Designing for Impact III: Workshop on Building the National Network for Manufacturing Innovation

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Summary Report

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Acknowledgment
Thank you to everyone who participated in *Designing for Impact III: Workshop on Building the National Network for Manufacturing Innovation* held on September 27, 2012, at the Arnold and Mabel Beckman Center of the National Academies of Sciences and Engineering in Irvine, California. The presentations and discussion that took place during the workshop provided the foundation for this report. A complete list of participants is provided in Appendix B.

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Preface

In May of 2012, the Advanced Manufacturing National Program Office (AMNPO) issued a formal request for information (RFI) on a new public-private partnership proposed by President Obama: the National Network for Manufacturing Innovation (NNMI).

Published in the Federal Register[1] and posted on the AMNPO's Advanced Manufacturing website,[2] the RFI seeks ideas, recommendations, and other public input on the design, governance, and other aspects of the proposed network.

In addition to the RFI, the AMNPO solicited input through four regional workshops. The first workshop took place on April 15, 2012, at the Rensselaer Polytechnic Institute in Troy, New York. The second was held on July 9, 2012, at Cuyahoga Community College in Cleveland, Ohio. The subject of this report is the third workshop: *Designing for Impact III: Workshop on Building the National Network for Manufacturing Innovation.* The workshop took place at the Arnold and Mabel Beckman Center of the National Academies of Sciences and Engineering in Irvine, California on September 27, 2012. The event attracted over 220 participants across a diverse and wide-ranging mix of sectors, including:

- 38% from academia
- 31% from industry
- 13% from state or federal government
- 13% from economic organizations
- 5% from other organizations

Although most participants came from California and neighboring states, some attendees traveled from as far as the United Kingdom, Boston, Atlanta, and Chicago. Federal government representatives participated only to explain the NNMI concept and proposed principles.

The workshop featured welcoming remarks by Donald A. Norman, Co-Founder of the Nielsen Norman Group and representing the National Academy of Engineering (NAE); Wayne Johnson from CalTech and representing the National Academy of Sciences Government-University-Industry Research Roundtable (GUIRR) and University-Industry Demonstration Project (UIDP); Michael V. Drake, Chancellor of the University of California, Irvine; and Lew Soloway of the Jet Propulsion Laboratory.

The workshop featured prominent keynote addresses, a panel of recognized regional industry leaders in advanced manufacturing, and extended public dialogue sessions on key design aspects of building the proposed NNMI. Speakers included:

- Jason Miller, Special Assistant to the President for Manufacturing Policy and the White House National Economic Council, who presented the talk, “Advanced Manufacturing and the Federal Perspective.”

[1] https://www.federalregister.gov/articles/2012/05/04/2012-10809/request-for-information-on-proposed-new-program-national-network-for-manufacturing-innovation-nnmi
[2] http://www.manufacturing.gov

- Mike Molnar, Director of the interagency AMNPO, who laid out the motivation for the creation of the proposed NNMI and provided the framework and charge for the workshop's facilitated dialogue discussion in his talk, "Framing the Challenge."
- Dr. Perry Wong, Director of Research at the Milkin Institute, who gave the talk, "Why Manufacturing Matters to California," wherein he described the economic reasons that the Advanced Manufacturing sector is critically important.
- An *Industry Perspectives* panel moderated by Anthony Boccanfuso of UIDP, and featuring: Dianne Chong, Vice President of Assembly, Factory and Support Technologies at Boeing; Pamela Kan, President of Bishop-Wisecarver Corp and Chair of the California Manufacturers and Technology Association; Edward Tackett, Director of Rapidtech; and Brian Wong, President and CEO of Enevate Corporation.

The majority of the workshop featured breakout discussions, or dialogues, on the following topics:

- Dialogue 1: Technologies with Broad Impact
- Dialogue 2: Institute Structure and Governance
- Dialogue 3: Strategies for Sustainable Institute Operations
- Dialogue 4: Education and Workforce Development

The objective of the four dialogues was to inform workshop participants about proposed basic principles of the NNMI initiative and to solicit insights and ideas to assist in the development of the program should it move forward. Two teams of facilitators hosted each dialogue topic, with four separate sessions held on each individual topic. The dialogues were facilitated by representatives from Departments of Commerce, Defense, Energy, and Education, the National Science Foundation, and NASA. In all, sixteen sessions were held over the course of the day. This report summarizes the results of the sixteen workshop dialogues.[3]

The facilitators were instructed to encourage individuals to express their ideas and to foster discussion and debate rather than consensus. As a result, this report does not reflect a group consensus but rather a summary of the main points that arose from the dialogue sessions.

[3] All sixteen dialogue discussions were transcribed. In addition, at the beginning of each session, workshop participants were given forms with space to respond to the dialogue questions. Completed forms were submitted at the conclusion of each dialogue session. Furthermore, at the end of the day, workshop facilitators reported the main points that were covered in each dialogue session.

Executive Summary

U.S. manufacturing plays a critical role in America, whether looking at it through the lens of job creation and retention, innovation, trade, or national security. Its strongest impact is on the American economy itself, a point stressed by President Obama in his 2012 State of the Union address. In setting forth his plan to rebuild a strong economy, the President stated, “This blueprint begins with American manufacturing.”

According to the non-partisan Council on Competitiveness, “U.S. manufacturing is more important now than ever.” But a strong economy built on a foundation of U.S. manufacturing requires that Americans embrace manufacturing in a way they haven’t for decades. In the past ten years, the U.S. has watched nearly one-third of its manufacturing jobs leave its shores. In raw numbers, it has lost 687,000 high-tech manufacturing jobs since 2000.

