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

Boulder, CO October 18, 2012

Summary Report

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Acknowledgment
Thanks to everyone who participated in *Designing for Impact IV: Workshop on Building the National Network for Manufacturing Innovation* held on October 18, 2012, at the Millennium Harvest House in Boulder, Colorado. 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 as indicated in Table 1.

Table 1: Four Designing for Impact Workshops

Locations for the four workshops were chosen across the country to lower the barriers to participation in NNMI, maximize the amount and quality of stakeholder input, and ensure that regional industries without a strong presence nation-wide had an opportunity to engage.

April 15, 2012: Troy, NY
July 9, 2012: Cleveland, OH
September 27: Irvine, CA
October 18, 2012: Boulder, CO

This report summarizes stakeholder feedback from the fourth regional workshop held at the Millennium Harvest House in Boulder, Colorado on October 18, 2012. The workshop attracted 134 participants representing a diverse and wide-ranging mix of sectors including:

- 25% from academia
- 34% from industry
- 19% from federal, state, and local government
- 5% from economic development organizations
- 17% from other organizations

A full list of conference participants can be seen in Appendix B.[3]

[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/amp/nnmi.html
[3] A portion of these attendees did not give permission to publish their information in Appendix B

The workshop began with welcoming remarks from Kathleen Hogan,[4] William Farland,[5] and Patricia Rankin[6] to set the stage for discussions throughout the day. Keynote presentations by Ken Lund,[7] Phillip Singerman,[8] and Mike Molnar[9] provided context and background on NNMI to orient participants on the workshop goals and objectives. Keynote topics included an overview of regionally important manufacturing issues and opportunities, a discussion of the relationship between innovation and manufacturing, and a framing of the current NNMI concept and vision. In the early afternoon Drew Crouch,[10] Jason Gies,[11] Naseem Munshi,[12] Kathy Rowlen,[13] and John Vukich[14] provided focused regional perspectives on education and workforce development issues related to advanced manufacturing during an expert panel facilitated by Tim Heaton.[15] The panel was a general session activity and included a follow-up question and answer session to engage participants.

The remainder of the workshop was focused on soliciting feedback from individual participants through a series of 12 dispersed breakout dialogue sections. Each participant had the opportunity to offer their feedback in three of the four dialogue session topics. The primary purpose of these dialogues was to gain insights from academia, industry, non-profit organizations, local and state agencies, and other stakeholders on some of the technical issues regarding the design and implementation of the proposed National Network for Manufacturing Innovation (NNMI).

The dialogues were guided by representatives from the Departments of Commerce, Defense, Energy, Education, the National Science Foundation, and NASA along with a team of facilitators. The primary role of the discussion leaders was to ensure that all voiced ideas, concerns, and recommendations were heard and properly recorded as they were intended, without any consensus building, ranking, prioritization or other bias. Discussions were structured similarly to the past three workshops with a series of leading questions as organized within this report and Table 2 below. The sections below provide a summary of the transcripts generated at all of the 12 discussion sessions held throughout the workshop, and include additional input received in written form from individual participants.

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[4] Deputy Assistant Secretary Energy Efficiency, U.S. Department of Energy

[5] Senior Vice President for Research, Colorado State University

[6] Associate Vice Chancellor for Research, University of Colorado Boulder

[7] Director, Colorado Office of Economic Development and International Trade

[8] Associate Director for Innovation and Industry Services, NIST/U.S. Department of Commerce

[9] Director, Advanced Manufacturing National Program Office

[10] Vice President, Technology, Ball Corporation

[11] Vice President, Firehole Technologies

[12] President and CEO, Composite Technology Development, Inc.

[13] CEO, InDevR

[14] Dean, Economic and Workforce Development, Pueblo Community College

[15] President, Colorado Advanced Manufacturing Alliance

Table 2: Four discussion dialogues

Throughout the course of the workshop, breakout sessions allowed participants an opportunity to discuss four major topic areas related to IMIs: • **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 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.

Executive Summary

The U.S. has long relied on a strong industrial base to lead world markets and drive a thriving economy. Manufacturing firms are important drivers for innovation and account for 70 percent of private sector R&D funding and over 90 percent of patents issued.[16] This innovation leads to new products that improve the way of life for many and creates high-quality jobs and tax revenue in the process. In 2010, manufacturers produced about $1.7 trillion of goods - about 12% of US GDP - and produced 86% of all U.S. goods exports.[17] Furthermore, the benefits of manufacturing are not confined to the industrial sector. For every $1 of manufacturing value added, and additional $1.4 is added in other sectors.[18]

However, the state of the U.S. manufacturing sector has shifted significantly over the past decade. Thirty-three percent of all manufacturing jobs were lost during the 2000s - a job rate loss that exceeds that of the Great Depression.[19] Moreover, real value added dropped 11% between 2000 and 2010.[20] Manufacturing output decreased across the economy with only a few sectors showing positive growth in output.

