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Sent: Tuesday, September 20, 2011 9:48 AM
To: EWI Government Proposal Coordinator; amtech
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Subject: AMTech Comments

We are pleased to submit EWI and The Manufacturing Institute's repose to the NIST AMTech Request for Information.

Please feel free to contact us if you need a hard copy or have any questions.

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Revitalizing America's Manufacturing Innovation Infrastructure

Response to the NIST AMTech Request for Information

by

EWI, Columbus, OH
The Manufacturing Institute, Washington, D.C.

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Introduction

EWI and the Manufacturing Institute are pleased to offer this joint response to the NIST AMTech RFI. In February 2011, EWI published the report of a leadership conference involving industry, government, and academia to identify opportunities to advance manufacturing competitiveness[1]. The report identified the need to strengthen our nation's innovation infrastructure for maturing and commercializing advanced manufacturing technologies. Increased industry collaboration and public-private partnership were seen as necessary elements of any successful manufacturing innovation strategy. As a follow-up to the report, EWI and the Manufacturing Institute are holding a Manufacturing Innovation Summit on October 27, 2011, for industry representatives to discuss collaboration models and identify a preferred approach. The AMTech initiative is highly relevant to the goals of the summit, and the recommendations put forth in this RFI response will form the basis for the summit discussion.

In summary, we believe that road-mapping is important and necessary, but not sufficient, and that consortia by themselves will not produce technical innovations which result in sustained competitive advantages for a broad range of U.S. manufacturers. An additional mechanism is needed to source, develop, mature, commercialize, and insert globally leading manufacturing technologies. We believe a network of non-profit Manufacturing Technology Application Centers with world-class technical expertise and capabilities would provide that mechanism. Once established, these applications centers would primarily provide innovation services to industry, and would require only a small proportion (<20%) of Federal funding to seed high-risk manufacturing technology innovations. Industry consortia would engage these applications centers to develop and deploy new technologies throughout U.S. manufacturing supply chains.

This document is organized into a number of sections to describe this concept. The section which immediately follows describes the need for sustained Federal investment to establish an effective manufacturing innovation infrastructure. Next, a recommended innovation model is described which involves both focused industry consortia to identify needs and a network of manufacturing technology application centers with deep technical capabilities to develop practical solutions. Finally, specific responses are provided to the AMTech RFI questions.

Need for a U.S. Manufacturing Innovation Infrastructure

Manufacturing is vitally important to our economy. If U.S. manufacturing were a country by itself, it would be the eighth largest economy in the world. In 2008, U.S. manufacturing generated $1.64 trillion worth of goods. Manufacturing also has the highest multiplier effect among the major sectors, with every dollar in final sales of manufactured products supporting $1.40 in output from other sectors of the economy. Manufacturing employees earn higher wages and receive more generous benefits than other working Americans. In March 2009, manufacturing employers paid $32 per hour in

[1] "EWI report Advancing Manufacturing Competitiveness: Report from the 2010 conference on the future of materials joining in North America.", February 2011, EWI

wages and benefits, while all employers in the economy paid about $29.39 per hour. That is a 9 percent premium for working in manufacturing[2].

Over the past decade the U.S. has fallen from first to third in total exports behind China and Germany[3]. Thirty years ago, America was the undisputed world leader in manufacturing. Today we struggle to even support our National defense needs. As the Milken Institute put it, "*there is no denying that the dominance of U.S. manufacturing has been steadily eroding*"[4]. The decline in manufacturing has disproportionately impacted manufacturing-oriented states like Ohio, which alone has lost over 400,000 manufacturing jobs over the past decade.

Increasing our capacity to innovate will strengthen our nation's manufacturing competitiveness and exports. A global survey of 400 manufacturing executives found the number one driver of manufacturing competitiveness to be "talent-driven innovation"[5]. This finding flies in the face of the common perception that manufacturers are simply "chasing cheap labor" around the globe. Contrary to the views of many, the current threat to US manufacturing is not low-cost, unskilled labor. Rather, the threat is from highly educated and trained labor, working in highly capitalized factories with modern equipment, set in an environment that enables innovation, encourages risk taking, and rewards success. U.S. manufacturers recognize the need to innovate their manufacturing technologies. A recent EWI survey[6] asked manufacturers how important having world-class manufacturing technology is to their competitiveness. On a scale of 0 to 5, with 5 indicating extremely important and 0 indicating no importance, over 87% of the respondents selected 4 or 5 (Figure1).