While this shift has directly impacted the U.S. workforce, it also points to a decline in a crucial American capability: innovation. Design and innovation are integral aspects of manufacturing, yet manufacturing itself has grown deeply unpopular over the decades. In the education sector, two prominent programs that focus on manufacturing—one at Northwestern University’s Kellogg School of Management, one at the Massachusetts Institute of Technology—were renamed in recent years to remove the word “manufacturing” because students perceive manufacturing to be uninteresting and prefer to focus on the programs’ other facets, such as design. To strengthen America’s commitment to manufacturing, in March of 2012, President Obama proposed the development of up to 15 regional Institutes for Manufacturing Innovation (IMIs), leading to a nationwide resource known as the National Network for Manufacturing Innovation (NNMI). The NNMI is designed to unite industry—from the largest corporations to small- and medium-sized manufacturing enterprises (SMEs)—academia, and the public sector in creating an infrastructure that drives manufacturing innovation, educates and populates an industry workforce, and catalyzes meaningful collaboration built upon concepts of industrial commons.

A pilot institute was launched in Youngstown, Ohio on August 16, 2012, using limited but available fiscal year 2012 funding. Though smaller and more limited in scope than an envisioned individual IMI, this institute—the National Additive Manufacturing Innovation Institute (NAMII)—is intended to help transform the U.S. manufacturing sector while advancing industry and workforce development efforts in the Ohio-Pennsylvania-West Virginia “Tech Belt.”

Thus, within the President’s blueprint for American manufacturing, IMIs are critical to the future of the U.S. and to a robust and growing advanced-manufacturing economy. On September 27, 2012, *Designing for Impact III: Workshop on Building the National Network for Manufacturing Innovation* was held in Irvine, California. The purpose of the meeting was to engage representatives from industry and academia and to solicit their input in defining the role and scope of the IMIs. Four dialogue topics were addressed:

- Technologies with Broad Impact
- Structure and Governance
- Strategies for Sustainable Institute Operations
- Education and Workforce Development

In discussing the focus of the IMIs, workshop participants positioned regional resources and industry needs as key criteria. They stressed the importance of determining what a region required from an IMI as well as what infrastructure or expertise the region had in place to catalyze an IMI; and they focused on the need to define the technologies that industry could best support as well as those areas where industry could benefit from assistance. A powerful refrain among participants was the importance of addressing SME concerns in order for the initiative to succeed.

Structure and governance discussions centered around the question of having a standardized structure and policies that could be applied across the IMIs. This approach would streamline functionality within individual IMIs and facilitate interactions between IMIs. SMEs remained a factor in participants' conversations, with many voicing concerns about the degree to which the needs of SMEs will be represented at the highest governing levels. Additionally, the question of "Who owns the intellectual property (IP)?" resounded throughout the discussions. IP ownership will be a defining element of the IMIs. As one participant noted, "It is critical that that intellectual property rights get sorted out in a way that is not only acceptable, but attractive to corporate partners."

In debating the question of how make IMIs self-sustaining, participants introduced a number of concepts for moving beyond federal support to generating income from within. However, more than one participant wondered if the IMIs need to be self-sustaining. "What if [through the IMIs] a manufacturing ecosystem is established along with associated jobs? Once that happens, the Institutes could be declared a success and then shut down." This raised questions about the long-term role of the IMIs. To use a medical analogy, are they best used to jump-start the heart of the U.S. manufacturing sector, or must they act as a pacemaker to support manufacturing over time?

The final dialogue explored ways in which IMIs could drive education that addresses industry needs and leads to workforce development. Participants felt that the negative perception of manufacturing—that it's just for the "knuckleheads," as one participant put it—is a significant barrier to reviving the industry that must be changed. Most stated that the best means of doing so is to begin seeding relevant education into the school system from the start. "K to gray" was a rallying call that emphasized the importance of building industry-relevant skills and generating enthusiasm for the industry at every educational level.

There were clear points of agreement across the dialogue discussions. In order for manufacturing to be revived and to thrive in America, a new generation of manufacturers is needed. The IMIs must attract talented new workers into the field who will not only benefit from the resurgence in job opportunities but who can eventually lead the industry forward using emerging technologies better explored and mastered in academic environments than on the job. To achieve this goal, emphasizing manufacturing within our education system is imperative. Fortunately, the IMIs are uniquely positioned to serve as the link between industry and educational forums.

But that isn't enough. Change must take place at the government level as well. Countries that have prioritized the manufacturing sector—such as China, Korea, and Germany—not only teach relevant materials in their schools, they invest government funds in manufacturing over the long term. U.S. investment in the NNMI is an important starting place for the country to begin recovering its leadership position in the field.

An equally vital starting point is in the hearts and minds of the American public. As mentioned earlier, many of the participants in the workshop spoke about the negative perception Americans—particularly young Americans—have of manufacturing. It's critical to change that perception, they agreed. "We need to define manufacturing as the process or system by which scientific discoveries and technological advances are converted to useful products for humanity," stated one participant. Only when that link between the unique abilities of the manufacturing industry and the daily lives of Americans is established can the U.S. move forward toward embracing the critical role that manufacturing must play in its future.

Dialogue 1: Technologies with Broad Impact

Across the Dialogue 1 sessions, participants discussed the ongoing problem of getting technology out of the lab and into the hands of consumers. Initially, several wondered why the group thought that government intervention could accomplish what the free market has been unable to do. But as they debated the scope and role of the IMIs, a palpable belief in the potential of the initiative emerged. A range of technologies could provide appropriate avenues for development of the Institutes for Manufacturing Innovation (IMIs, also known as "Institutes"), with meaningful returns to the regions. A critical question will be the relationship between IMIs and small- and medium-sized manufacturing enterprises (SMEs): if the IMIs can support both the needs of big business and the potential of SMEs, a radical shift in the American manufacturing frontier might be realized. Finally, participants stressed the role of design in the manufacturing world. Both engineering design and industrial design are critical to manufacturing breakthroughs. Participants suggested that any proposal regarding an area of focus for the IMIs should address design as well.

1. What criteria should be used to select technology focus areas?
Participants explored a number of criteria for establishing the areas of technology on which the IMIs should focus. Regional resources, industry needs, and SME solutions were considered crucial.