On March 09, 2012 President Obama unveiled a plan to reverse this trend and spark a renaissance of American manufacturing. His plan called for the establishment of A National Network for Manufacturing Innovation (NNMI) to strengthen the innovation performance, competitiveness, and job-creating power of U.S. manufacturing. In his budget for fiscal year 2013, the President proposed the creation of a network of up to 15 regional Institutes for Manufacturing Innovation (IMIs). Funded by a proposed one-time, $1 billion investment, this network—the NNMI—responds to a crucial competitiveness challenge and threat to future prosperity: Closing the gap between research and development (R&D) activities and the deployment of technological innovations in domestic production of goods.

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[16]Gene Sperling. Remarks at the Conference on the Reconnaissance of American Manufacturing. March 27, 2012. http://www.whitehouse.gov/sites/default/files/administration-official/sperling_-_renaissance_of_american_manufacturing_-_03_27_12.pdf

[17] Bureau of Economic Analysis and Census, U.S. International Trade in Goods and Services.

[18] The Manufacturing Institute. The Facts About Modern Manufacturing, 8th Edition. 2009.

[19] Bureau of Labor Statistics, Current Employment Statistics (manufacturing employment, seasonally adjusted; accessed March 14, 2012), http://www.bls.gov/ces/; Census Bureau, *Statistical Abstract of the United States*: 1941(Washington, D.C.: 1942), http://www.census.gov/prod/www/abs/statab1901-1950.htm. Jobs figures are for January 2000 to December 2010, and 1929 to 1933. From 1929 to 1933, U.S manufacturing employment fell by 31 percent. Through: http://www2.itif.org/2012-american-manufacturing-decline.pdf

[20] Bureau of Labor Statistics, International Labor Comparisons (output; accessed January 18, 2012), http://www.bls.gov/fls/. Through: http://www2.itif.org/2012-american-manufacturing-decline.pdf

According to The Council on Competitiveness, "U.S. manufacturing is more important now than ever." [21] In recognizing the timeliness of this challenge, the President has initiated a pilot effort to help develop the NNMI using limited but available fiscal year 2012 funding. Announced on August 16, 2012, the National Additive Manufacturing Innovation Institute (NAMII) is focused on accelerating additive manufacturing innovation by bridging the gap between basic research and mature development work. This pilot effort will help advance a critical set of manufacturing technologies and inform the development of future IMIs.

On October 18, 2012, *Designing for Impact IV: Workshop on Building the National Network for Manufacturing Innovation* was held in Boulder, Colorado. As the fourth in a series of regional meetings with the same name, this workshop engaged industry, academia, state and local governments, and other stakeholders to solicit feedback on the NNMI effort. This report summarizes participant feedback from this workshop based on the four dialogue topics discussed throughout the day:

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

Within these discussion topics, participants had the opportunity to express their individual opinions on how IMIs should be administered to achieve the greatest benefit for U.S. manufacturers. Comments and suggestions from this and the other Designing for Impact workshops will be considered during the ongoing development of the NNMI.

Within the Technologies with Broad Impact dialogue, participants discussed challenges of commercializing technologies, the scope and breadth of the IMI technical focus, the orientation of IMIs across industry sectors, the impact from investments in various technologies, and the ability of certain technologies to reach a variety of markets. Effective engagement with small and medium sized enterprises (SME) was considered at length in discussions. A list of potential focus areas for Institutes is provided in the main body of this report.

Discussions regarding Institute structure and governance focused on the operational structure of potential IMIs. The most prevalent topics of discussion concerned cost-share arrangements, IMI funding options, time horizons and period of performance, long-term stakeholder roles, and dynamic/changing markets and industries. Considerations for effective handling of Intellectual Property (IP) were seen as a major challenge by many. Participants suggested several business and governance model for consideration the structure of future IMIs.

[21] http://www.compete.org/

Within the Sustainable Institute Operations dialogues, participants focused on the long-term operational considerations of IMIs and the outcomes that might lead to long term benefits. Prevalent topics of discussion concerned cost-share arrangements, IMI funding options, time horizons and period of performance, long-term stakeholder roles, and dynamic/changing markets and industries. IP rights and licensing was also seen as an important factor that will contribute the long-term viability of an IMI revenue stream.

Within the Education and Workforce Development dialogue, participants focused on the near and long-term human capital challenges and the potential for NNMI to provide the solutions that U.S. manufacturers need to become and remain globally competitive. Though discussion was varied, many individual participants expressed similar concerns and challenges related to the topics within this dialogue. Several comments suggested that the workforce aspects of NNMI will be very important, but that it will also be very challenging to adapt current educational systems and reverse negative cultural perceptions of manufacturing.

Dialogue 1: Technologies with Broad Impact

Throughout Dialogue 1 sessions, participants expressed their opinions related to the technical focus of the IMIs. This discussion included a wide range of topics regarding the challenges of commercializing technologies, the scope and breadth of the IMI technical focus, the orientation of IMIs across industry sectors, the impact from investments in various technologies, and the ability of certain technologies to reach a variety of markets. In addition to this broad range of topics, specific technologies and sectors were occasionally discussed in detail by meeting participants. These discussions were generally guided by the set of leading questions distributed to participants as summarized and organized below.

1.1. What criteria should be used to select technology focus areas?

Throughout the discussion a variety of high-level criteria themes emerged as described in Table 3.