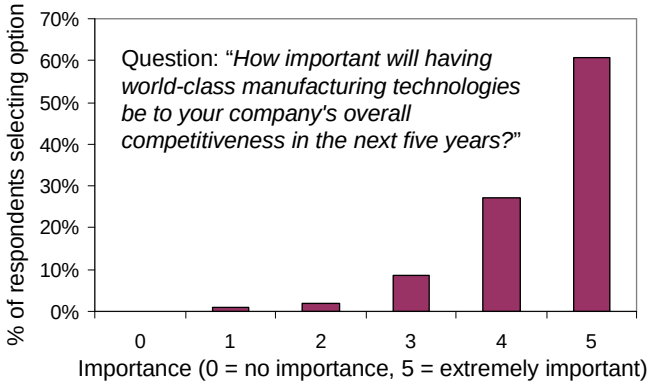

Figure 1: Survey indicates that manufacturers believe they must have world-class manufacturing technology to be competitive

There is nothing new about the drive for manufacturing innovation, as evidenced by the strong manufacturing productivity growth in comparison to the remainder of the U.S. economy over the past 50 years. What is new is the heightened rate of change and innovation required to keep pace with global competitors. As a Chicago Federal Reserve Bank President put it[7] "*Globalization has sharpened competition in recent years so that survival requires ever more dedication to staying one step ahead and at the*

[2] "The Facts About Modern Manufacturing", 8th Edition, 2009, The Manufacturing Institute
[3] "China Passes Germany as World's Top Exporter", New York Times, By KEITH BRADSHER and JUDY DEMPSEY, Feb 2010, www.nytimes.com
[4] "Jobs for America: Investments and Policies for Economic Growth and Competitiveness," DeVol, Ross, Wong, Perry, January 2010, Milken Institute
[5] "2010 Global Manufacturing Competitiveness Index", Deloitte and The Manufacturing Institute
[6] September 2011 survey of EWI members with 350 respondents
[7] "Productivity Growth in Manufacturing", Remarks by Charles L. Evans, President and Chief Executive Officer, Federal Reserve Bank of Chicago, Association for Manufacturing Technology Lost Pines, Texas October 2008

forefront of innovation." The increased pace of technological change is posing a serious challenge to the manufacturing industry. A 2010 EWI industry survey[8] asked about the most important manufacturing challenges they will face in the next five years. A theme which emerged was the need for more effective ways to mature and transition new manufacturing technologies from R&D to production.

Today, the U.S. Federal government distributes innovation investment across a dizzying array of agencies and programs, such as DOE National Laboratories, university NSF centers, DoD Research Labs, NIST Manufacturing Extension Partnership (MEP) programs, small business innovation research (SBIR) programs, and DoD ManTech programs to name a few. Unfortunately, **there are very few if any examples of Federal programs with a focus on developing, maturing, and commercializing manufacturing technologies** to advance U.S. manufacturing competitiveness. Rather, the vast majority of the investment is in basic research (e.g., national labs, NSF centers), industrial outreach programs that introduce established best-practices (e.g., MEP), or programs to evaluate commercially available technologies for defense applications (ManTech). This leaves a large unmet need for manufacturing technology innovation, maturation, commercialization, and insertion (Figure 2). There are occasional individual agency solicitations (e.g., DOE-ITP Innovative Manufacturing Initiative, DARPA Open Manufacturing initiative) that attempt to address this space. However, these temporary funding sources lack the permanent infrastructure necessary to broadly disseminate the results to a wide range of commercial manufacturers and to tailor the technology solutions to individual commercial applications.

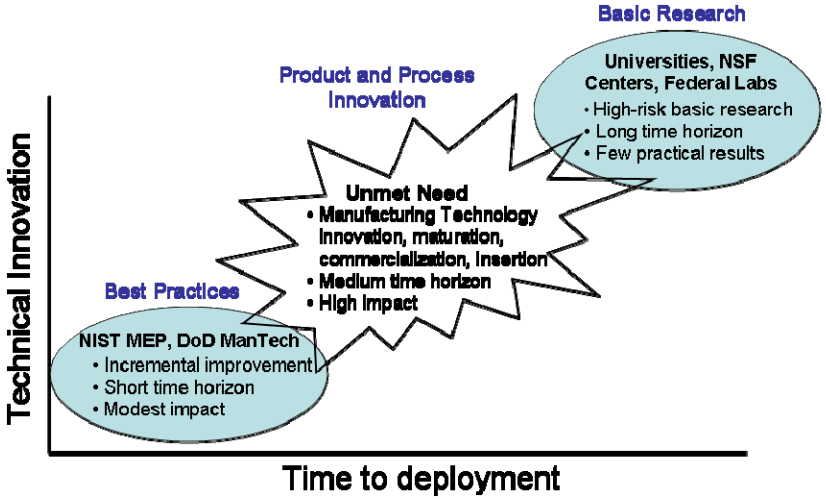

Figure 2: The U.S. needs organizations focused on developing, maturing, and commercializing advanced manufacturing technologies

There are successful manufacturing innovation models in other countries that bridge this gap. For example, Germany exports significantly on the basis of innovation without the advantage of low-cost labor. They create competitive advantage for their manufacturers in part through technology centers that develop world-leading manufacturing technologies, in close collaboration with universities and industry, to enhance quality, productivity, agility, and product performance. The resulting technical innovations are commercialized to support a vibrant manufacturing sector. While we can borrow

[8] August 2010 EWI member survey with 550 respondents

elements from such foreign models, America's unique economic, cultural, and political environment demands a uniquely American innovation model.