Table 1.1: Criteria for Selecting Technology Focus Areas

1. ***Regional needs***: What manufacturing exists in the region, and what technology does it support (or could it support)? What is the greatest need in the region? Does the region have a robust supply chain infrastructure in place?
- ***Manufacturing ecosystem***: The technologies should encompass a complete supply chain for the region, or go even further to pull together the manufacturing ecosystem, including suppliers, customers, and regulators.
- ***SME impact***: The technologies must reach out to, and support, SMEs.
- ***Outsourcing resistance***: The technologies must be resistant to outsourcing. Korea and Germany use technology that cannot be outsourced.
- ***Flexibility***: The technologies should have applications across industries
- ***Cross-fertilization***: The technologies should encourage interaction, cooperation, and opportunities among industries.
- ***Workforce preparedness***: The technologies being developed should have an existing workforce in place in the region that is trained and ready to work
- ***ROI potential***: The key criteria should be simple: return on investment (ROI) and the amount of time until ROI is observed.
- ***Problem-solving capacity***: The technologies should help manufacturers address existing problems.
- ***Strategic focus***: The technologies should be strategic for the region or the U.S.
- ***Industry need***: The technologies should address a clear industry need, evidenced by industry's willingness to invest in the technologies.
- ***Job generation***: The technologies should lead directly to jobs creation
- ***IP***: The technologies should generate intellectual property (IP).
- ***Government support***: The technologies should be ones the government will

invest in, as it invested in solar and wind for the energy sector.
- ***Scale***: The technologies should demonstrate a potential for large-scale production.

Participants wondered whether there should be two separate focal points for each Institute: one aimed at developing startups or emerging technologies, the other—representing the lion's share of the budget—driving Technology Readiness Level (TRL) and Manufacturing Readiness Level (MRL) 4-7 initiatives.

Given the recurring theme of SME support, participants suggested that the National Network for Manufacturing Innovation (NNMI) identify "shared points of pain" for both large corporations and SMEs, that is, areas of mutual need that the IMIs could address. These points of pain could be identified through a survey.

Competitive realities were another important aspect of the discussion. The U.S. has more strict environmental regulations than do some of its key competitors. For example, U.S. facilities are prohibited from using certain lubricant additives that enable the production of motor-drive actuators and gearboxes. A question raised was whether IMI's could concentrate on developing alternative materials such as "green lubricants" that would enhance U.S. competitiveness.

Suggested model: Fraunhofer-Gesellschaft in Germany. Set up with a similar mission to the IMIs, participants suggested that the NNMI would do well to examine Fraunhofer successes and challenges.

2. What technology focus areas that meet these criteria would you be willing to co-invest in?

Table 1.2: Co-Investment Areas

- ***Advanced manufacturing***, such as printing techniques
- ***Amorphous metals manufacturing***, as these have applications across multiple fields, from aerospace to consumer (iPhones)
- ***Biomanufacturing***, including medical devices, tissue engineering, and synthetic biology
- ***Composite materials manufacturing***, which meet the needs of multiple industries
- ***Conventional manufacturing*** to keep industry and production in place
- ***Energy-conversion technologies manufacturing***
- ***Large-scale manufacturing***
- ***Laser manufacturing*** to offer unique functionalities
- ***Nanotechnology manufacturing***, as it has widespread application
- ***Prototyping***, which could become an area of IMI ownership
- ***Robotics/autonomous systems manufacturing***

An overall focus of group discussion was on technologies that could help the U.S. become self-sustaining, such as energy, medicines and medical devices, food production, and transportation. Participants also stressed the need to invest in technologies that cannot be imported, such as large-scale manufacturing focused on buildings or roads.

A key area of discussion was whether to prioritize returning outsourced jobs or areas of expertise to the U.S., or to concentrate on developing new initiatives and technologies. For example, participants stated that machine manufacturing is challenging in the U.S. today, as companies that cast, grind, and machine have moved to China. Is it worth the effort to attempt to attract these capabilities, or should the focus be on innovating new technologies that can be wholly U.S.-owned?

3. What measures could demonstrate that Institute technology activities assist U.S. manufacturing?

Table 1.3: Measures for Determining the Positive Impact of Institute Activities on U.S. Manufacturing

- ***Jobs creation***: Number of new jobs created in manufacturing-related industry
- ***Jobs retention:*** Number of jobs retained or returned to the U.S.
- ***Unemployment reduction***: Decrease in applications for unemployment benefits, especially in IMI regions
- ***Lower need for federal support***: Decrease in requests for federal support from companies or entire industries
- ***Startup/SME increase***: Number of startups or SMEs in IMI-related industries

Measures for demonstrating the impact of Institute technology activities on U.S. manufacturing are somewhat personal in scale. The focus for the individual is on employment: whether people have jobs to seek or can retain their existing jobs, and whether they can decrease their reliance on state unemployment benefits. The focus for business is similarly individual, noted by a decrease in need for federal support or an increase in company growth. This suggests that the NNMI has the ability to make an impact on the lives of Americans throughout the IMI regions in a meaningful, measurable way.

4. What measures could assess the performance and impact of Institutes?

Table 1.4: Measures for Assessing the Performance and Impact of IMIs
• ***Product development:*** Number of new products generated in U.S. • ***IP generation:*** Number of patents applied for within IMI-related industries • ***Student attraction:*** Number of graduating students absorbed by IMI-related industries • ***Student-to-faculty ratio:*** Number of students pursuing IMI-related study • ***Academic focus:*** Shift in curriculum among industry-related academic programs • ***Investment:*** Amount of private capital invested in industry or dollars directed to IMI-related industries by investment bankers • ***Proposals:*** Number of proposals submitted to IMI sites • ***New factories:*** Number of factories opened in IMI regions or related industries • ***Jobs creation***: Number of new jobs developed or individuals hired at IMI sites • ***Sales:*** Increase in sales in IMI regions or businesses • ***Startup/SME increase***: Number of startups or SMEs in IMI-related industries

Simply put, the success of IMIs will be measured in terms of flow of people into available jobs, of students into industry, of money into industry and IMIs, of ideas turned into actualized products. Currently, manufacturing is at a standstill in America. For the nation to regain a global leadership position, movement has to begin again across all aspects of the industry.