Table 3: Selected criteria for technology focus areas

- **Globally relevant**. The technology should be cost competitive, with multiple global markets in addition to being important regionally around an IMI.
- **Enhance complete technology systems**. The technology should enable (technically or economically) other advanced technologies, new types of systems, and new combinations of existing technologies that lead to more efficient production; "systems approach" to technology development.
- **Build upon national strengths and resources.** The technology should support industry and capitalize on national resources to increase global competitive advantage, e.g. capitalize on natural gas resources and improve top US export sectors
- **Adequate availability of "enabling science".** The technology should have an adequate body of research to draw from so that knowledge bottlenecks do not slow technology progress; e.g. advanced materials science is required for additive manufacturing
- **Timeliness**.
    - The commercialization of technology should occur when there is a demand in the value chain for that particular capability.
    - The technology development cycle should correspond with manufacturing equipment lifecycles
    - The technology should lead to impact over the short, medium, and long-term
- **Adaptability of technology.** The technology should be configurable to a variety of product cycles – quickly and at low cost

- **Addresses manufacturing bottleneck.** The technology should address a limiting factor, whether in the manufacturing process, time to market, or supply chain.
- **High compatibility and interoperability.** The technology should lead to predictable and stable platforms, rather than propriety; e.g. railroads and TCP/IP.
- **Increased productivity**. The technology should improve labor, energy, and resource productivity to lead to competitive advantage.
- **Relevance to multiple industries**. The technology should help U.S. industry broadly with multiple potential markets and end-uses.
- **Leapfrog capability**. The technology should enable the delivery of a next-generation technology ahead of international competition.
- **Satisfy stakeholder needs**. The technology should provide a true value proposition for all stakeholders including the public, industry, and academic partners.
- **Benefits across product lifecycles**. The technology should lead to improvements in competitiveness, energy use, productivity, water use, and other impacts across the entire lifecycle of products.
- **Increased adaptability and agility**. The technology should provide the tools manufacturers need to adjust to changes in product cycles, markets, new technologies and unexpected conditions.
- **Highly "Invasive"**. Once established, markets for the technology should naturally replicate without additional support and tend to remain over time.

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

Following the discussions on criteria, participants focused in on specific technology domains to answer this question. A specific list of technical domains discussed is provided in Table 4 below.

Table 4: Participant suggested technology focus areas for co-investment

Advanced robotics for production	**Technologies exploiting natural gas**	**High-temperature composites**
Advanced robotics for civil service	Separations and purification	Multi-material assembly
Metrology and sensing	Energy equipment	Lightweight structural ceramics
Roll-to-roll processing	Custom electronics – design and production	Ultra-thin functional materials
Modeling and simulation	Surface treatments and coatings	Net-shaped processing
Tissue engineering	High-performance computing	Additive manufacturing

Biomanufacturing	Pharmaceuticals	Mass customization
Batteries	Nanotechnology	Grid technologies and integration
Energy storage	Wastewater reclamation and reuse	Lightweight alloys
Democratized, customizable manufacturing tools	"Smart" materials	Solid state welding and joining
Servo technologies		

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

Table 5: Measures to assess the assistance of IMI activities to manufacturers

- **Partnership revenue generation**. A focus on revenue generation among IMI partners provides an even scorecard regardless of firm size and indicates true progress.
- **Jobs**. The number of jobs created was described as an important measure of success by many participants, though some participants noted that job growth goals should not be used by IMI's or partners.
- **Creation of technology**. IP generation, product commercialization, number of patents issued to IMI participants.
- **Use of new technologies**. Licensing, IP output, product/process sales.
- **Membership growth and sustainment**. Increasing membership, low churn rate, and lasting partnerships were all discussed as strong indicators of success.
- **Institute Operational revenues**. A compelling financial backbone was considered a good measure, with possible revenue streams from a variety of sources including membership fees, licensing revenue, partnership cost-share, and foundation support.
- **Reshoring**. Movement of plants from foreign locales to close proximity to the IMI and/or the domestic supply network for a sector would be a strong measure of success for U.S. manufacturers
- **Workforce improvements**. Improving opportunities for advancement, longer worker retention, growing workforce, increasing recertification and other metrics may indicate IMI assistance to manufacturers.
- **Trade balance**. Increasing exports and decreasing imports for a sector supported by an IMI could be a useful, though indirect, measure of effect.
- **Direct sales/service to industry**. Services, technologies, and trainings purchased directly from IMI's indicate a supplied demand to industry.
- **Decreased time- to-market.** Decreasing product development times in IMI targeted sectors may confirm the ability of IMIs to improve competitiveness

and perhaps profitability. • **Increased value added for goods produced by partners**. Units sold and revenue do not tell the full story; improved capabilities could lead to higher value, higher quality goods which improve partner profitability. • **Decreased cost of production for partners**. New technologies may increase profitability directly through lower energy costs, improved productivity, feedstock substitution, or many other avenues. • **Small and medium enterprise interactions**. Growing engagement with small and medium sized firms indicates a value proposition across supply chains. • **Index of collaboration**. Increased interactions, partnerships, and communications between industry, government, and the private sector will help support manufacturers.

