Response to Request for Information on Proposed New Program: National Network for Manufacturing Innovation (NNMI)

submitted by
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Contents

1.0 Introduction

EWI and the Manufacturing Institute are pleased to offer this joint response to the NNMI Request for Information. In February 2011, EWI published a report from a leadership conference involving industry, government, and academia which explored opportunities to advance manufacturing competitiveness[1]. The report identified two overarching "grand challenges": 1) the need to strengthen our nation's innovation infrastructure for maturing and commercializing advanced manufacturing technologies; and 2) the need for a more competitive workforce which is capable of adopting advanced manufacturing technologies quickly and effectively. Increased industry collaboration and public-private partnership were seen as necessary elements of any successful strategy to address these challenges.

The Manufacturing Institute and EWI have been active in developing strategies to support the U.S. manufacturing competiveness by addressing these grand challenges. A series of expert focus group exercises and industry surveys were conducted to rank industry needs and identify potential barriers to collaborative innovation. In October 2011 EWI and the Manufacturing Institute held a Manufacturing Innovation Summit[2] for industry representatives to discuss collaborative innovation models and identify a preferred approach. A *sustainable, lean, industry-focused* innovation model was identified to create an environment for manufacturing innovation that will advance U.S. manufacturing competitiveness and drive export growth. In parallel, the Manufacturing Institute has led an initiative to bridge the manufacturing workforce skills gap and to develop portable credentials for manufacturing skills. EWI and the Manufacturing Institute also informed initiatives led by other organizations to develop strategies for advancing manufacturing competitiveness. These include participation in three of the NNMI regional workshops, responding to NIST AMTech RFI, responding to the NNMI pilot BAA, and providing input to various activities by the Advanced Manufacturing Partnership (AMP), the National Academy of Sciences (NAS), the Defense Production Act Committee (DPAC), and the DOE Advanced Manufacturing Office (AMO).

The recommendations presented in this document were also informed by EWI's experience as a sustainable business model[3] which bridges the "missing middle" by innovating, maturing, commercializing, and applying advanced manufacturing technologies to improve U.S. manufacturing competitiveness.

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[1] "EWI report Advancing Manufacturing Competitiveness: Report from the 2010 Conference on the Future of Materials Joining in North America.", February 2011, EWI

[2] Manufacturing Innovation Summit, held in Columbus OH October 2011, involving representatives from 25 large, medium and small companies across a diverse range of industry sectors.

[3] EWI was founded over 28 years ago, and today receives no on-going government base funding. In October 2012, Time Magazine described EWI as a "*state initiated, privately funded enterprise that does cutting-edge manufacturing research resembling the German Fraunhofer institutes*". Additional information on the EWI business model is available upon request.

2.0 Technologies with Broad Impact

2.1 Criteria

It is recommended that highest priority be given to *manufacturing technology areas* which are:

- Identified in the Advanced Manufacturing Partnership report as *Top Cross-Cutting Technologies*[4]
- *Broadly applicable* to a wide range of manufacturing sectors and products, especially those that are relevant to both established "legacy" industry sectors (e.g., automotive, aerospace, consumer products), as well as emerging sectors (e.g., renewable energy)
- Sufficiently *well established* that there are existing professional societies, technical constituencies, and educational programs that can be engaged as partners
- *Currently being used* by small, medium, and large companies to produce U.S. manufactured products and infrastructure that represent a significant fraction of the GDP
- Important for not only *economic competitiveness*, but are also relevant to relevant to supporting *defense* and *energy* security goals so there is broad support for the investment
- Sufficiently *broad* so as to encompass a wide range of individual manufacturing processes, materials, and alternative approaches, where a large institute is most needed to maintain the full range of leading edge capabilities
- *Complex, not widely understood, evolving, and have technical challenges* to provide manufacturers an opportunity to create competitive differentiation through specialized technical expertise, technical innovation, and a highly skilled workforce
- Where the *U.S. is facing competition* from other countries which have greater established manufacturing technology innovation capacity and are graduating more engineering talent

2.2 Technology Areas

Specific technology areas of interest include:

- *Advanced forming and joining technologies*, especially advanced dissimilar materials joining methods and net-shape forming of advanced materials needed for light-weight structure optimization
- *Industrial Robotics*, especially flexible "smart" automation technologies to allow small batch sizes, reduced tooling, and greater part variability
- *Advanced sensing and measurement and control technologies*, especially for real-time quality monitoring and post-process nondestructive evaluation of part quality

[4] Report to the President on capturing domestic competitive advantage in advanced manufacturing, July 2012, Page 18

2.3 Technology Metrics

Consider using "Level A, B, and C metrics" to measure both outcomes and progress. Level-A metrics are desired *outcomes*, and take the longest time to achieve. Level-B metrics are objective measures of *progress* toward desired outcomes. Level-C metrics are *activities* that lead to Level B and A metrics. The following are suggested technology metrics in each of these categories.