Recommended Innovation Model

The Federal government should set a goal for the United States to establish a world-class manufacturing technology innovation infrastructure. We recommend this infrastructure be built upon **two foundational elements: 1) Focused Industry Consortia which identify key technology gaps and form project teams to develop solutions, and 2) Manufacturing Technology Applications Centers with world-class capabilities to develop, mature, commercialize, and broadly deploy innovative manufacturing technologies.** Consortia will form to develop roadmaps and develop project teams to address specific opportunities, and will continue only until needed solutions are commercialized. Application centers will persist to ensure results are broadly disseminated to a wide range of commercial manufacturers. Figure 3 illustrates the close synergistic relationship between these industry consortia and applications centers. A single consortium may access capabilities at multiple application centers to address a particular industry challenge, and each application center will engage multiple consortia to develop a range of solutions to the challenge.

Manufacturing Technology Applications Centers

Focused Industry Consortia	Automation	Casting	Electronic assembly	Forming	Inspection	Joining	Additive manufacturing	Machining	Etc…
Aerospace metal additive manufacturing	X				X	X	X	X	
Automotive structure light-weighting		X		X	X	X	X		
Battery high-speed assembly	X		X		X	X			
Electronics sustainable manufacturing	X		X			X			
Nuclear power equipment fabrication		X			X	X	X	X	
Heavy equipment manufacturing automation	X				X	X	X	X	
Etc…									

Figure 3: Each industry consortium will access capabilities of multiple manufacturing technology applications centers to develop needed solutions to emerging challenges

Focused Industry Consortia

Consortia would be formed for particular industry segments where industry has demonstrated a commitment to address an identified opportunity or need. Consortia members will include businesses throughout the supply chain. They may also involve research partners with particular technical expertise and interest. The consortia will form program teams involving industry, Manufacturing Technology Applications Centers, university partners, and commercialization partners to tackle specific technical challenges. Federally funded programs will focus on developing and maturing pre-competitive manufacturing technologies. Commercial funding will be used to refine and implement the developed technologies for specific applications. Having industry

drive the agenda and commit to adopt sufficiently mature technologies will maximize the likelihood of successful implementation.

A 2011 survey of EWI members asked “how likely would it be for your organization to participate in an industry-led, government-supported consortium to identify emerging needs and develop innovative manufacturing technologies?” On a scale of 0 to 5, with 5 indicating extremely likely and 0 indicating not at all likely, over 70% of respondents selected 3 or higher, and another 14% were not sure. Industry clearly has concerns which would need to be addressed, however. A 2010 EWI survey asked “what are the biggest barriers to successful collaborative manufacturing technology development?” The barriers which were more often selected were:

- Insufficient funding to execute programs
- Intellectual property ownership
- Industry competition stifles collaboration.

To overcome these barriers, federal funding will be needed to sponsor the development and maturing of advanced manufacturing technologies. Intellectual property ownership should be retained by the non-profit application centers which are responsible to shepherd the technology through to commercialization, and make it available to consortium members. Consortia funded activities should focus on developing pre-competitive technologies to minimize competitive concerns. EWI has developed a successful consortia model to identify emerging needs and develop collaborative programs to address those needs. The following are two specific examples.

Additive Manufacturing Consortium (AMC). Recent articles in The Economist and Aviation Week have highlighted the disruptive nature of Additive Manufacturing (AM). This technology involves producing complex metal parts directly from a computer model by precisely depositing and fusing successive layers of material (Figure 4). Elimination of the hard-tooling associated with many conventional manufacturing operations reduces both the time and cost required to introduce new product designs. AM also enables improved product designs which cannot be efficiently produced with conventional manufacturing methods. There are several emerging Additive Manufacturing technologies, each with unique capabilities. Metal Additive Manufacturing technologies are relatively immature as compared with conventional manufacturing methods, and U.S. industry is only just beginning to explore their potential. The U.S. risks falling behind, as many commercial Additive Manufacturing technology suppliers are European, and Europe has at least $25M in active government programs to accelerate AM applications.

Figure 4: Additive manufactured metal aircraft engine part

To realize its potential within the U.S., emerging Additive Manufacturing technologies must be matured, commercialized, and introduced into the supply chain. Not even the largest U.S. corporations can afford to do this alone and a public/private partnership was needed. With urging from EWI’s aerospace clients, in 2010 EWI formed the AMC with a mission to advance the manufacturing readiness of metal AM technologies to benefit consortium members. Today the consortium has grown to over 24 members and research partners. Industry members include major OEMs and their suppliers.

Research partners include five universities as well as Army, Air Force, Navy, NIST, and NASA representatives. Industrial members pay annual dues to be a part of the consortium and drive the agenda. During the first year of operation the AMC has conducted a state of the art review of metal AM technology, and performed road mapping exercises to identify and rank technology gaps, and has developed plans to begin to address these gaps.

The AMC has also proactively sought government funding opportunities to mature and commercialize AM technologies. The State of Ohio has awarded a multi-million dollar grant to productize a large-scale metal AM technology developed by EWI, resulting in a joint venture spin-out company to supply systems to the market. So far the technology has attracted over $1 million dollars in commercial funding and the joint venture spin-out has received its first equipment order. Still, the consortium will only be successful if significant sustained Federal resources are committed to mature, test, qualify, and transfer metal AM technologies into the aerospace supply chain. AMC members have worked together to attract Federal funding, but have yet to obtain the resources needed to address the portfolio of technical challenges identified by the consortium.

