EWI
We Manufacture Innovation

1250 Arthur E. Adams Drive, Columbus, Ohio 43221
614.688.5000 • ewi.org

RFI Response: Federal Technology Transfer Authorities and Processes

Submitted by: EWI, Columbus, Ohio

Authors: C. Conrardy, J. R. Pickens[1]

Introduction

EWI is pleased to provide this response to the NIST Request for Information Regarding Federal Technology Transfer Authorities and Processes (Docket Number: 180220199–819–01). Specifically, the following RFI questions are addressed:

> (2) What are the issues that pose systemic challenges to the effective transfer of technology, knowledge, and capabilities resulting from Federal R&D? Please consider those identified in the RFI as well as others that may have inhibited collaborations with Federal laboratories, access to other federally funded R&D, or commercialization of technologies resulting from Federal R&D.
>
> (3) What is the proposed solution for each issue that poses a systemic challenge to the effective transfer of technology, knowledge, and capabilities resulting from Federal R&D? Please consider the approaches identified in the RFI.
>
> (4) What are other ways to significantly improve the transfer of technology, knowledge, and capabilities resulting from Federal R&D to benefit U.S. innovation and the economy? What changes would these proposed improvements require to Federal technology transfer practices, policies, regulations, and legislation?

Our response focuses on the opportunity to improve the competitiveness of the U.S. advanced manufacturing sector through new partnering models and technology transfer (T2) mechanisms. It is based on EWI's 35 years' experience as a "catalyst" helping to mature and transition manufacturing technologies for thousands of private sector and government applications. It is also based on recent thought leadership from other organizations that recognize the importance of improving T2 for U.S. manufacturing competitiveness[2]. We make the argument that the government should give urgent attention and priority to creating *new T2 mechanisms for advanced manufacturing technologies*, to overcome pervasive market failures and create sustained competitive advantages for manufacturing in the United States.

Background

Advanced manufacturing is an area of strategic national importance both to economic prosperity and national security. Technical innovation is an increasingly crucial factor in determining an industry's, or a nation's, ability to compete globally. New manufacturing technologies not only have the potential to improve efficiency, enhance quality, and reduce energy usage, but also to enable entirely new product designs that offer higher performance and reliability at reduced cost. Unfortunately, America has lost its

[1] Contact Information: Chris Conrardy, EWI CTO, cconrardy@ewi.org, (614) 688-5191; Joe Pickens, EWI Chief Scientist, jpickens@ewi.org. (410) 489-9696

[2] "Manufacturing Prosperity – A Bold Strategy for National Wealth and Security", published by MForesight, June 2018 (http://mforesight.org/download-reports/)

1250 Arthur E. Adams Drive, Columbus, Ohio 43221
614.688.5000 • ewi.org

leadership position in creating and commercializing advanced manufacturing technologies. Increasingly, the innovation, commercialization, and early adoption of manufacturing technologies happen elsewhere, and U.S firms are relegated to chasing foreign competitors and importing the advanced manufacturing technologies they need. Fostering a domestic ecosystem for developing and introducing new manufacturing technologies (i.e., including research, commercialization, technology suppliers, trained talent, and end-users) can create sustained competitive advantage and jobs that are difficult to outsource to low-wage nations.

America's national labs and university research infrastructure are unmatched globally. The federal government invests more than $150B annually in research, yielding many new discoveries and inventions. Some portion of these discoveries has the potential to improve manufacturing competitiveness. However, a relatively small percentage of these research outcomes are matured to the point where market forces drive implementation. This RFI response suggests a strategy to dramatically increase the ROI from the federal research investment by improving the commercialization and adoption of new manufacturing technologies in the U.S.

Systemic Challenges for T2 of New Manufacturing Technologies

Federal R&D investment should lead to strengthening the US national security innovation base and lead to economic growth. For this to happen, R&D results must be efficiently transferred to private sector companies to create new and useful products and services. Barriers to efficient T2 need to be identified and policies adopted to remove or circumvent these barriers and streamline the technology transfer process. This is particularly challenging for new manufacturing technologies. The following describes some of the barriers to commercialization of new manufacturing technologies that result from federally funded research.