Dialogue 2: Institute Structure and Governance

The structure and governance dialogues got to the heart of how the IMIs might function. While there was support for a cooperative approach to functionality and governance, especially as that would appear to be an ideal scenario for SME involvement, some participants felt that an absolute hierarchy, both in terms of decision making and governance, is critical to the success of any endeavor as large as the IMIs. Most participants agreed that a standardized structure (and processes) across IMIs was needed to facilitate shared knowledge, best practices, and workflow. The roles of large corporations versus SMEs was intensely debated, focusing on the question of whether small business could have a significant voice in the overall process or whether a concentration on big business was necessary to create a value chain that would benefit all.

An additional area of concern was the potential contradiction between the goal of the IMIs and the nature of government. "How can the IMIs do what they need to do—provide space for ideas to flourish or fail—when Congress is risk averse?" One participant pointed out that all of Thomas Edison's businesses failed (except GE, which was taken away from him), yet his innovations were unparalleled. The structure of the IMIs needs to be flexible enough to support the realities of manufacturing innovation: that for one great idea to flourish, a thousand ideas must be tried and allowed to fail. But participants wondered whether a federal backer could afford—literally and figuratively—to let this happen.

1. What business models would be effective for the Institutes to manage business decisions?

Table 2.1: Proposed Business Models

- **National access network**: Provides access to tools, technology, and machines that members might not have on hand individually. Particularly beneficial to SMEs, models for this concept include Fab Lab, TechShop, and SemaTech.
- **Fee for service**: Under this subscription model, members would pay to join the Institute and so gain access to resources including materials, partnership potential, IP, structure, and governance. Very similar to the proposed national access network concept but less skewed toward SME needs.
- **Open source**: A collaborative resource through which institutions work to uncover and establish standardized processes to create best practices that can be shared across institutions and industries.
- **Academic partnerships**: Based on successful collaborative ventures between academia and industry used at Cambridge University, University of California at Berkeley, and the Massachusetts Institute of Technology, this concept features shared technology and unites researchers with developers. Enables an idea to move from initial concept and design through prototype to the point where a commercial entity can produce it on a large scale.
- **Applied research**: Following the Fraunhofer-Gesellschaft model, this concept brings together researchers, developers, designers, creative visionaries, producers, and manufacturers to realize products that meet a spectrum of national and commercial needs.

- **Business model**: This approach would feature primary stakeholders (investors), smaller companies, and a management staff from academia and industry. The goal would be to facilitate technology transfer between industry and academia. Key industry members would integrate information from their groups with the overall Institute in order to share information, establish accountability, and define metrics. A technology road map would be created and followed to provide structure.
- **Central hub**: Under this approach, one Institute would be nominated to act as a business-decision hub, determining IMI activity and brokering work into and out of the other 14 Institutes.
- **Non-profit association**: This model could allow the IMIs to develop technology with more weight given to innovation than profitability, and with a greater opportunity to share knowledge, best practices, and IP with industry
- **Distribution center model**: Would permit IMIs to invest in technology development specifically rather than bricks and mortar.

Existing models cited by participants included Fab Lab, TechShop, SemaTech, Fraunhofer-Gesellschaft, Joint BioEnergy Institute, and Cambridge Enterprises. Participants agreed that regardless of the model, flexibility is an imperative element in developing the IMIs as they must be able to meet the needs of industry in their individual regions and evolve as they transition from federally funded projects to private enterprises.

2. What governance models would be effective for the Institutes to manage governance decisions?

Table 2.2: Proposed Governance Models

- **"Hub and Spoke"**: This approach would introduce a Board of Directors to oversee multiple industry-related subgroups. The subgroups would manage or supervise industry-specific activities, then report back to the Board of Directors regarding their activities in order to promote information sharing and best practices across Institutes.
- **Cooperative and collaborative**: Concern about SME representation led participants to suggest a more cooperative governance structure. In this model, SMEs would be fully represented at the governing level and stakeholders would be held accountable for decisions. Advisory boards or a guidance council would provide input to the governing board in order to avoid favoritism. This model encourages collaboration, which leverages an important strength of the IMI program.
- **Two-pronged approach**: Because the Institutes must be both self-sustaining as well as technology developing, participants suggested two governing or advisory boards: one that addresses issues surrounding sustainability (including financing), the second concentrated on the work, ensuring the Institute delivers on its primary objective of driving manufacturing.
- **Vertical governance**: This model advocates creating a lean structure to avoid complications and provide critical focus. The Director would have full control, working with the advisory board and governing the Institute.

The topic of governance raised red flags among SME proponents. Many were convinced that governance would favor large corporations because those corporations would provide greater financial support to the IMIs than SMEs could. However, a cooperative governing structure worried others, who wondered if such a model would be effective or could distract from the ultimate goal of the IMIs: to promote technology development and production.

3. What membership and participation structure would be effective for the Institutes, such as financial and intellectual property obligations, access, and licensing?

Several different membership models were discussed, including a tiered membership structure, a fee-for-service structure, an open structure with multiple options for purchase, and stakeholder membership.

The key concern among participants during these discussions was, "Who owns the IP in a collaborative structure?" IP is a motivating factor across industries and academia. *Owning the idea* drives researchers; *making something work* drives producers. Allowing Institute members to achieve these goals despite the inherent question of IP ownership will be critical to the success of the Institutes.

IP is also valuable to the Institutes themselves. If the IMIs retain the rights to IP, they can employ user fees to make the Institutes self-sustaining. Furthermore, Institute-owned IP makes the technology or technique available to all, which will benefit manufacturing in general.