- *Level A-metric: commercialization.* Successful institutes should be producing innovations that reach the market and are implemented by U.S. manufacturers. This can be measured in terms of the number of commercialized technologies, the number of client implementations of the technology, the number of licenses, and the amount of commercialization revenue produced. Growth in domestic commercialization partners' businesses is a measure that the U.S. is developing supply chains for the technology.
- *Level-B metric: Growth in technical capabilities.* The institutes should be acquiring new capabilities (expertise, equipment, IP) in response to the changing needs of the market. Successful institutes should be internationally recognized as global leaders in targeted technologies areas. Successful institutes will develop unique, leading-edge, differentiating capabilities; rather than merely assembling a collection of commercially available off the shelf equipment.
- *Level-B metric: Technical advancement.* Successful institutes should be maturing manufacturing innovations to "bridge the valley of death". This could be measured in terms of advancement in Technology Readiness Levels of key technologies, patent awards, and productization of new technologies. Adoption of institute innovations into industry standards also demonstrates technical advancement.
- *Level-C metric: pre-competitive R&D.* Successful institutes should be investing in precompetitive technology development. The diversity and extent of their research portfolio should grow over time and is measureable in terms of number of projects and total investment. Successful institutes should also see growth in high-value intellectual property to create a competitive advantage for U.S. commercialization of manufacturing technologies.
- *Level-C metric: thought-leadership/road-mapping activities.* Successful institutes will be hosting national and regional events, leading industry road-mapping exercises, broadly disseminating information, and creating forums to convene industry, academia, and government to respond to industry challenges. Successful institutes will see a growth in the number and breadth of these thought-leadership activities.

3.0 Institute Structure and Governance

The NNMI initiative represents a rare opportunity to establish a manufacturing innovation infrastructure which bridges the "missing middle" and boosts the competitiveness of U.S. manufacturing for decades to come. The challenge is to create an effective, and sustainable model that will *produce tangible results quickly* enough to garner ongoing support. Fortunately, there are proven, sustainable innovation models to build from which will greatly increase the likelihood of success and produce results quickly. We recommend the government learn from these time-tested models to create a manufacturing innovation infrastructure which is built to last. The following are some specific suggestions based on EWI's experience operating a sustainable business model.

3.1 Structure

The NNMI should be comprised of a network of independent, non-profit, membership based institutes each having a mission to advance manufacturing competitiveness through technology innovation, maturation, commercialization and insertion. Each institute should be organized as an independent 501(c)(3) corporation. As independent businesses, each must be responsible for their own financials (profit & loss, balance sheet, and cash flow). Governance should be provided by a Board of Directors which appoints a President and CEO, who is responsible for implementing a management structure and for day-to-day operations. Institutes should not be operated by a universities, national labs, or governmental entities, as this would undermine their independence, agility, entrepreneurialism, and focus on delivering solutions to industry. The institutes should, however, have close partnerships with one or more leading research universities to enable collaboration for education and technology transition. The government should have no role in governance. Rather the NNMI should be managed as a contract between the government and the non-profit corporation. Contract continuation would be contigent upon meeting contract deliverables and performance metrics.

3.2 Business Model

The institute business model should be based on providing high-impact manufacturing innovation services to industry. Each institute should have a unique technical area of expertise in which they will develop world-leading technical capabilities. To sustain its business, each institute must be responsive to the evolving needs of industry, and provide unique capabilities and services which industry values. This will drive market-based decisions on the targeted technologies, service offerings, target markets, and business development approaches.

Sources of revenue should include fee-for-service projects, membership fees, commercialization royalties, and equipment access fees. Federal NNMI program funding should be used primarily to build core institute capabilities, including procuring leading-edge equipment, and investing in high-risk pre-competitive technology development to grow unique expertise and IP. Federal NNMI program funding would also be used to develop linkage with other institutes, research partners, MEP providers, and educational institutions. During initial start-up, a significant majority of funding will come from the NNMI program. As sustainability is achieved over time, a significant majority (>70%) of each institute's funding should be derived from fee-for-service engagements. These may include a wide range of service offerings such as:

- **Single sponsored projects** to refine, pilot test, scale-up and implement advanced manufacturing technologies for individual clients' proprietary products and applications
- **Jointly sponsored projects** where industry and government pool resources for pre-competitive research programs
- **Industrial training** courses and technical seminars fees
- **Equipment access fees** to allow companies to use institute assets
- **Government sponsored projects** awarded on a competitive basis