Cultural Disconnect

It is not unusual for talented researchers performing federally funded work to have a very different experience base, priorities, and pace of execution from that of manufacturers. While the researchers may be technical subject matter experts, they often lack deep insight into shop floor needs and technology implementation requirements. In many institutions, researchers lack the incentives, resources and institutional support structures to help get a technology matured to the point where it can be commercialized. Well intentioned Government bureaucracy often involves many permission givers including tech reviewers, several levels of R&D management, legal assessments and the associated required signatures to proceed. Institutional T2 metrics often focus on total licensing revenues, rather than implementation and use of a technology to make an impact for the country. Most research institutions also lack the contacts and expertise to engage the industrial market in order to assess the value proposition of a new technology and identify early adopters.

Insufficient investment

Primary considerations for venture capital investors include the size of the addressable market, the degree of risk, and the time required to achieve attractive return on investment (ROI). Many capital investors insist that the technology developer shares some of the risk. New manufacturing technologies typically are characterized by long adoption cycles, high technical risk, and high product launch costs,

1250 Arthur E. Adams Drive, Columbus, Ohio 43221
614.688.5000 • ewi.org

which make attraction of investment capital very difficult. Funding for this "Valley of Death" is a persistent and pervasive problem. The net result is often market failure in transitioning manufacturing technologies from the lab to commercial use.

Slow adoption rates

Manufacturers are slow to adopt new technologies for many reasons. In many cases a product design must be modified to take advantage of a new manufacturing technology, which must wait for the next product design cycle. Designers are often reluctant to incorporate a new technology until there is an extensive database of performance data. Manufacturers also want the technology suppliers to have a proven track record of equipment reliability and a robust product support network, which takes years to develop. For regulated industries, the expense of qualifying new technologies that are not yet included in industry accepted codes and standards can be also cost prohibitive and create long delays. Additionally, manufacturing quality control methods are based on eliminating sources of variability, and new manufacturing technologies represent an unknown risk factor that must be thoroughly understood and tested before introduction. Finally, adoption of new technologies typically requires training programs for upskilling of the workforce who will be implementing, using, and maintaining the manufacturing equipment, which requires additional time and expense.

High technical risk

The cost to develop new manufacturing technology products is high and escalates throughout the product development cycle. Because manufacturing is diverse, there are many different use-cases for the introduction of a new manufacturing technology, which necessitates extensive testing to optimize and validate the performance for different applications. Manufacturing technologies must also be integrated with numerous other shop floor technologies, thereby increasing complexity. Manufacturing technology intellectual property (IP) landscapes are also complex, and the costs of IP protection to create a defensible position and ensure freedom to operate is often high. Managing the costs and risks of a new manufacturing technology product development requires specialized skills and rigorous new product development (NPD) processes, which are not common to most research institutions performing federally funded R&D.

High product launch costs

Even when the product development has been completed, getting a new manufacturing technology product to market can be difficult and expensive. Some manufacturing market segments are difficult to address without established sales channels, which increases marketing and sales costs. Most manufacturers (particularly SMMs) don't have the time to seek-out and screen new technologies for their applications, so proactive outreach efforts are necessary to build awareness. This end-user engagement must be accomplished quickly and efficiently to meet capital investment cycles and implementation windows. Once a product is sold, the supplier must have the infrastructure to install, commission, and support the technology in production, which creates a barrier to entry for many startup companies. These implementation tasks are far downstream from the original invention in the government lab, and few research organizations have the resources or skills to effectively execute them.

1250 Arthur E. Adams Drive, Columbus, Ohio 43221
614.688.5000 • ewi.org

Proposed Solution

We believe that overcoming these pervasive and persistent market failures will require new approaches. Specifically, the following are recommended:

Nonprofit Intermediaries

T2 is a "contact sport". The technology inventor, the scale-up developer of the commercial solution that incorporates the discovery, and the end-user who will ultimate implement the innovation should be in constant contact. In fact, the probability of successful T2 increases dramatically when the end user is involved early in the technology development. The end user can clearly articulate needs and requirements that must be met for the technology to be used. Engaging end-users to identify and document these "functional requirements" is an essential step of successful product development which is outside the skillsets of most researchers.