One suggested approach was to foster research within the universities, then use the Institutes to turn those ideas into marketable products. Participants suggested that in this instance, the companies that produced the product would keep the IP rights. But not all participants agreed this would solve the problem.

It became clear that figuring out IP issues be a defining element of the IMIs. As one participant said, "It is critical that that intellectual property rights get sorted out in a way that is not only acceptable, but attractive to corporate partners."

4. How should a network of Institutes optimally operate?

The industries should function as a hub to document and share protocols, resources, human capital, procedures, and communications. They would be used as a "knowledge tool" library for academia, industry, and government.

Many felt that it was important to establish an overall structure as well as standard procedures for all Institutes to follow in order to facilitate focus and progress. This could foster a positive competitive atmosphere that spurs member to challenge themselves while promoting the sharing of best practices. There was agreement that the sharing process must be formally instituted or it won't occur. Sharing is important, as it will help avoid effort duplication across or within Institutes.

Participants suggested creating a “Coordination Institute”: a center—funded at a lower rate—designed to keep track of everything that occurs across the Institutes. It would track all activities and centralize information so that members could access what they need at any time. The desire to nominate a central Institute that tracks information and processes or make decisions about business or governance was repeated throughout the Dialogue 2 sessions. Participants felt strongly that having a “Coordination Institute”—regardless of what it’s called—would increase the functionality of the IMIs while facilitating the “real work” (which would take place at the remaining IMIs): developing ideas, putting them into production, and bringing them to the world.

5. What measures could assess effectiveness of Network structure and governance?

Table 2.3: Measures to Assess Effectiveness of NNMI Structure and Governance

- Economic development and manufacturing jobs creation as seen across the U.S. or in IMI regions
- Self assessments, performed pre- and post-project, to determine if objectives were met
- Amount of reinvestment into Institute
- IMI membership growth
- Ability to attract outside capital and investment
- Increase in academic enrollment or graduation in industry-related fields
- Increase in exports or buyers of product
- Number of students trained by IMIs and then hired by companies
- ROI, revenues, profit
- IP generated, licensing deals

Dialogue 3: Strategies for Sustainable Institute Operations

In discussing the transition from the public sector to the private sector, an ongoing question among participants was how the IMIs should be used. One participant said he wasn't excited about running a user facility; he felt the strength of the IMI proposition was in the collaborative opportunities. Yet charging fees for the use of IMI facilities is a straightforward means of generating profitability to achieve financial independence.

Some participants questioned the need for IMIs to be self-sustaining. In certain countries, the manufacturing sector receives significant government support. Furthermore, several participants expressed the view that keeping the government involved would prevent the IMIs from being controlled by larger stakeholders, helping preserve the power of the SME voice in the Institutes.

Additionally, participants wondered whether the need for IMIs to be financially viable would override their ability to foster innovation by splitting their focus.

1. How should initial funding co-investments of the federal government and others be organized by types and proportions?

Table 3.1: Approaches to Organizing Initial Funding for Institutes

Structured federal funding:
For example:

- Start with 100% federal funding.
- Move to 90% for months 12-23.
- Shift to 75% for months 24-35.
- Reduce to 50% at month 36 and beyond.

Funds for usage:

- Charge subscription rates to companies or use a time-slice structure in which companies pay for the time they use Institute resources.

Industry funding:

- In addition to subscription rates or time-slice pricing for companies, industry associations should provide funding.

Business model funding:

- Accept investments (i.e., contributions) from interested parties, but also sell the services of the Institute, the products produced, and commercialize the R&D.
- Licensing is a critical part of this strategy.

Scaled industry and academic funding:

- Large corporations would contribute a specified, substantial amount.
- Small companies would give a percentage of their revenue.
- Universities would match funds at a pre-defined rate.

Mixed funding sources:

- Solicit government grants/funds.
- Offer yearly subscriptions to industry.
- Create a time-slice opportunity for individual companies to use IMI resources.

Limits-based funding:

- No more than 25% contributions from industry
- No more than 40% in state funding
- No more than 30% exclusively focused on education
- No more than 5% other

The rationale behind this approach is to ensure that Institute funding is not overly weighted in any direction so that the IMIs are free to evolve to meet market needs rather than funding obligations.

The most commonly suggested approaches were structured federal investments and business-model funding. Nonetheless, many participants questioned the need to phase out federal funding over time, as they think federal support plays an important role in the lifecycle of the Institutes. Other nations—ones with ongoing and significant investment in making manufacturing a national priority—continually fund manufacturing R&D. Participants questioned the wisdom of removing the U.S. government from the manufacturing equation at all.

2. What arrangements for co-investment proportions and types could help an Institute become self-sustaining?

Table 3.2: Approaches to Organizing Co-Investments to Help Institutes Become Self-Sustaining

- **Plan for federal phase out**: Begin with government funding supplemented by local industry investments to cover operating costs and materials, but plan to shift away from federal funding by a specified date.
- **Institute a co-sharing structure**: 70% of the proceeds from technology or techniques innovated through an Institute is returned to it, while 30% is given to members.
- **Implement downstream reinvestment**: Ensure the Institutes receive a fee or percentage from all successful technologies developed through their program. A variation on this approach is through licensing agreements, which could be critical to Institute success.
- **Focus on the bigger opportunity**: Emphasize TRL 4-7 to maximize return as quickly as possible.
- **Promote new investments**: Once technologies begin to emerge from the Institutes, capitalize on investment bank interest to promote investment
- **Introduce a 50/50 funding structure**: Government contributes 50% of funds while industry contributes the other 50% and pays a fee for use of Institute resources.
- **Create a local advanced prototyping shop**: Along the lines of UC Irvine's Rapidtech, this approach would ask users to pay for access to Institute

resources. Could also charge training fees to students (high school, community college, university) and the workforce.