Single sponsored projects will likely be the largest source of funding for the institutes. To be successful, institutes must have structures, processes, systems, and roles in place (e.g., certified program managers, client quality surveys) to ensure they consistently meet client expectations for quality, cost, and schedule. Manufacturers (including SMEs) will invest in proprietary single-sponsored projects where they see an opportunity to create a competitive advantage by improving their product designs, performance, quality or cost. In general, it is not appropriate for government to subsidize work done for individual commercial clients as single sponsored projects. Companies (particularly SMEs) are much less likely to engage in pre-competitive research if there is not a clear link to their products and opportunity for near-term return on investment. Government funding will likely be needed to help incentivize industry funding for joint sponsored projects to develop pre-competitive technologies. The following are suggested business performance metrics:

- *Level-A metric: Customer Quality Survey Scores.* Every project should be assessed in terms of customer satisfaction. Customer satisfaction can also be assessed by the amount of repeat business.
- *Level-B metric: On-time delivery.* Projects must executed professionally in accordance with the statement of work and delivered on time and within budget.
- *Level-B metric: Project Sales.* Successful institutes will see increased sales over time leading to a healthy backlog of business.

- *Level-C metrics: Sales pipeline.* Successful institutes will have a strong sales pipeline across a range of commercial sectors, company types, and government agencies.

3.3 Membership

A membership model will help the institute establish long-term relationships with member companies, and will position the institute to be a convener of industry to address common challenges. Memberships would provide a vehicle for engaging industry, providing access to the institute's capabilities, and efficiently delivering a bundle of pre-paid services. A relative small (<15%) but important portion of the institute's funding would come from membership fees. These fees should vary based on company size, as SMEs are unlikely to use the member services as frequently or be willing to pay significant fees. Member services provided would include dissemination of technical information, answering of technical inquiries, and participation in member-only events and consortia. Members would also have preferred rates for funded projects. A portion of the membership fees should also be invested in pre-competitive research to continuously develop innovative technologies, and for maintaining linkage with other organizations.

- *Level-A metric: Growth in membership.* Successful institutes should see increasing membership revenue and growth in the number of member companies, with a high retention rate.

3.4 Intellectual Property

Each institute should manage its own intellectual property portfolio, and be responsible for making sound business decisions to protect and commercialize innovations. Standard terms and conditions should be established which protect the owners of background IP, allow institute clients to implement innovations, and provide the institute with potential revenue streams through the broader commercialization of technologies. Because of the complexity of manufacturing technology IP landscapes and the frequent need for creative commercialization partnerships, the institutes must have the sophistication and flexibility to adapt to individual circumstances. The following are suggested IP related metrics:

- *Level-A metric: Commercialization revenue.* While IP commercialization revenues will be likely be modest (<10%) for the foreseeable future, commercialization of IP is important to enable industry to implement institute innovations.
- *Level-A metric: Client implementations of institute innovation.* IP policy must allow clients to implement results.
- *Level-B metric: commercialization partnerships.* Institutes can commercialize IP through licensing, spinouts, joint ventures, pooling arrangements, or other means.
- *Level C metric: patents issued.* Institutes should be protecting valuable IP which can provide competitive advantage to U.S. manufacturers.

3.5 NNMI Network

For a network of institutes to operate effectively, some ongoing funding will be needed to sustain the linkage and communications between the independent institutes. A third party NNMI organizing body can help promote common practices, facilitate exchange of information, and organize regular collaboration discussions between institutes. As independent non-profit companies, each institute will act in its own best interest. If the NNMI institutes have unique but complimentary capabilities, then the network is much more likely to be effective. The following is a suggested metric:

- *Level-A metric: Network effectiveness.* For the NNMI to be most effective, there should be coordination between institutes and other programs and organizations (e.g., NIST MEP, technical societies, trade groups, regional economic development organizations). A measure of this is the number of referrals that are occurring between various organizations. Successful institutes will continually grow both the extent of their network and the number of referrals.

4.0 Strategies for Sustainable Institute Operations

4.1 Co-investment Proportions

The Federal government should not require 50/50 up-front cost share commitments to match a $1B NNMI Federal investment. Many companies and State governments do not have the flexibility to commit resources for out-year expenditures. It is also difficult for companies, particularly SMEs, to commit resources to an institute before it has acquired capabilities that are relevant to their businesses. Rather, the government should require institutes to commit limited (<20%) up-front cost share and then demonstrate that they are attracting additional funding over time to balance the NNMI Federal program investment.