Nuclear Fabrication Consortium. Through extensive conversations with EWI's members in the nuclear industry, it was recognized that the US nuclear energy equipment supply chain and its regulatory infrastructure needed a better system to implement recent manufacturing technology advances in order to be competitive in a global market. The strategic players in the nuclear marketplace noted that manufacturing technologies currently in various levels of development and/or deployment in other industries were not available to the nuclear industry due to the prohibitive cost and effort required for implementation. There is potential for new plant construction, but the industry does not yet have the backlog needed to justify the significant investments required to push new technology through the required testing programs.

EWI responded to the need for a pre-competitive, collaborative industry wide approach that would allow for the rapid vetting, development, and deployment of improved fabrication technologies. This proactive effort broadly supported by industry led to the creation of the Nuclear Fabrication Consortium (NFC) in 2009. Today the NFC includes 27 industry members from throughout the U.S. nuclear supply chain. The NFC is a unique model in which industry (NFC members) performs road mapping to determine the critical needs required to be competitive, while ensuring that the new nuclear plants are built to the highest level of safety, are cost effective, and can be fabricated domestically (creating long term U.S. jobs). EWI's expertise in maturing relevant fabrication technologies made it uniquely qualified to lead the NFC, to implement the critical technology advancements necessary to be competitive in this international arena.

The operating structure of the NFC creates a framework where existing Government (federal and state) initiatives could be used to transition technologies into industry and quickly demonstrate their benefit to industry. The NFC members then fund continued development and deployment of these technologies to fit their specific commercial needs. In essence creating an effective public/private partnership, in which industry determines the need, the NFC and EWI pulls the technology forward to a deployable point, then industry continues the development using their own internal resources and funding.

To date the NFC has conducted approximately 20 such projects. One example involved the maturation of an emerging technology known as Ultrasonic Machining. Ultrasonic Machining technology was initially developed by EWI using internal company funding in combination with resources provided by the State of Ohio. After hearing from the NFC members that machining time is one of the critical path bottle necks in the fabrication of nuclear components, the DOE-NE and the NFC worked together to demonstrate a new machining technology on a nuclear pressurizer component. The technology demonstration was conducted in an open, public forum at AREVA's Mock-up facility in Lynchburg, VA. Following the demonstration, multiple companies have continued interest, funding and support of the technology. Within a few months of the demonstration, at least 5 companies have continued investment in the technology. Based on feedback thus far, it appears that industry will outpace the federal investment by nearly 10 fold.

Manufacturing Technology Applications Centers

An infrastructure consisting of a network of independent, non-profit, membership based Manufacturing Technology Application Centers should be created. Each application center would have world-class capabilities in a particular manufacturing technology field. These centers should advance manufacturing competitiveness by innovating, maturating, commercializing, and inserting advanced manufacturing technology. Once established, the Manufacturing Technology Application Centers would become a primary resource for intermediate-range manufacturing innovation focused on emerging industry needs.

A 2010 EWI member survey identified that industry struggles to identify, select, and effectively introduce advanced manufacturing technologies into production. The Manufacturing Technology Applications Centers will help manufacturers address this need. A recent industry survey[9] asked how beneficial it would be to have access to non-profit technology centers with world-class capabilities to evaluate applications. On a scale of 0 to 5, with 5 indicating extremely beneficial and 0 indicating no benefit, 88% of the respondents selected 3 or higher (Figure 5).

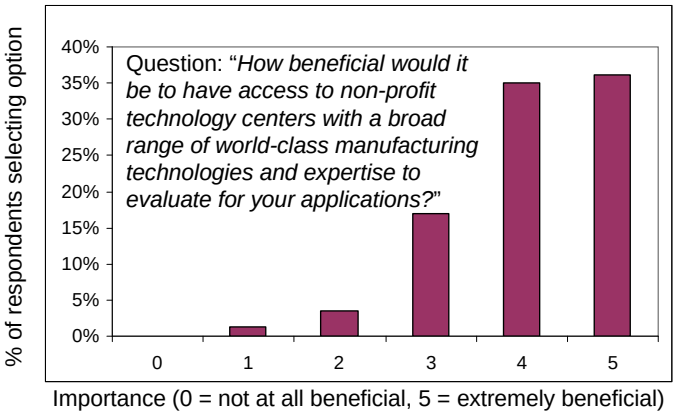

Figure 5: Survey indicates that manufacturers view application center model as beneficial

Access to physical technology assets and world-class expertise with a real-world applications focus will allow manufacturers to identify, select, develop, and pilot test advanced manufacturing technologies. This will greatly reduce technology adoption time and risk. The effectiveness of the centers should be measured in terms of contract R&D funding, technology commercialization, technology insertion, and improved manufacturing competitiveness of their target industry segments. Center members and industry consortia will identify emerging needs which drive pre-competitive technology

[9] September 2011 survey of EWI members with 350 respondents

development using Federal funding. The centers will engage commercial companies on a fee-for-service basis to refine and deploy the developed technologies for specific industrial applications. Approximately 70% of each center's revenue should derive from contract research and royalty payments on commercialized IP; approximately 20% from Federal investments in pre-competitive technology innovation; and approximately 10% from membership fees. Obtaining a majority of their funding from contract engagements and licensing will ensure that these organizations are focused on technology insertion with material impacts for industry. Obtaining some revenue from membership will ensure that each application center develops strong, long-term collaborative relationships with industry.