We suggest that non-profit intermediary institutions should be enlisted to connect federal R&D results with potential manufacturing applications. These intermediary institutions must have the resident capabilities to screen, mature, validate, and implement new technologies. They must also have deep industrial relationships to understand needs, test value propositions, and identify early adopters. By connecting the research of a federal lab or university to practical manufacturing applications, the intermediaries would help create the market-pull necessary to attract the commercial investment needed to transition the technology. They would also help de-risk technologies by pilot testing them under real-world conditions and uncovering potential problems as early as possible. In a recent informal survey[3], 95% of industry respondents indicated they would highly value such an intermediary role to help connect them with emerging manufacturing technologies. The idea of engaging intermediary institutions for T2 is also described in the previously referenced report[1].

Examples of non-profit intermediary institutions that facilitate T2 to manufacturers include Southwest Research[4], SRI International[5], Battelle[6], CCAM[7], SCRA[8], and EWI[9]. These types of organizations have deep resident T2 capabilities; full-time staff dedicated to delivering customer solutions; extensive industrial and academic relationships; and a track record of inserting advanced technologies into commercial applications. Manufacturing USA institutes could also play a valuable role in leveraging their precompetitive collaborative R&D model to further develop early-stage research for possible T2. Additional information about EWI's T2 approach is provided in a subsequent section of this response.

Licensing

Selected intermediaries should be enlisted to help the government labs identify federal research results with commercial impact potential. When potential is found the intermediary can also help to develop licensing agreements with third parties, within boundaries previously agreed to by the research

[3] Member survey conducted by the LIFT Manufacturing USA institute, and publicly reported to the LIFT Technology Development Committee May 30, 2018
[4] https://www.swri.org/industries/manufacturing-technologies
[5] https://www.sri.com/about/capabilities
[6] https://www.battelle.org/commercial-offerings/industry-solutions/manufacturing
[7] http://www.ccam-va.com/
[8] http://scra.org/what-we-do/connect-ecosystem
[9] https://ewi.org/technologies/

1250 Arthur E. Adams Drive, Columbus, Ohio 43221
614.688.5000 • ewi.org

institution. The terms should incentivize the government lab researcher to invent and see the invention commercialized. In addition, the terms should incentivize both the research institution and commercialization partners to invest their time and resources to help overcome barriers to technology transition.

Resources

The "valley of death" exists for a reason. Manufacturing technologies that are too immature to create market pull will not attract the investment needed to transition the idea from the lab. Public resources are needed for the intermediary institutions to mature these technologies until the point where they attract commercial interest. Not all T2 activities will be successful, and intermediary institutions should focus on "failing fast" so that available resources can be reallocated to the best opportunities. When technologies are determined to not be commercially viable, feedback should be provided to the research organization in order to inform future research efforts and continuously improve T2 potential.

Metrics

The metrics for effective T2 should come from the T2 customers—the user community in commercial industry. The Federal Government should consider T2 metrics that accurately assess the **impact** of successful transfer. The assessment of the customer, i.e. the end-user, is absolutely critical as the end user can provide quantifiable information on the impact of the transferred technology. Even a small improvement in T2 could more than justify the investment in overcoming the valley of death for new manufacturing technologies. For example, 3D printing has shown that a new manufacturing technology can spawn and entire industry, and transform legacy industries. Growing businesses earn greater profits which lead to them paying more taxes. These increased tax revenues provide the opportunity for the Federal Government to increase R&D spending, as well as to address myriad national problems. To complete the virtuous cycle, improved quantifiable impacts of T2 would help to justify greater Federal spending in manufacturing technologies basic research.