The Federal NNMI program investment must also be front-loaded to build institute capabilities before significant industry investment will occur. A reasonable model may assume 80 percent of the institute's revenue from the Federal NNMI program in year 1, transitioning to 20 percent by year 5. As the institute's capabilities grow, the institute will attract significant funding from fee-for-service projects, membership, and other sources (as described in the Business Model section).

4.2 Use of Federal Funds

To help the institute become self-sustaining, the largest proportion (>75%) of the Federal NNMI Program funding should be devoted to building world-leading technical capabilities. This includes acquisition of leading-edge equipment, growing technical expertise, and execution of precompetitive development programs to create completely unique capabilities. To support sustainability, institutes must also be allowed to use equipment purchased with Federal funding to perform fee-for-service programs for commercial clients without restriction. Ideally, the government would eventually transfer ownership of the equipment to the NNMI institutes so that they can manage the assets as they see fit. The balance of the Federal NNMI program funding should be used to build linkage with partners, demonstrate capabilities, promote the institute, and stand-up programs. Sources of cost share should include project funding, membership fees, facility improvements, equipment donations, and in-kind work.

4.3 Assessing Progress toward Sustainability

As discussed previously, growth in fee-for-service project funding is strong evidence of impact and progress toward sustainability. This could be measured in terms of the total project revenue. Successful institutes should be growing service revenues to >70% of total revenues to become self-sustaining. The breadth of client engagements should be increasing over time, and demonstrate increased market penetration. The following are suggested sustainability metrics:

- *Level-A metric: Growth.* Successful institutes should increase in assets, staff and annual revenue.
- *Level-A metric: Net Income.* Successful institutes should be generating revenues in excess of expenses so they can reinvest in expanding technical capabilities.
- *Level-B metric: Funded fee-for service engagements.* Manufacturers will act in their own best interest. If they are purchasing innovation services from the institute, then they must receiving benefit from the services the institute provides. Thus, growth in fee-for-service project funding is strong evidence of impact. This could be measures in terms of the total project revenue. Successful institutes should be growing service revenues to 70% of total revenues to become self-sustaining.
- *Level-C metric: number, range, and type of client-funded engagements.* Successful institutes should be providing services to small, medium, and large clients across a broad range of manufacturing sectors and geographies. The breadth of client engagements should be increasing over time, and demonstrate increased market penetration. The types of services provided will vary widely depending on the size and type of client, but the amount of repeat business is an important indication that the client is seeing value. To ensure the institute remains focused on industry, the majority of the institute's total funding (from all sources) should come from industry.

4.4 Advantaging Domestic Manufacturing

Proximity will play a significant role in supporting preferential adoption of innovations by domestic manufacturers. If the expertise and equipment to pilot test new manufacturing technologies resides in the U.S., and supply chains are established to commercialize the technology in the U.S., and the trained workforce that understand how to implement the technology remains in the U.S., then the technology is much more likely to be implemented domestically than elsewhere. To promote domestic SME suppliers for new technologies, Federal programs (e.g., SBIR phase 3 project funding) should support domestic commercialization of new manufacturing technologies. To give institute members the opportunity for first-mover advantage, new technology developments produced with Federal NNMI program funding should be disseminated to the NNMI members and partners first, with a 12 month moratorium on broader public dissemination. The intellectual property policy could also provide competitive advantage for domestic manufacturers. If the institute develops IP with Federal NNMI program funding, the institute should give preferential treatment to implementing the technology into U.S. manufacturing operations.

4.5 Engaging Other Programs

Because State and Local authorities vary widely in terms of structure and resources, no one-size-fits-all approach can be articulated. Institutes will need to adapt their approaches to integrate with a variety of entities. For the NNMI to be most effective there should be coordination between institutes and other programs or organizations that share a common interest (e.g., NIST MEP, technical societies, manufacturing organizations, regional economic development organizations). A measure of this is the number of referrals that are occurring between various organizations. Successful institutes will continually grow both the extent of their network and the number of referrals. Institutes can use these relationships to disseminate information on manufacturing technology advancements to small, medium, and large companies; and will benefit from identifying new clients for their services.

4.6 Assessing Contribution to Competitiveness

The impact of the NNMI institutes on macro-economic performance (export growth, job creation, etc.) cannot be effectively measured, since these statistics are influenced by many external factors not related to NNMI. Reporting institute impacts for individual clients is also problematic, because individual manufacturers will be extremely reluctant to disclose competitive information regarding specific engagements. Therefore, the most accurate and useful metrics will be aggregated information on each institute's individual performance.