EWI is a successful example of the manufacturing technology applications center model. It is an independent nonprofit corporation with the mission to advance manufacturing competitiveness through innovation in joining and allied technologies. Located adjacent to a major research university, EWI acts as an intermediary to develop, mature, commercialize and transition technologies to industry for specific applications. It has over 230 member companies, representing a diverse range of industry sectors and thousands of plant locations across the nation. Sustained investment by the State of Ohio since 1984 has allowed EWI to develop world-class technical capabilities. In 2010, EWI attracted 20 times as much funding from other sources than from the Ohio Edison Program; demonstrating sustainability and a strong return on investment.

The Federal Government should leverage the successful EWI model to create a network of Manufacturing Technology Application Centers to help U.S. manufactures innovate their products and processes. As the President of the Manufacturing Institute put it after a recent visit to EWI, "I am growing more convinced that the EWI applications center model should be explored further for replication and policy/investment support". It was this realization that led to an ongoing collaboration between the Manufacturing Institute and EWI to promote the application center innovation model. This joint response to the NIST AMTech RFI is an example of this ongoing collaboration.

Specific Responses to AMTech RFI Questions

The sections which follow will elaborate on the above concept in response to the AMTech questions.

Question 1.

Should AMTech consortia focus on developments within a single existing or prospective industry, or should its focus be on broader system developments that must be supplied by multiple industries?

The industry consortia should have a relatively narrow focus within a single industry sector and opportunity space (e.g., nuclear power equipment fabrication technology advancement, aerospace metal additive manufacturing technology). The application centers should have world-class technical capabilities in targeted areas and focus on maturing emerging manufacturing technologies which are relevant to multiple sectors.

Question 2.

Who should be eligible to participate as a member of an AMTech consortium? For example, U.S. companies. i.e., large, medium, and/or small; institutions of higher education; Federal agencies; state, local, and tribal governments; and non-profit organizations?

The industry consortia should be organized by a non-profit application center and be comprised primarily of for-profit U.S. manufacturers and their suppliers. The entire supply chain should be eligible to participate, including major original equipment manufacturers (OEMs), part suppliers, raw material suppliers, etc. The companies which will ultimately adopt the technologies that are developed should drive the agenda, prioritize needs, identify requirements, and rank technical solutions. Potential commercialization partners should also be involved as early as practical to ensure a viable commercialization path. Other entities, such as universities, national labs, and government agencies, may participate on individual project teams.

Question 3.

Should AMTech place restrictions on or limit consortium membership?

Membership should be limited to businesses having U.S. manufacturing operations which will either supply or utilize the developed manufacturing technologies.

Question 4.

Who should be eligible to receive research funding from an AMTech consortium? For example, U.S. companies i.e., large, medium, and/or small; institutions of higher education; Federal agencies; state, local, and tribal governments; and non-profit organizations?

Project teams should be formed involving any entities necessary to develop an effective solution, without restriction. It is anticipated that this may include consortia member companies, research partners, government agencies, and commercialization partners. The applications center which organized the consortia should be responsible to program manage the project team.

Question 5.

What criteria should be used in evaluating proposals for AMTech funding?

AMTech should fund three related activities: 1) industry consortia formation and road-mapping activities, 2) application center capability development, and 3) industry consortia directed projects. The criteria for these three types of activities should be as follows.

- Consortia formation and road-mapping. Proposals should be evaluated based on the importance of the sector to the region and nation, competitive challenges facing the sector, potential for new manufacturing technologies to impact these challenges, and willingness of companies within the sector to collaborate.
- Application center capability development. Proposals should be evaluated based on importance of the technology to multiple industry sectors, potential for innovation, individual road-mapping results, potential for non-AMTech funding to further mature and deploy the technology, and the application center's track record in maturing and commercializing technologies.
- Industry consortia directed projects. Proposals should be evaluated based on the need for investment to mature pre-competitive technologies, potential economic impact, identification of a viable commercialization path, intellectual property freedom to operate, and commitment of industry to implement developed technologies. It is not recommended that industry cost-share commitment be a primary consideration until technologies near commercialization.

Question 6.

What types of activities are suitable for consortia funding?

AMTech should fund three related activities: 1) industry consortia formation and road-mapping activities, 2) application center capability development, and 3) industry consortia directed projects. For example, an automotive industry consortia may be formed to develop light-weight body structure manufacturing processes. A subsequent road-mapping exercise may identify the need for investment to advance hot-press forming of ultra-high strength steels for body structures. A metal forming application center may propose to develop core capabilities for hot-press forming. The automotive

industry consortium may then form a project team to advance the state of hot-press forming die designs which utilizes the application center capabilities. The following summarizes the suggested activities.