Participants explored a number of approaches, many of which built on their initial ideas for organizing funding for the Institutes. A key question remained about the self-sustaining element. “Do the Institutes have to be self-sustaining?” asked one participant. “What if a manufacturing ecosystem is established along with associated jobs? Once that happens, the Institutes could be declared a success and then shut down.” This raised a broader question: what is the long-term role or goal of the Institutes? Are they conceived to become a permanent fixture in the U.S. manufacturing landscape or should they serve to jumpstart the U.S. manufacturing ecosystem and then be discontinued?

3. What measures could assess progress of an Institute towards being self-sustaining?

Table 3.3: Measures Assessing Institute Progress Toward Being Self-Sustaining

- Jobs creation
- New products developed
- Patent applications
- Value added: product enhancement due to Institute initiatives
- Training, as measured by student enrollment or graduation numbers
- International involvement
- Revenue, market share
- Number of startups transitioned into established companies
- Amount of non-government funding directed at Institutes

Measures for assessing IMI progress toward sustainability reflect growth in the manufacturing sector overall. Progress may differ by region; also, it may be easier to note increases in one area (jobs creation, for example) than another (such as value added). Altogether, however, there should be many different means of assessing IMI progress toward financial independence.

4. What actions or conditions could improve how Institute operations support domestic manufacturing facilities while maintaining consistency with our international obligations?

Many of the participants stated that the emphasis should remain firmly on developing the U.S. manufacturing ecosystem rather than considering international factors. Some stressed the need for the U.S. to provide tax incentives for R&D in order to create a domestic advantage. A few participants said that the U.S. government should put pressure on foreign countries to adopt similar regulations to those enforced in the U.S. as a means of making U.S. manufacturing companies more competitive.

Clearly defining the charter of the Institutes is one method of reinforcing Institute support for domestic manufacturing endeavors. Also, Institutes could engage with foreign companies to entice them to invest in the U.S. while filling gaps in the supply chain. Finally, a more modest approach could be successful: encourage or incentivize U.S. manufacturer involvement without restricting global participation. This, one participant believed, is most likely to establish a position of global leadership for the U.S.

5. How should Institutes engage other manufacturing-related programs and networks?

Table 3.4: Methods for Engaging with Other Programs or Networks

Through collaboration:

- Encourage collaborative funding of projects.
- Seek out collaborative and interdisciplinary research.
- Contracts: Encourage all local companies to have one contract with the Institute.
- Advocate for regulatory changes that benefit all.

Through teaching or training:

- A membership requirement should be to reach out to industry and academic partners.
- Institutes should sponsor training initiatives that are open to other programs and networks.
- Institutes should sponsor professional development programs for local communities.
- Institutes should offer problem-solving services based on best practices/shared knowledge arising within the IMIs.

Through conferences and societies:

- Engage technical societies, perhaps through reciprocal membership agreements between societies and Institutes.
- Attend industry conferences to make connections and share concepts.
- Create/host an annual conference highlighting Institute accomplishments.

6. How should Institutes interact with state and local economic development authorities?

Participants stated that the Institutes should serve as the region's first line of technological information. State and local economic development authorities should turn to the Institutes for details and resources regarding regional manufacturing issues and solutions. Institutes should be able to approach state and local authorities to discuss means of improving the regional regulatory environment. Institutes should also support state and local concerns, for instance by connecting with community colleges to create training or other programs.

Some participants felt that state and local authorities should be Institute advocates, either by providing funding or tax incentives. They should also take a role by actively enticing industry to the region, and should support local startups by providing low-cost land, buildings, and/or equipment.

7. What measures could assess Institute contributions to long-term national security and competitiveness?

Table 3.5: Measures to Assess Contributions to Long-Term National Security and Competitiveness
• Number of products incorporated into Department of Defense and intelligence community systems • Increase in private investment dollars • Change in perception about the role of manufacturing in the U.S. • Increased technology production • Increase in patent applications • Growth of supply chain; in particular, an increase in percentage of domestic participation in supply chain

Dialogue 4: Education and Workforce Development

Workshop participants wholeheartedly agreed on one point: Americans have a negative perception of manufacturing. When they think about manufacturing—if they do at all—most people picture loud, dirty facilities and dead-end jobs. In schools, the best students typically move into business or finance while, as one participant employed in the industry said, "The knuckleheads go into manufacturing."

To revive manufacturing in the U.S., it is critical to re-focus the American perception of the industry. Americans need to see the high-tech plants of today, the realities of data-driven manufacturing, the application of machine robotics and simulation software. They need to understand that manufacturing is a demanding and technical profession that requires distinct skills and knowledge.

Reeducating Americans about manufacturing—and preparing new generations for careers in the industry—must begin at a young age. As participants noted, education relevant to manufacturing should span "K to gray." This doesn't mean that everyone interested in becoming part of the industry workforce must go to college. Certification programs can provide needed skills to students less interested in academics. Community colleges can play a critical role in training and developing a workforce. But wherever the students are, from the very young to those pursuing the most advanced degrees, education that introduces them to the concepts involved in manufacturing, that excites them about the work done by engineers or designers, and that prepares them to enter the manufacturing workforce should be available. According to participants, that will require a significant change in today's education system.

1. How could Institutes support advanced manufacturing workforce development at all educational levels?

In order to revive American manufacturing, it is necessary for industry to establish a presence across the education spectrum, from grade school through graduate school. Such a plan faces challenges, including the fact that basic math and reading skills are poor in the U.S., with adult literacy halted at the seventh-grade level. Since much work in the manufacturing sector is highly technical, a good education is critical. Nonetheless, participants proposed a range of ideas for integrating education with workforce development to prepare the country for a manufacturing renaissance.