About EWI

EWI is a non-profit organization that provides technology solutions to problems in the private and Government sectors. Many technologies require adaptation before the end-user client can "transition" the technology to applications. EWI has been assisting in this process for over 30 years. EWI is widely recognized as America's premier materials joining institute with the broadest range of materials joining technical capabilities. As manufacturing innovation needs have evolved, EWI has changed with them and expanded its core capabilities to become state-of-the-art in areas such as metal stamping, metal additive manufacturing, laser processing, high-power ultrasonics, sensors and controls, structural integrity analysis, and non-destructive evaluation. With more than three decades experience in delivering MRL 4-8 manufacturing innovation services to industry and government agencies, EWI is an example of a sustainable, market-driven non-profit innovation model. The majority of EWI revenues come from the private sector to help manufacturers apply technical innovations. This involves identifying technology needs and mapping them to the most cost-effective high TRL solution, as well as developing leading edge solutions that could be transitioned in a time frame needed by the specific client.

1250 Arthur E. Adams Drive, Columbus, Ohio 43221
614.688.5000 • ewi.org

EWI's T2 Approach

EWI maintains strong relationships with hundreds of material and industrial equipment suppliers and manufacturers across diverse industrial sectors; and works to transition technologies in partnership with many leading academic institutions, R&D organizations, government agencies and national labs. EWI's industrial services range from materials development and characterization, design support and advanced component life simulation and testing, development and optimization of improved fabrication and processing methods, to specialist post-mortem analyses to improve component or product life and performance. EWI also facilitates commercialization of new manufacturing technologies by actively maturing technologies, validating them for particular end-user applications, and working with commercial technology suppliers to take the innovation to market. The T2 approach is tailored to each specific opportunity, but generally involves the following activities:

- Screening new research findings to uncover discoveries that have potential industrial value.
- Engaging potential manufacturing end-users early to identify target applications, specify the technical requirements, and understand the value proposition.
- Involving technology subject matter experts and pilot-scale production equipment to mature and validate technologies for targeted industrial applications.
- Seeking commercial companies and investment to develop manufacturing technology products and deliver them to the market.
- Providing the rigorous engineering analysis, test data, and implementation support needed to ensure successful transition.
- Maintaining a high-degree of confidentiality to protect client's sensitive data and trade secrets.
- Employing flexible IP strategies to enable clients to create sustained competitive positions and facilitate technology transfer.

EWI has many examples of helping to mature and transition new manufacturing technologies. The following illustrate the range of approaches employed.

<u>New Manufacturing Process Introduction</u>

Figure 1 - EWI FSW Pilot Test Cell

Friction Stir Welding (FSW) is a solid-state materials-joining process originally invented in the early 1990's. It offers some unique property advantages for joining certain high-performance metal alloys and dissimilar material combinations. The equipment, tooling, and processing parameters are very different from legacy joining methods, and required years of development to fully understand, mature, and transition to industrial products. EWI built a nationally prominent team of technical experts and acquired full-scale equipment for pilot testing client applications (Figure 1). More challenging applications, such as FS welding of high-strength titanium alloys, required some invention. EWI recognized the need to have access to a patented tool material owned by a third party. Because the patented material proved to be ideal when working with high-strength alloys like titanium, many companies sought the use of the tool material, but had no access. EWI successfully negotiated a license with the third-party so the material could be combined with EWI's patented tool designs and

1250 Arthur E. Adams Drive, Columbus, Ohio 43221
614.688.5000 • ewi.org

offered broadly as a product. EWI also developed a commercial source to produce the tools and conducted technology transition work for a wide variety of customers. EWI's expertise, test equipment, and access to IP enabled clients to screen, de-risk, and apply the technology for a wide range of applications. Example applications include aircraft wing spars, aircraft engine cowlings, military vehicle structures, naval ship panels, oil pipelines, and nuclear power components. Each application contributed to maturing the technology and expanded the application knowledgebase, enabling individual end-users to make informed decisions about the value of the technology for their applications.