- Consortia formation and road-mapping. Application center would lead expert focus groups, industry surveys, economic impact analysis, and industry road-map development exercises. The deliverable would be a report analyzing the industry segment, identifying emerging needs, and assessing industry collaboration opportunities to advance precompetitive technologies. The success metric would be the formation of an effective, functioning consortia to identify and address technology gaps.
- Application center capability development. Application centers would build globally leading capabilities in key manufacturing technology areas. The deliverable would be a technical capability (including facility, equipment, expertise, and IP) which is available for industry development programs. The success metric would be a significant majority of application center funding from non-AMTech sources.
- Industry consortia directed projects. Execution of focused projects to develop and mature pre-competitive technologies up to the point of commercial introduction. The deliverable would be a more mature technology. The success metrics would include manufacturing readiness level advancement, commercialization partner involvement, and follow-on industrial funding to develop or implement the technology.

Question 7.

Should conditions be placed on research awards to ensure funded activities are directed toward assisting manufacturing in the U.S.?

Yes. Funded programs should be directed toward developing manufacturing technologies which will benefit U.S. manufacturing operations. Having an applications center infrastructure located throughout the U.S. will facilitate the broad transfer of knowledge and technology to U.S. manufacturing entities. However, because many manufactures have global operations, it is not practical to prevent the eventual dissemination of technology overseas. The goal should be that U.S. manufacturers have a competitive advantage by getting the technology first and by getting the technical support needed to effectively implement it.

Question 8.

What are ways to facilitate the involvement of small businesses in AMTech consortia?

Small business will participate in consortia when their clients (or potential clients) are involved. In our experience, involving the major OEMs first will attract tiered suppliers, particularly when the OEM publicly endorses the consortium.

Manufacturing Technology Application Centers will naturally attract small to medium sized enterprises (SMEs) which lack internal resources (R&D centers, engineering talent, capital equipment) to investigate new manufacturing technologies on their own. Participation in application center technical workshops and seminars will make SME managers aware of emerging technologies.

Question 9.

What are best practices for facilitating the widest dissemination and adoption of knowledge and technology through consortia?

This is the crux of our argument that the Manufacturing Technology Application Centers are a necessary element to an effective innovation infrastructure. Individual consortia projects will come and go, but the applications center persist; retain knowledge; and grow in technical capabilities and industry relationships over time. The connection to multiple industry based consortia promotes regular dissemination of technical information to industry. Also, if a significant majority of each application center's revenue must come from non-AMTech sources, the centers have a strong incentive to disseminate information, make industry aware of their technical capabilities, and to promote technology adoption. For example, EWI hosts regular technical seminars and demonstrations, participates in dozens of national conferences, hosts thousands of visitors each year, distributes monthly technical updates to over 8,000 member contacts, answers over 3,000 technical requests for information annually, visits every member regularly, and conducts over 700 funded projects for clients each year.

Question 10.

While it is expected that the research efforts of AMTech consortia (including participants from the Federal, academic, and private industry sectors) will take place largely at the pre-competitive stage in the development of technologies, the generation of intellectual property is possible, and even likely. What types of intellectual property arrangements would promote active engagement of industry in consortia that include the funding of university-based research and ensure that consortia efforts are realized by U.S. manufacturers?

Intellectual property ownership and access is one of the most important barriers to a successful collaboration and must be dealt with early in the consortia formation. Consortia members will expect the application center to make the developed technology commercially available through commercialization partners under reasonable license terms. Consortia members who contribute financially may expect special consideration. The following summarizes a general philosophy:

- The non-profit application center should retain IP developed with AMTech funding so it can be effectively managed and commercialized.
- The application center should be held accountable for protection and commercialization of valuable IP.
- The application center should have the freedom to in-license or pool IP as necessary to ensure freedom to operate and commercialize the technology.
- Commercialization revenues should be reinvested to building the capabilities of the application center.
- Terms on subcontracts to research partners (e.g., universities) must allow for a financially viable commercialization path.
- Actively engaged industry partners may receive a royalty-free license to IP developed with AMTech funding.
- When an industry partner is making a significant investment to further develop the technology, the partner should receive preferential license terms for their

specific field of use. The partner may also receive a portion of future royalties received through commercialization.
- The application center should avoid long-term exclusive licenses which prevent the deployment of the technology to a broad range of U.S. manufacturers.

Question 11.

Would planning grants provide sufficient incentive for industry to develop roadmaps and initiate the formation of consortia? If not, what other incentives should be considered?

A 2011 EWI expert focus group exercise revealed a strong desire among industry for collaborative road mapping to identify technologies that address emerging needs. Based on this finding, we believe a planning grant should be sufficient to bring industry together to start the road-mapping process. However, for on-going industry involvement there must be an opportunity for additional government funding to develop technologies that address roadmap priorities. The Nuclear Fabrication Consortium (described previously) is a useful example. The DOE Nuclear Energy Office has funded a portfolio of technology development projects of interest to the NFC members. These high-impact projects have kept industry closely engaged an is leading to rapid adoption of innovations by industry.