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

Table 6: Measures to assess the performance and impact of IMIs

• **Jobs**. The number of jobs created was described as an important measure of success by many participants, though some participants noted that job growth goals should not be used by IMI's or partners • **Return on investment (ROI)**. Through somewhat controversial in discussions, some measure of economic returns from IMI metrics were seen as a useful performance metric • **Return on average net assets**. Return on net assets was suggested as a more holistic alternative to ROI for measuring the impact of IMIs • **Membership growth and sustainment**. Increasing membership, low churn rate, and lasting partnerships were all discussed as strong indicators of success • **Institute Operational revenues**. A compelling financial backbone was considered a good measure, with possible revenue streams from a variety of sources including membership fees, licensing revenue, partnership cost-share, and foundation support • **Profitability at globally competitive price**. Sustained profits from technology sold on the world market indicates IMI success • **Creation of technology**. IP generation, product commercialization, patents • **Use of new technologies**. Licensing, IP output, product/process sales • **Workforce improvements**. Increasing high school, university, and community college graduates employed by manufacturers and links to educational programs • **Spillover effects**. Secondary economic and knowledge benefits from the establishment of industry around an IMI; industry as an anchor for other

types of economic activity

- **Progress towards shared industry goals**. Accelerating industry sectors down a path to success (such as defined in existing roadmapping efforts) can provide large benefits to the economy

Dialogue 2: Institute Structure and Governance

This dialogue provided workshop participants an opportunity to consider the potential operational structure of IMIs. This included a discussion of business and governance models, participation structures, partnership engagement pathways, and regional and/or technological specificity. Elements of many existing business and governance models were discussed in detail by participants to provide awareness of past examples of failures or successes. There was also much discussion on how IMIs should be structured differently from existing models due to the proposed scale of investment for NNMI. Participants indicated the scope of NNMI is unique and no individual existing structure can adequately be applied across IMIs without adaptation.

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

For any model, public-private partnerships were seen as crucial to success with every participating party needs to bringing both their own self-interest and resources to the table. A summary of business models discussed is provided in Table 7.

Table 7: Proposed business models

- **Industry-led 501(c)(6)**. IMI's could be managed or coordinated by a not-for-profit governing body that partners with academia and the government to support manufacturers.
- **Pay-as-you-go, need-driven partnerships**. Somewhat analogous to a Fraunhofer model, this approach starts with an industry-identified need and follows with cost-share from partners who intend to provide a solution.
- **Phased government cost-share**. Though various proportions were discussed, many participants seemed to favor a high initial government cost-share that gradually decreases over the course of the partnership to a relatively minor contribution towards the end, leading to a self-sustained Institute.
- **Portfolio management model**. Set a defined mission and set of objectives then choose partners and technologies based on these objectives within a certain risk profile. Corrective actions are used for partnerships that do not achieve directives.
- **Adapted Sematech-like model**. Establish a not-for-profit consortium model that emphasizes collaboration to address regional policies and infrastructure, coordinated industry research, regional industrial Laboratory/Hub facilities, training, and technology commercialization.
- **Hub-and-spoke model**. As the center of the "Hub", the IMI establishes a cross-functional team or Board of Directors to strategically bridge outlying resources (e.g. existing supply chains, industry subsectors, venture capital)

with “Hub” goals by using partner organizations, or “spokes”.

Flexibility was seen as very important part of the business plan since one single model will not work for every Institute or even every partnership. The model should scale equitably from small business to large business and ensure that voting rights are not biased. Similarly, costs of entry should be scaled based on the intended scope of contribution to provide similar incentives to entrants of any size. The model should also be adaptable to different industries – each of which has a unique set of challenges to overcome.

Several participants were concerned about the scale of the NNMI investments. First of all, small and medium sized enterprises may be daunted by the absolute funding rates of IMIs and may be discouraged from participating based on that the amounts of capital they can contribute. Relatively small contributions from SME’s could seem insignificant, with limited impact on the IMI mission compared to large industry and federal cost share. It was suggested that SMEs should be allowed to contribute in-kind contributions and expertise to address this. Secondly, there was concern that large businesses would only be interested in supporting a couple of IMI’s and that the upper limit of 15 IMI’s is perhaps too high.

Other comments suggested that the business model should also be dynamic and give partners the opportunity to move in and out as needed. IMI goals should be set on multiple time horizons to allow for measured progress towards short-term goals in addition to providing pathways towards long-terms goals that are intended to produce a measurable outcome in industry.

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

Table 8: Proposed governance models

- **“Hub and spoke”**. Groups are established to manage and coordinate a variety of industry-related projects/partners and report back to the IMI Board of Directors on progress towards goals, best practices, and other operational information.
- **Adapted Commonwealth Center for Advance Manufacturing (CCAM) model**. IMI’s focus on the needs of OEMs and foster collaboration throughout the supply chain to build a shared direction and develop effective advisory panels.
- **Adapted NSF Industry and University Cooperative Research Program (I/UCRC).** IMIs require universities to work together to pull together industry-relevant research focus areas that are then selected by industry to

establish co-funded partnerships.

- **High sovereignty.** Each IMI has Board of Directors that appoints an Executive Director to manage IMI. A Board of Directors and an Advisory panel at the national NNMI level focuses on collaboration between IMIs and "cross-pollination" for technologies relevant to multiple IMI's.

