expectation is that not only would this improve food safety, but once an end-to-end digital thread is established, it can be used for other analyses such as to study time delays in each step of the supply chain. Real-time digital threads established throughout the DOD military-industrial supply complex could contribute toward national security interests by reducing lead times, cutting costs and curtailing criminal or terrorist activities in their supply chains. SCA technologies provide increasingly vital tools for state and federal agencies to achieve their missions in the future.

Fraunhofer Institutes in Germany with major funding from the European Commission via their Factories of the Future economic stimulus program have already been developing alternative supply chain approaches since 2010. Their ManuCloud Project is the development of a service-oriented IT environment as the basis for the next level of manufacturing networks by enabling production-related inter-enterprise integration down to shop floor level. http://www.manucloud-project.eu/ The ManuCloud project is evaluating and developing a suitable IT infrastructure to provide better support for on-demand manufacturing scenarios, taking multiple tiers of the value chain into account. On this path, ManuCloud seeks to implement the vision of a cloud-like architecture concept. It provides users with the ability to utilize the manufacturing capabilities of configurable, virtualized production networks, based on cloud-enabled, federated factories, supported by a set of software-as-a-service applications.



- Education and Workforce Development
  - How could Institutes support advanced manufacturing workforce development at all educational levels?
  - How could Institutes ensure that advanced manufacturing workforce development activities address industry needs?
  - How could Institutes and the NNMI leverage and complement other education and workforce development programs?
  - What measures could assess Institute performance and impact on education and workforce development?
  - How might institutes integrate R&D activities and education to best prepare the current and future workforce?

Since supply chain innovations and SCA breakthroughs will impact literally every manufacturer, especially SMEs because they represent the majority of enterprises in the industrial ecosystem today, these SCA innovations need to leverage the proliferation of IT tools and technologies being developed for consumers. This strategy vastly minimizes the educational requirements and significantly ramps up viral adoption rates by simply re-purposing the proliferation of IT tools and technologies that the workforce already uses and understands from their daily lives as consumers. The easy-to-understand user interfaces for these IT tools and technologies further minimizes the need to reinvent this aspect of SCA innovations. This is essential to simplify the wide range of SCA educational requirements from the farmer entering crop yield data to multi-national oil & gas giants entering their field production data.

While there are many other formal pathways for educating the workforce, it is essential that university and college curricula incorporate courses and training in new SCA technology. Inclusion of these concepts in higher education will ensure a cadre of operators and engineers trained in the needed disciplines. Operations staffs who can see the impacts of supply chain decisions on plant operations and learn from those decisions become highly efficient assets.