Question12.

Should each member of an AMTech consortium be required to provide cost sharing? If so, what percentage of cost sharing should be provided?

No. Requiring cost share necessitates accounting bureaucracy which drives away industry partners, and especially small to medium size businesses. A more effective model is for the government to invest to develop pre-competitive technologies, and then industry and commercialization partners to invest to refine and insert technologies for particular applications. The application centers should be measured in part by their ability to attract follow-on funding necessary for technology insertion. This model will allow the applications centers to retain ownership for the pre-competitive technology and shepherd it through to commercialization. It also allows application centers and consortia to be agile enough to kill programs which are not meeting stage gates or start new programs to address an urgent need without the time-consuming step of lining up cost share.

Question 13.

What criteria should be used in evaluating research proposals submitted to an AMTech consortium?

Consortia should not accept unsolicited proposals. Rather, the consortia should identify industry needs and proactively solicit proposals to develop *practical, implementable* solutions to those needs. Individual proposals should be evaluated based on the alignment with the consortia roadmap priorities; breakthrough nature of the proposed technology solution; resources required; completeness of the technical plan to mature the technology; technical and business risks; identification of a viable commercialization

path; projected time to deployment; and intellectual property freedom to operate. It is not recommended that project cost-share commitment be a primary consideration until technologies near commercialization.

If sufficient funding is available, each industry consortia should administer a diversified portfolio of projects addressing multiple roadmap priorities in parallel. The portfolio should include both near-term and longer-term projects, as well as some high-risk / high-reward opportunities. High-risk projects would be structured in gated phases to manage the risk. EWI has effectively used this diversified portfolio approach to manage its Cooperative Research Project portfolio to evaluate high-impact pre-competitive manufacturing technologies and report the results to its members.

Question 14.

What management models are best suited for industry-led consortia?

An effective and scalable model is for the consortia to be organized and facilitated by a non-profit application center. The application center maintains close ties with industry and research partners, deep technical capabilities, effective technology transfer vehicles, certified program managers, government-approved accounting practices, industry and government contracting experience, as well as IP protection and commercialization abilities. The application center tracks metrics and reports results to the funding agency. In effect the application center removes the burden of management from the industrial members of the consortia, allowing them to focus on identifying needs and developing potential solutions.

As discussed previously, EWI is an example of an application center with a focus on innovative materials joining technology. To scale this model, application centers would be founded in other important technology areas, such as materials forming, inspection, automation, coatings, machining, casting, etc. Adding a single application center each year would create a world-class network of applications centers within a decade. Within a few years after its founding, each center would be largely self-sustaining, with only about 10-20% Federal funding to seed pre-competitive technology development and on-going technical capability acquisition.

Question 15.

Should the evaluation criteria include the assessment of leadership and managerial skills?

Yes. Applications centers should be assessed on a variety of management and leadership metrics, including capabilities and effectiveness with regard to industry consortia facilitation, program management, IP management, IP commercialization, and technology transfer.

Question 16.

Should limitations be placed on the duration of consortia?

Applications centers persist to provide U.S. manufacturers access to world-leading manufacturing technologies. As manufacturing technology evolves, the applications centers will maintain expertise in the latest developments. Manufacturers will access these capabilities to develop and implement practical solutions to improve products and processes. Within a few years after its founding, each applications center would be largely self-sustaining, with 10-20% Federal funding to seed pre-competitive manufacturing technology capability acquisition.

Consortia are more dynamic. Consortia should be founded to address a particular industry challenge, and persist only until commercial solutions become available to address the challenge. To ensure that there is time pressure to produce results, consortia funding should be re-competed on a regular basis. Additionally, the federal review/award committee should be comprised of a broad mix of Federal staff from various levels within the major Federal programs and agencies that touch manufacturing (DOC, DOE, DoD, DOL and DOT). This will help ensure that the consortia are adding value and mitigate the impact of political relationships and lobbying.

Question 17.

How should an AMTech consortium's performance and impact be evaluated? What are appropriate measures of success?

The suggested three primary AMTech sponsored activities are as follows:

- Consortia formation and road-mapping. The success metric would be formation of an effective, functioning consortia to identify and address technology gaps and develop scalable solutions.
- Application center capability development. The success metrics would include world-leading manufacturing technology capabilities, a growing and diverse customer base, and a significant majority of application center funding from non-AMTech sources.
- Industry consortia directed projects. The success metrics would include manufacturing readiness level advancement, commercialization partner commitment, and follow-on industrial funding to develop or implement the technology.

Question 18.

What are the problems of measuring real-time performance of individual research awards issued by an industry-led consortium? What are appropriate measures of success?

The ultimate goal of the investment (measurably improved competitiveness through the implementation of advanced technology on the manufacturing floor) may take years to reach. Intermediate measures are needed to demonstrate progress toward the goal. These may include manufacturing readiness level advancement, capturing of valuable

IP, commercialization partner commitment, and follow-on industrial funding to develop or implement the technology.