Table 4.1: How Institutes Could Support Workforce Development at All Levels: Overview
• **Provide hands-on learning** • **Incorporate technology** • **Sponsor competitions** • **Guide curriculum development** • **Provide teacher certification**

- **Develop online programs**
- **Donate lab equipment**
- **Create "tech scouts"**
- **Offer training**

Hands-on learning is impactful
This approach plays a critical role in engaging the potential workforce at a young age. "That's how kids learn," said one participant. Whether through field trips to a manufacturing facility or virtual class "visits" to an off-shore drilling rig, students need to see, smell, and touch (literally or virtually) the experience to make it real. By bringing the world of manufacturing into the classroom experience, manufacturing can begin to establish a presence in young minds in a positive way.

Technology is a powerful tool
For students in junior high and high school, technology makes learning "cool," which gives it a meaningful advantage in engaging students. For younger children, **robotics** is especially impactful. Participants suggested that a manufacturing company could host a robot event at a school or create a child's manufacturing center to connect with children at a young age. If there isn't time during the traditional school day to incorporate manufacturing-related events or education, after-school programs—such as the Rocket Science Tutors—could be offered, using volunteer retirees from industry or academia.

For older students, **simulation** is both an effective and exciting learning tool. Computational simulations or 3D exploration can turn learning into a video game, which is an excellent means of interacting with students "where they're at." Simulation can also provide meaningful training to those ready to enter the workforce.

For students of all ages, **social networking** can expose Americans to the ways that other nations incorporate manufacturing-relevant work into the classroom. U.S. schools could partner with learning institutions in Germany that have a manufacturing focus, using social networking (including YouTube) to bring the experience to life.

Competitions generate awareness and encourage excellence
Math and science competitions are exciting ways of encouraging students to focus on manufacturing-relevant fields. Unfortunately, entrance fees for some competitions can be prohibitive, limiting the number of students who can participate as well as the types of schools involved. Institutes could play a crucial role by paying the entrance fees to assist students. In addition, if schools applied directly to Institutes for these "fee scholarships," that interaction could build relationships supporting future joint programs.

Curricula and teachers are critical
To integrate industry with education, **curriculum planning** and development is needed. Institutes can help educational facilities reach out to industry before establishing the curriculum so that the resulting classes are more relevant to manufacturing. In addition, **teacher certification** could be linked to funding. Institutes could help develop industry-sponsored teacher certification programs that require teachers to expand their learning about industry-relevant topics in return for grants.

The online solution
Participants felt strongly that education geared toward manufacturing is ideally suited to the online environment. Students could proceed at their own pace through the learning modules and then exhibit mastery of the information through testing. This could lead to online matching with internship opportunities that further the students' education. This approach conserves resources while expanding educational opportunities to anyone with access to the internet.

Additional education-oriented roles for Institutes
On a practical level, Institutes can provide **lab equipment** to schools through grants or by delivering hand-me-downs from industry. Institutes can sponsor "**tech scouts**" who go into the academic arena to identify students with an interest in manufacturing-relevant fields and guide their education. Finally, Institutes can provide a **forum for people to train** for jobs in manufacturing.

2. How could Institutes ensure that advanced manufacturing workforce development activities address industry needs?

Table 4.2: Aligning Workforce Development Activities with Industry Needs

- **Change perceptions**: Institutes must take a leadership role in educating the public about what manufacturing involves, the education required, and the career potential.
- **Emerging technologies**: Institutes could encourage schools to offer classes in emerging technologies so that the graduating workforce can move industry forward.
- **Local sponsorship**: Industry could provide some of the equipment for school labs, helping focus education on industry-relevant subjects.
- **Advisory capacity**: Industry members could join advisory boards to help guide curricula.
- **Internships**: Institutes could facilitate internships for high school or college students in manufacturing facilities. Working with local schools and universities to arrange college credit for long-term internships would further advance the potential for students to get involved in industry.
- **Specialized skills**: Institutes could help shape curricula so that students are taught skills that are relevant to the manufacturing field, such as problem solving or broad thinking. Approaching problems from different perspectives is critical for many of the careers involved in manufacturing, yet is often not taught in schools
- **Faculty focus**: Institutes could prompt individuals with industry backgrounds to become faculty members at local high schools, community colleges, or universities. "Educators should know how to run a machine" is the way one participant put it.

3. How could Institutes and the NNMI leverage and complement other education and workforce-development programs?

Table 4.3: Means of Leveraging and Complementing Other Programs

- **Shift perceptions to benefit all**: As stated previously, one barrier to developing a workforce is common misconceptions about manufacturing. Institutes could facilitate factory-based internships to emphasize that the manufacturing environment can be a learning environment. This will benefit all manufacturing-focused education and workforce-development programs, not just the Institutes themselves.
- **Provides access to needed resources**: Other groups may have training programs in place but lack key resources such as equipment. Institutes can support their efforts by offering access to Institute resources.
- **Act as an information hub**: IMIs can serve as resources for students, offering information about training programs, internships programs, and other educational opportunities, including those not offered by the Institutes directly.
- **Become community activists**: Institutes can go out into the community—for instance, to community colleges—to offer training programs or inform students about opportunities in the manufacturing field as well as the associated educational requirements.
- **Create a third space**: Institutes can use creativity and innovation to identify opportunities for education outside of schools or universities. It may be possible to repurpose old or abandoned warehouses as training facilities or to encourage retired professionals to volunteer to be instructors.
- **Mentoring**: Institutes are in an ideal position to establish mentoring programs that complement the work done by other groups or schools.

Participants felt that this discussion was imperative as manufacturing-related programs are disappearing from schools and professors are leaving schools that offer manufacturing degrees. Institutes need not reinvent the wheel by starting training programs from scratch: they can be advocates, sponsors, or partners in resuscitating existing programs in need. The introduction of the IMIs will generate awareness of the need to focus on manufacturing in our schools and should generate interest in the field. The Institutes can then work with existing programs to capitalize on the new focus on manufacturing in America.