Invention Maturation and Commercialization

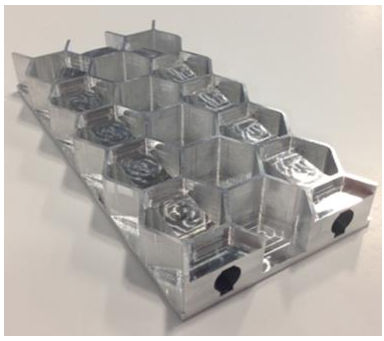

Figure 2- Multi-material heat exchanger produced with Fabrisonic process

EWI has more types of commercial metal additive manufacturing (AM) processes than any independent lab in the country, and has a team of experts who use this equipment to develop and test applications for industrial clients. EWI also works with equipment builders and innovators to mature new AM technologies. For example, a small technology start-up company invented a metal 3D printing process using ultrasonic energy to produce solid-state net-shape deposits. The technology was initially restricted to low-strength aluminum alloys due to ultrasonic power limitations. EWI recognized an opportunity to scale up the process to enable higher-strength alloys to be used for a far greater range of applications. EWI successfully pursued government funding and invested its own resources to build and test a higher energy system in close collaboration with the start-up company. The result was a system capable of ultrasonic 3D printing a wide range of alloys, such as 7000 series aluminum alloys, titanium, stainless steel, copper, etc. Importantly, the technology is uniquely capable of producing multi-alloy components, as well as embedding electronics, wires, fiber optics, etc. To commercialize the technology a joint venture spinout company was created (Fabrisonic LLC) which is rapidly growing and is financially self-sustaining.

Investment Attraction

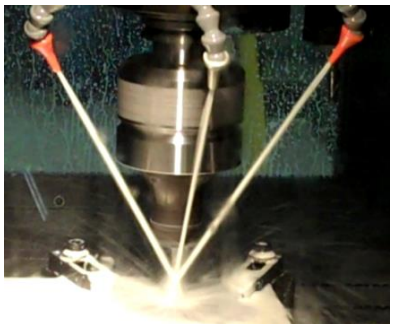

Figure 3- Ultrasonic machining invention dramatically improves productivity of conventional machine tools

University researchers had demonstrated that conventional machining processes, such turning lathes, could be dramatically enhanced by applying high-power ultrasonic energy. While an interesting phenomenon, the benchtop laboratory equipment applied the ultrasound to fixed tools in ways that could not be adapted to conventional industrial drilling and milling equipment. EWI applied its high-power ultrasonic engineering expertise and development methods to invent a novel way of applying the energy to rotating components while isolating any ultrasonic vibrations from damaging the machine tool spindle bearings. EWI constructed prototype devices to allow the technology to be demonstrated for a variety of aerospace, nuclear, automotive, heavy-truck, and industrial product applications. In some cases, machining productivity was more than doubled while extending tool life. End-user

1250 Arthur E. Adams Drive, Columbus, Ohio 43221
614.688.5000 • ewi.org

interest created sufficient market-pull to attract over $10M in private equity investment to commercialize the technology. The investment group has created a start-up company which is developing a product line to take the technology to market.

Concluding Remarks

The benefits of successful technology transfer from the federal R&D investment are diverse and wide ranging. Inventions in metrology, chemistry, physics, life sciences and others will benefit the nation if effectively transitioned to commercial applications. However, EWI recommends that improving the transfer of *manufacturing technology* research results be made a very high priority because of the potential to impact U.S. manufacturing competitiveness and defense preparedness. The U.S. is falling behind peer nations in the development and commercialization of new manufacturing technologies. Persistent, pervasive market failures in transitioning manufacturing technologies result from the high technical complexity, long product development cycles, slow adoption rates, and high manufacturing product introduction costs. Commercial investment is unlikely until technologies reach sufficient maturity to de-risk the product development and create market-pull for specific end-user applications. National labs and universities conducting federally funded research lack the industry insights, relationships, and product development skill-sets necessary to mature manufacturing technologies, find early adopters, attract investment, and support commercialization. We believe that *non-profit intermediary institutions* are best suited to transition manufacturing research results, provided sufficient resources to bridge the valley of death. Doing so would unlock tremendous value from the federally funded research that would more than justify the T2 investment, and promote the long-term economic prosperity and security of the United States. EWI would be pleased to discuss the approach suggested here and to work with the government to help flesh out the concept in greater detail.