An effective governance model relies on a well-defined "sharpened edge" value proposition for all partners to determine appropriate roles and responsibilities. These value propositions should remain central to IMI governance and goal setting. IMI governing bodies should ensure that the goals of IMI should primarily be focused on providing value through partnerships rather than ensuring the survival of the IMI.

Participants expressed some concerns about top-down government control over technical direction and research focus. On the contrary, a wide range of perspectives and member feedback should inform Institute governance. Power should not be available for appointees to direct research based on a narrow technical expertise in efforts to support any one particular sector or set of organizations. A high sovereignty model was suggested to allow flexibility in focus at individual centers while still providing focus through directors meetings, a national board of directors, and a national advisory panel.

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

A tiered participation structure could incentivize participation from a wide variety of members. The resources available to partner organizations could scale with the magnitude of the contribution so that there are a variety of options for engagement depending on strategic focus and needs. This structure might encourage healthy competition among partners within a sector while also providing value to both large and small businesses.

Demonstration projects are a powerful tool for contribution. IMI's should allow for companies to demonstrate equipment as a form of contribution to encourage partnership development, incentivize others to demonstrate equipment, and even potentially provide hands-on resources for educational programs and other workforce development activities.

Flexibility was a key theme discussed in this dialogue. The pay-as-you-go model was recommended because it allows partners opportunity to invest in discrete partnerships without necessarily committing to long-term investments. Flexible partnership models should also allow members to come and go easily. In-kind contributions and knowledge/expertise should be accepted in addition to cash to encourage SME partnerships.

It is important to have competitors in the same industry come together in IMIs to tackle pre-competitive challenges. However, it is also very important to have boundaries on participation so that sensitive information can be easily and securely withheld.

IP management was seen as a crucial challenge by participants. University corporate relationships often result in IP licensing issues. If all three “legs of the stool” (public, private, academic) develop their own IP structures there will be barriers to collaboration. Any IP process should be vetted up front at the onset of a partnership to limit conflict down the line. Some participants recommended that IP management plans be submitted by IMI proposal team and evaluated by the government as section criteria. However, it was also agreed that there is no one-size-fits-all solution as IP issues depend on the nature of the technology, sector, and challenge. A set of pre-determined IP templates was discussed as a potential solution that allows a bit of flexibility and an element of standardization on a case-by-case basis.

2.4. How should a network of Institutes optimally operate?

A critical aspect raised by participants was the need for a peer-review process. The focus and approach of each IMI should be peer-reviewed for effectiveness by an independent board to drive competition among the Institutes and ensure accountability in achieving goals. To enable meaningful peer-review, IMI’s must also be highly transparent with established reporting structures and conventions.

Each individual IMI should function as a gateway to the NNMI network in addition to being a standalone Institute. This could be accomplished through the use of “open access” memberships that allow partners at any center access to the resources of other centers as well, much like a health club membership. A common central NNMI website could help integrate the activities of the IMIs under one roof to increase the networks usefulness to members. There could also be dedicated personnel within the centers who are responsible for connecting users to the full network.

Another idea that might improve the success of the network as a whole is to designate one IMI to handle “overhead” and cross-cutting operational support to all the other technology or industry focused IMIs. The duties of this Institute could include legal issues, NNMI IP management and dispute resolution, entrepreneurial and startup guidance programs, and educational program harmonization across the other IMIs.

It was also noted that while a successful network of IMIs fulfills the intent of government stakeholders, the success of the network may not be so valuable to all other stakeholders. Small business, for instance, may derive much more value from a single focused technology project at one center than access to a distributed network of disparate capabilities across the country.

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

Measures of success for government models were similar to those expressed in Table 6 above. Table 9 indicates the most prominent suggested measures.

Table 9: Measures of network structure and governance effectiveness

- **Jobs created**. As indicated in Table 5 and Table 6, the number of jobs created was described as an important measure of success by many participants
- **Membership growth and sustainment**. Trust in governance was discussed as an important foundation for IMIs; membership growth could indicate partnership strength
- **Increased value added for goods produced by partners.** Value added is closely tied to profitability and can also indicate success towards governance objectives related to capturing competitive advantage
- **Strong Institute Operational revenues**. Sustained membership fees, licensing revenue, partnership cost-share, foundation support, and venture capital funds raised could indicate effective governance techniques
- **Creation of technology**. IP generation, product commercialization, and patent generation all indicate successful governance
- **Results from peer-reviews and success meeting milestones.** Peer-reviews can potentially provide feedback and deep insight on unanticipated issues in time to affect management decisions
- **Membership diversity**. Broad industry engagement may imply a successful governance model

Dialogue 3: Strategies for Sustainable Institute Operations

Within the sustainable Institute operations dialogues, participants focused on the long-term operational considerations of IMIs and the outcomes that might lead to long-term benefits. Many discussions focused on cost-share arrangements, IMI funding options, funding time horizons and period of performance, long-term stakeholder roles, and dynamic/changing markets and industries. Participants expressed a variety of well-defined and sometimes contrary opinions and on cost-share arrangements and time horizons (for instance, many participants noted that it will likely take more than 3-5 years for IMIs to become sustainable). However, opinions were perhaps most polarized regarding the value of self-sustaining IMIs and the appropriate measures of success.