Institutes should help make U.S. manufacturers more competitive by improving products and processes through the application of innovative manufacturing technologies. The most

direct measure of the institute's contribution to competitiveness is the adoption of the world's most innovative manufacturing technologies into U.S. manufacturing facilities to increase manufacturing agility, improve product performance, and reduce cost. This can only be achieved if the institute is engaging a broad range of manufacturers, technology suppliers, professional organizations, and educators to develop, mature, commercialize, promote, codify, demonstrate, pilot test, and transition advanced technologies into the U.S. market.

Institutes can also contribute to competitiveness by improving the reliability and efficiency of U.S. transportation, energy, and communications infrastructures. This could be measured in terms of advanced technologies developed by the institute which are implemented for the construction or life extension of infrastructure, such as pipelines, power plants, rail roads, bridges, etc.

4.7 Assessing Contribution to National Security

The relevance of the institute's technical capabilities to U.S. defense systems is an important consideration. Successful institutes should be contributing to the manufacturing capabilities of the defense industrial base and positively impacting the performance, sustainment, and lifecycle cost of U.S. weapon systems. Successful institutes should be performing fee-for-service work for the DoD and defense contractors to develop and introduce advanced manufacturing technologies. The institute should also be convening defense suppliers and DoD representatives to identify manufacturing challenges and important emerging manufacturing technologies to address those challenges. Institute contributions could be assessed in terms of manufacturing technology advancements and insertions into defense suppliers for the manufacture or sustainment of specific weapon systems.

5.0 Education and Workforce Development

5.1 Approaches

Institutes should complement and inform existing education and workforce development organizations, rather than establishing new structures which compete with them. The institutes can support education and workforce development in the following ways:

- **Talent Attraction.** Perhaps the most important contribution an institute can make to the workforce is to help promote advanced manufacturing technology fields at the primary and secondary school levels. Each institute will be a showcase for the practical application of advanced manufacturing technologies. Institutes should foster interest in manufacturing disciplines to teachers and students by making facilities available for activities such as tours, demonstrations, and teacher-camps.
- **Informing Educational Programs.** Institutes should convene industry to identify emerging skill needs. Providing this information to secondary schools, community colleges, and universities will help administrators set priorities. Institutes can also be a resource to help educational institutions develop curricula in their areas of technical expertise.
- **Experiential Learning Opportunities.** Institutes should provide opportunities to work with leading-edge manufacturing technologies by integrating R&D activities and education. By collaborating with universities, undergraduate and graduate students can participate in client funded programs to develop and test new technologies. The institute and its clients will benefit by developing the next generation of engineering talent, while the student will have an opportunity for hands-on practical learning. Industrial clients will also have an opportunity for experiential learning, by working with institute staff and equipment to develop solutions for their specific applications.
- **Industrial Training Services.** Institutes will have unique specialized expertise in advanced manufacturing technologies and will provide training to help industry identify, screen, and implement technologies for their applications. Institutes will offer fee-based technical seminars, workshops, and targeted training to engineers, designers, and managers. These could be delivered at the institute, at the customer site, or over the web. Programs will include a combination of technical and business topics, and include hands-on demonstrations. Institutes will also broadly disseminate technical information using electronic media as a free service to member companies.
- **Manufacturing Skill Credential Support.** Institutes will engage standards bodies and national manufacturing organizations, such as the Manufacturing Institute, to inform the development of credentials for new manufacturing technologies.

5.2 Sustainability

Initial Federal NNMI Program funding should be used to develop these programs and establish linkage with educational institutions. Some activities, such as providing industrial training services, will generate revenue to offset costs. Limited ongoing funding may be needed to sustain some of other activities, such as informing educational programs.

5.3 Metrics

Success metrics could include adoption of curricula incorporating advanced manufacturing technologies by educational organizations; number of students exposed to the institute's advanced manufacturing technologies; and growth in workforce with advanced manufacturing credentials.

- *Level-A metric: Skilled workforce growth.* Successful institutes should be helping to improve curricula and attract talent to education and workforce development programs at all levels. Over time, there should be a measureable increase in the number of employees with advanced manufacturing skills.
- *Level-B metric: School curricula incorporating advanced technologies.* Overtime, institutes should influence educational curricula to incorporate more advanced manufacturing technologies.
- *Level-C metric: Education and workforce initiatives.* Successful institutes will be engaging educators and training providers at all levels to influence their priorities. Over time the range and scope of these engagements should increase. Metrics include the number of engagements with universities, colleges, training programs, and STEM programs, leading to growth in trained technical professionals and skilled trades.