Question 19.

How should the NIST AMTech program be evaluated?

The application center network will provide U.S. manufacturers access to world-leading manufacturing technologies that offer competitive advantages. The AMTech program should be evaluated in terms of the growth of the network capabilities. Individual applications centers should be evaluated in terms of their effectiveness in helping U.S. manufacturers develop innovative products and processes. The relevance of each application center's capabilities can be assessed in terms of the number and diversity of its paying customers. An objective measure of the impact they are having is the attraction of funding from other sources, beyond AMTech. Each applications center should be largely self-sustaining, with no more than10-20% on-going Federal funding to seed pre-competitive manufacturing technology capability acquisition.

Consortia should be focused on implementation of solutions to address specific emerging needs of particular industry sectors. An objective measure of the impact they are having is the investment of consortia members to implement the developed technical solutions. Intermediate metrics may include breadth of industry consortia, maturation of break-through technologies, and commercialization of technologies.

Question 20.

What are lessons learned from other successful and unsuccessful industry-led consortia?

Through EWI's two decades experience managing multiple centers and consortia, several important lessons have been learned. These lessons should be considered during the development of the AMTech program to ensure sustainability and effectiveness.

- The consortia and application centers should involve a wide range of stakeholders. It has been found particularly useful to have the synergy represented by the entire supply chain from service bureaus, through tier suppliers, to OEMs/primes on the industry side, teamed with military agencies and academia.
- If consortia membership fees are too high, company justification to participate becomes difficult and time consuming. Only the largest companies participate, resulting in sub-critical consortia not involving much of the supply chain. Participants who are paying high fees also demand their individual needs be addressed rather than targeting a common goal. Conversely, if the membership fees are very low, participants are not sufficiently committed to advancing the consortium's goals. It becomes more of a networking and sales opportunity for the smaller companies. Based on our experience, a tiered membership fee is appropriate, based on the size of the company and their influence in the consortium decision making processes.
- Our experience suggests that a model with clearly defined criteria for program selection, execution, and termination that can be run semi-autonomously by the

consortia (with minimal day-to-day government bureaucracy) is ideal. This approach promotes agility, entrepreneurial risk-taking, and a competition for ideas to select the best technologies for investment.

- The consortia need to be nimble. As industry needs change, the industry focus and related research needs to be changed with it. This means federally funded programs in support of consortia needs should be reviewed regularly and portfolios adjusted to maximize the impact from the available resources.
- The consortia and application centers should be encouraged to leverage multiple funding sources (commercial, State, and Federal) to advance manufacturing technologies quickly through to implementation. However, requiring upfront cost share actually impedes progress and distorts decision making processes. AMTech funding alone may be necessary to demonstrate feasibility of a technology, then other sources can help to mature and commercialize it.
- Unsuccessful consortia usually fail for two reasons: 1) lack of leadership, and/or 2) lack of resources. The applications centers can provide the leadership to bring industry together, identify common industry needs, and manage project teams which develop solutions. AMTech can provide the initial resources needed to demonstrate the viability of a solution and attract other funding.

Question 21.

How can AMTech do the most with available resources? Are there approaches that will best leverage the Federal investment?

The application center model ensures a high degree of leverage. Application centers should be incentivized to seek out leverage multiple funding sources to develop and commercialize useful intellectual property. The key is giving the application center a stake in the success and the flexibility to make entrepreneurial decisions to mature and commercialize the technology.

EWI has many examples of leveraging disparate funding sources to advance and commercialize leading edge manufacturing technologies. For example, in the case of Ultrasonic Machining technology, EWI has matured the technology with funding from EWI internal investment, the State of Ohio, NASA, DoD, DOE, and several commercial clients in widely differing industry sectors. Over a period of five years technology has matured to the point it is ready to implement and negotiations are underway with commercial clients.

Question 22.

How should AMTech interact with other Federal programs or agencies?

Applications centers should develop relationships with all relevant agencies to share information and leverage resources. As described previously, there is a need to fill an unmet need (Figure 2) between Federal programs and agencies that sponsor basic research and those that support instruction of established best practices. The optimum solution involves collaboration with other programs to mature high-potential, early stage technologies through to commercial implementation, and then to wide-spread best-practice deployment. The NSF centers, SBIR programs, and national labs are a large source for early stage innovations which could be screened for applicability to

consortia objectives. The application centers could play a key role in identifying emerging technologies from other programs and reaching out to make connections.

Question 23.

What role can AMTech play in developing, leading, or leveraging consortia involving other Federal agencies?

There are many opportunities to collaborate to broaden the scope and impact of the consortia. For example, DARPA, OSD, or individual armed services may establish consortia or centers focused on DoD manufacturing applications and suppliers. There are likely opportunities to extend results to commercial application without compromising security considerations. Similarly, there are likely synergies with DOE-NE and DOE-ITP programs, again leveraging investments to extend the impact to a broader range of industries. Adoption of key manufacturing innovations by the application centers will maximize the opportunities for technology transfer to U.S. manufacturers.