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

While participants recommended a wide variety of initial funding options, there were a few common themes that emerged from the discussions:

- Government cost-share should begin high and decline with time
- Government funds should be spent on building capability, acquiring equipment, convening partnerships, and potentially qualifying supply chains
- Industry funds should pay for access, use, and services, with a potential for in-kind contributions of equipment, knowledge and expertise, or other service
- Some portion of initial funding should go towards demonstrations to help build the value proposition
- Industry should invest initially (if only a small portion) to demonstrate the value of the approach/technology, especially since industry cost-share will eventually be essential for product commercialization and possibly Institute sustainability

Proposed initial investment themes:

Government-initiated, privately-sustained.

- Large initial federal investment in the form of an award
- Federal investment would continue for 3-7 years depending on the awards
- During this period, the Institute establishes non-federal revenue streams and becomes self-sustaining

Government-initiated, mission-driven.

- Large initial federal investment in the form of an award with the mission of solving a specific problem or challenge

- Federal investment would continue for a number of years commensurate with the timescale of the challenge
- During the life of the Institute, either:
  - the mission is completed and the Institute dissolves
  - the mission is abandoned and the Institute dissolves (mission has become irrelevant to national needs)
  - the mission remains or is adapted and the Institute is sustained to address the challenge (potential for more federal funding)

To help “prime the pump”, one participant suggested that NIST and Universities bring their portfolio of IP to Institutes from the onset. Private partners could then browse the “library” and pay a fee to work on commercializing the innovation.

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

Over the long term, IP ownership could lead to a significant revenue stream for IMIs and private partners, especially if it addresses appropriate industry needs and capability gaps. It is anticipated that it might take 7-10 years to capitalize on IP ownership as a significant revenue stream for the IMI.

Many participants suggested that a 3-5 year commitment from the federal government is not long enough to inspire confidence in the private sector. For some, long-term commitment from government would encourage partnership development.

Large OEM involvement is a crucial element for success because of large available cost-share. Additionally, OEMs will bring the involvement of their supply chains which otherwise might not have the capital resources to engage with larger entities at IMIs.

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

Table 10: Measures to assess the progress of an Institute towards being self-sustaining

- **Technology progress**. The ability of an Institute to move a technology through the Technology Readiness Level or Manufacturing Readiness Level scale is a measure of long-term effectiveness, especially if the technology eventually makes it to commercialization
- **Flow of research and IP from shared to proprietary**. Since Institutes are supporting pre-competitive technologies, the eventual proprietary use of previously shared ideas indicates a successful partnership.
- **Sustained interest from large companies**. Increasing interest from large

companies over the long term could be a strong indicator since there are many competing research activities (including internal, propriety product development) that would benefit from their research investments.

- **Increases in sponsorship of work in the higher TRL levels**. Trends toward higher TRL funding indicate movement towards commercialization and revenue.
- **Number of start-up and spin-off organizations created.** Spin-off and start-up organizations imply anticipated future markets from third parties
- **Number of commercialized technologies supported.** Successful commercialization could generate success stories and revenue streams to sustain IMIs
- **Membership growth and sustainment.** New entrants indicate a perceived need from industry

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

Several participants commented that IMIs should not exclude multi-national companies with facilities overseas and that foreign companies could potentially be included as well. It was noted that the culture of some other countries – Germany in this case – are generally inclusive to foreign companies and it is not uncommon for foreign employees to receive training on German soil. Furthermore, a few comments considered expanding the idea of the NNMI network out to the global level in order to advance the perception of the U.S. as a world leader in advanced manufacturing and global collaboration (see question 3.5). Beyond these topics, there was little discussion of actions that might support the U.S. manufacturing base with an international perspective.

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

Several manufacturing programs were described as being very valuable to the manufacturing base. Many participants suggested IMIs borrow elements of existing successful programs so efforts are duplicated and successful methods are replicated. The following programs were referenced frequently in discussion:

- NIST Manufacturing Extension Partnership (MEP)
- DOE Energy Innovation Hubs and Office of Science
- Colorado Association for Manufacturing and Technology (CAMT)
- NSF Adapted NSF Industry and University Cooperative Research Program (I/UCRC)

It was often suggested that IMIs should build upon and perhaps even incorporate existing programs where practical. For instance, it was suggested that the NIST MEP program could establish branch offices within IMIs.

It was also suggested that IMIs act as a vehicle to engage the international community and open the door for global collaboration on manufacturing challenges that are common to other economies. In addition, an IMI international presence could potentially influence treaties and trade agreements that affect U.S. business.

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

IMIs can help reverse the negative perception of manufacturing (i.e. the four D's of Manufacturing: "dirty, dumb, dangerous, and declining") if high-quality, well-paying technology jobs are available and the workforce is exposed to the workplace environment of modern advanced manufacturing. Changing this perception could go a long way towards gaining the attention of local economic development authorities (EDA's).

By bringing multiple industry sectors and firms together towards a set of shared goals, common regional issues may be more easily identified and addressed by economic development authorities. For instance, because tax structures can vary by region, there might be unequal treatment of similar businesses. Economic development authorities might be interested in any such discrepancy and may be in a position to improve conditions for manufacturers.