4. What measures could assess Institute performance and impact on education and workforce development?

Table 4.4: Means of Assessing Institute Performance and Impact on Other Programs
• Track ideas as they transition into the marketplace, noting the origin. • Measure the degree of student participation in science, engineering, math, and technology competitions. • Assess the number of students enrolled in relevant programs as well as the number of graduates from relevant programs. • Look at job placement for students moving from educational institutions to industry positions. • Determine the number of patent applications. • Assess certification levels in relevant fields. • Examine student drop-out rate. • Track industry-relevant mentoring requests from schools. • Look at graduate success 5 and 10 years after entering industry. • Compare the evolution of course curricula with industry training requirements over time.

The Vital Signs program found at www.changetheequation.org offers guiding principles for learning more about the impact of increased emphasis on science, technology, engineering, and mathematics in schools. IMIs should explore these principles to identify any with relevance to Institutes.

5. How might Institutes integrate R&D activities and education to best prepare the current and future workforce?

Table 4.5: Means of Integrating R&D Activities with Education
• Host “road shows” to highlight the relationship between current R&D and educational opportunities. • Offer hands-on 3D or robotics training for students, generating excitement while remaining educationally relevant. • Study how schools in Germany or Japan incorporate manufacturing-relevant teachings into their education systems and apply findings to the U.S., with a focus on R&D activities. • Invite schools into manufacturing facilities either in person or through virtual experiences. • Create a school-focused online newsletter highlighting current R&D activities. • Encourage project-based learning that reflects R&D objectives.

- Initiate a national campaign to define manufacturing and create interest in the field by focusing on emerging R&D activities.
- Facilitate corporate-sponsored programs in the classroom.
- Sponsor monthly school-based seminars and exchanges with industry.
- Serve as the link between industry needs and educational forums.
- Foster opportunities for deserving students to be placed into R&D as part of corporate internships.
- Harness schools or specific classes as "industry problem solvers" who take on tough R&D challenges and work toward innovative solutions.
- Create "development boards" at schools, in which students critique R&D proposals as part of their class assignments.
- Fund "sabbaticals" for industry workers to teach in schools (at any level)—and for academics to work in industry.

Throughout the discussion surrounding this question, participants stressed the need to educate Americans overall about what manufacturing is, how it is relevant to students, and the varied career options in the field. Without this crucial step, an increase in educational opportunities may go unnoticed or unsupported. Fortunately, the introduction of the IMIs will serve as a powerful public relations vehicle to raise awareness of the critical role of manufacturing in the economic future in America. It is up to the Institutes and the NNMI to capitalize on this awareness in order to realize a meaningful impact on education and workforce development.

Appendix A: List of Acronyms

AMNPO	Advanced Manufacturing National Program Office
GUIRR	Government-University-Industry Research Roundtable
IMI	Institute for Manufacturing Innovation
IP	Intellectual Property
MRL	Manufacturing Readiness Level
NAE	National Academy of Engineering
NAMII	National Additive Manufacturing Innovation Institute
NIST	National Institute of Standards and Technology
NNMI	National Network for Manufacturing Innovation
R&D	Research and Development
RFI	Request for Information
ROI	Return on Investment
SMEs	Small- and Medium-Sized Enterprises
STEM	Science, Technology, Engineering, and Mathematics
TRL	Technology Readiness Level
UIDP	University-Industry Demonstration Project

Appendix B: List of Participants

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Appendix C: September 27, 2012 Workshop Agenda

9:00 am **Registration and Light Refreshments**

Plenary Session

10:00 am ***Call to Order***

Robert Ivester, Department of Energy Advanced Manufacturing Office

Welcoming Addresses

National Academy of Engineering
Donald A. Norman, Cofounder of the Nielsen Norman Group

GUIRR and UIDP
Wayne Johnson, Assistant Vice President for Institute Corporate Relations

University of California (UC), Irvine
Michael V. Drake, Chancellor

NASA Jet Propulsion Laboratory
Lew Soloway, Deputy Division Manager
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Keynote Addresses

Advanced Manufacturing and the Federal Perspective
Jason Miller, Special Assistant to the President for Manufacturing Policy
White House National Economic Council

Framing the Challenge
Mike Molnar, Director, Advanced Manufacturing National Program Office

Regional Perspectives I
Why Manufacturing Matters to California
Perry Wong, Director of Research, Milken Institute

Lunch Program
11:50 am **Lunch and Networking**

Regional Perspectives II: ***Challenges and Solutions for Sustainable Engagement Across the Manufacturing Ecosystem – A Panel of Regional Leaders***

Featuring:

- Anthony Boccanfuso, Executive Director, National Academies' University-Industry Demonstration Partnership *(Discussion Leader)*
- Dianne Chong, Vice President, Assembly, Factory and Support Technologies, The Boeing Company

- Pamela Kan, President, Bishop-Wisecarver Corporation and Chair, California Manufacturers and Technology Association Board of Directors
- Edward Tackett, Director, RapidTech
- Brian Wong, President and Chief Executive Officer, Enevate Corporation

1:40 pm **Disperse for Dialogue I period**

Dialogue Period I
1:50 pm **Designing for Impact Dialogues**

- *Dialogue 1: Technologies with Broad Impact*
- *Dialogue 2: Institute Structure and Governance*
- *Dialogue 3: Strategies for Sustainable Institute Operations*
- *Dialogue 4: Education and Workforce Development*

3:00 pm **Break**

Dialogue Period II
3:20 pm **Designing for Impact Dialogues**

- *Dialogue 1: Technologies with Broad Impact*
- *Dialogue 2: Institute Structure and Governance*
- *Dialogue 3: Strategies for Sustainable Institute Operations*
- *Dialogue 4: Education and Workforce Development*

4:30 pm **Return to Auditorium**

4:40 pm **Concluding Remarks and Next Steps**

- Mike Molnar, Director, Advanced Manufacturing National Program Office
- Gregory Washington, Dean of the Henry Samueli School of Engineering, UC Irvine

5:00 pm **Workshop Adjourns**