It was suggested that state funded EDAs may need to establish new programs to reach out to IMIs but funding for such programs may not be available. In these cases, it may be helpful for EDAs to encourage university involvement in IMI since EDAs and universities often work together.

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

Table 11: Measures to assess national security and competitiveness

- **Productivity**. Continuous improvements in productivity will help the U.S. remain competitive, whereas metrics like job numbers will not necessarily shed any light on international competitiveness
- **Resource use efficiency**. The more effectively the U.S. can create value out of its often limited energy, water, and other resources the more competitive we will be in the long term.
- **Increasing supplier adaptability**. Manufacturers who need to rely on

unique single-capability suppliers are more vulnerable. Supply chains and manufacturers who move towards dual sourcing, adaptable processes, and other techniques to build supply consistently will be more secure.

- **Cost of national defense**. Lower costs for supplying the U.S. defense arsenal will lead to increased national security and/or competitiveness depending on investment decisions.
- **Sustained private investment.** Private investments indicate profit and near-term competitiveness

Many participants expressed concern that IMI's should address only a core set of challenges and that broadening the scope to include national security might lead to unfocused investments.

Dialogue 4: Education and Workforce Development

Within this dialogue, participants focused on the near and long-term human capital challenges and the potential for NNMI to provide the solutions that U.S. manufacturers need to become and remain globally competitive. Though discussion was varied, many participants expressed similar opinions within this dialogue. There was a strong sense that the workforce aspects of NNMI will be very important, but that it will also be very challenging to adapt current educational systems and reverse negative cultural perceptions of manufacturing. Several common themes emerged over the course of discussions:

- Start manufacturing education and workforce activities at young age
- Formalize pathways from early education into manufacturing
- Be inclusive to all students, not just top performing STEM-track
- Link local industry need with national certification

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

In discussions, curriculum development was quickly identified as challenge but the methods by which Institutes could affect this challenge were harder to establish. At the very least, it was agreed that Institutes should ensure that someone is responsible for developing the curriculum. This may require an examination of the entire spectrum of training and certification to assess completeness and identify roles for existing agencies along with any potential gaps that IMIs might help to fill. Some argued that much of the needed curricula already exist in various programs and could be more broadly applied to fill gaps.

All discussion groups discussed the IMI role as a type of "clearinghouse" to integrate information from the fragmented patchwork of educational programs that will exist across an IMI region. IMI's should serve as a central source of information on existing programs and also identify dependencies among programs. IMIs should also define key roles in the system so that the government and companies know what needs to be addressed.

Participants also noted that manufacturing education should begin at a younger age. Students must have clear pathways into manufacturing throughout their education so that they are trained from an early age that there is a viable alternative to the 4-year university path. Apprenticeship programs, high-school vocational programs, community college industry partnership programs and other avenues should be available and visible to all students, perhaps as early as middle school. Any program that could allow industry to work directly with high schools on internship or other programs could also be effective. The Institute could act as a “match-maker” to connect schools or even individual students to industry workforce demands. It was suggested that such a role needs to start with industry identifying a need rather than a program for the sake of education. There is often a strong need for specific skill-sets in industry that won’t be supplied unless industry can communicate the need to schools. IMIs could potentially have a role in this.

IMIs also offer potential as centers of excellence where young people can come to begin to imagine a career in advanced manufacturing. Field trips, site-visits, and class trips could also provide students an opportunity to engage with advanced manufacturing in a hands-on manner. Technologies like robotic welding are awe-inspiring to young adults.

To establish opportunities like these, the IMI’s operational plan should include outreach to schools, local governments, universities and industries. Teachers are a good audience for outreach because of a fair amount of discretion in student activities and the potential for IMIs to provide continuing education credits. Consider having 3-week on-site trainings for teachers as a means to establishing relationships with local schools. Attendees noted that such opportunities must be available and accessible to all students and not just STEM-track or those planning to attend a 4-year university.

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

Portable credentials can go a long way towards harmonizing the needs of industry as long as the credentials are properly focused. Universities are likely willing and interested to be involved in NNMI and are capable of providing space and resources for credentialing. However, IMIs would need to work closely with industry to identify the types of skillsets that could reasonably provide value through a portable credential format. Building on this concept, it was suggested that an immersion program similar to residency programs in the medical profession should be required prior to credentialing.

A ground-up approach to catalog industry need could also be very helpful. This process could begin with a local survey of need across the manufacturing base that could then be fed to a centralized database. To assess currently available programs, the needs could be compared against programs currently offered to identify any gaps. Universities, industry, and local government could then come together to address those gaps with coordination provided by IMIs.

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

IMIs should serve as a "matchmaker" to bring together industry-identified needs and available workforce development programs. Building on question 4.3, Institutes could also serve as an administrator for developing and dispensing portable advanced manufacturing credentials.

IMIs could also help extend existing workforce development programs into manufacturing plants to increase the impact and value of programming. Industry could benefit from the reversal of negative perceptions of manufacturing by providing hands-on experiences for students in clean, modern plants. Industries could also begin to develop relationships with students and teachers that might lead to a stronger workforce over the long term.

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

Table 12: Measures to assess Institute performance on education and workforce development

- **Number of on-site student visits**. Though lasting memories of positive experiences are very hard to measure, students can only have the opportunity to form these perceptions through hands-on experience. Higher visit rates indicate compatibility with teacher/school needs
- **Student tracking**. Follow-up with trained students could provide indicators on job retention, sustained manufacturing careers, and job quality
- **Testing results**. Evaluating the performance of students involved in manufacturing programs may reveal unrealized aptitudes
- **Number of partnerships formed between members.** Educational programs are often regional or local by nature; increased partnerships could indicate federal convening role for developing workforce by connecting the "patchwork"
- **Increased employment and education in ancillary disciplines (e.g. law, business).** Manufacturers rely on legal counsel, business leaders, and a variety of other professionals; growth in these roles could indicate increased industry need
- **Number of trainings completed.** If IMIs are proposed with a significant training focus, this metric could measure relatively direct resources to industry
- **Proportion of trained students finding employment.** This measure could help understand how effective IMI programs are at supplying industry needs

- **Manufacturing surveys on the effectiveness of trained workforce.** Direct input from industry could inform ongoing workforce efforts

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

One possible solution for integrating R&D activities and education is to distribute equipment and capability across a network of universities and community colleges. With such a model, Institutes could virtually manage access to all capabilities while also providing students an opportunity to act as technicians that learn to use technologies at a manageable pace. Such a distributed model could also potentially encourage partnership collaboration since companies seeking access to a set of capabilities could end up working with a whole network of universities and students rather than a single center.

Appendix A: List of Acronyms

AMNPO	Advanced Manufacturing National Program Office
CAMT	Colorado Association for Manufacturing and Technology
DOE	Department of Energy
GUIRR	Government-University-Industry Research Roundtable
IMI	Institute for Manufacturing Innovation
IP	Intellectual Property
MEP	Manufacturing Extension Partnership
MRL	Manufacturing Readiness Level
NAE	National Academy of Engineering
NAMII	National Additive Manufacturing Innovation Institute
NASA	National Aeronautics and Space Administration
NIST	National Institute of Standards and Technology
NNMI	National Network for Manufacturing Innovation
NSF	National Science Foundation
OEM	Original Equipment Manufacturer
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
TCP/IP	Transmission Control Protocol / Internet Protocol
TRL	Technology Readiness Level

Appendix B: List of Participants[22]

Margaret (Meg) Abraham	*The Aerospace Corp*
Steve Abt	*Colorado State University*
Richard Adams	*National Renewable Energy Laboratory*
Chuck Alexander	*Solid Concepts, Inc.*
William Alexander	*Qualtek Manufacturing, Inc.*
Igor Alvarado	*National Instruments Corp.*
Robert Anselmi	*Department of Veterans Affairs*
Jesse Aronson	*Worksystems, Inc.*
A.K. Balaji	*The University of Utah*
Ann Batchelor	*CSU Ventures*
Abby Benson	*University of Colorado*
Eric Bergeson	*Clemson University*
Stacey Bibik	*Stacy Machine & Tooling, Inc.*
Scott Boyce	*The Dow Chemical Company*
Ann Brennan	*NREL (National Renewable Energy Laboratory)*
Tom Bugnitz	*CAMT*
Brian Burney	*Oliver Manufacturing Co., Inc.*
Dana Christensen	*National Renewable Energy Laboratory*
Cynthia Christie	*Christie Consulting, LLC*
Chris Conrardy	*EWI*
Donald Cotchen	*McGraw-Hill Construction*
Susan Crumrine	*Southwest Research Institute*
Lynn Daniels	*A.A.A.S. Fellow at U.S. Department of Energy*
Gregory Drumm	*Nation Grinding Inc./Nation Coating Systems*
William Farland	*Colorado State University*
William Feiereisen	*Intel Corp.*
Chris Fish	*McAllister & Quinn*
Tim Goodpasture	*City of Wichita*
Nick Guerra	*Perfekta Aerospace*
Lance Guymon	*Wolf Robotics*
Kevin Hedin	*Colorado State University*
Gregory Henschel	*US Department of Education*
Tom Hildreth	*Hildreth & Associates*
John Hines	*NASA-Ames Research Center*
Roberta Hines	*SGL/HITCO CARBON COMPOSITES*
Terry Holesinger	*Los Alamos National Laboratory*
Michael Karpuk	*TDA Research, Inc.*
Angie Knepell	*Colorado Association of Commerce and Industry*
Michael Knotek	*Renewable and Sustainable Energy Institute, UC Boulder*

[22] This is the list of attendees who gave permission to publish their information, not the full list of attendees

Shawn Knowles	*Ball Corporation*
Neil Kolwey	*SWEEP*
Sam Licata	*Cummins, Inc.*
Kathleen Reneau Lorenzi	*University of Colorado Boulder*
Michael McGrath	*LASP -- University of Colorado*
Michael McIlwain	*Idaho National Laboratory*
Leslie McKay	*Metro state university*
Bill McMeekin	*North Seattle Community College*
Ashutosh Misra	*ITN Energy Systems, Inc*
Manoj Mittal	*University of Texas at Arlington Research Institute*
Michael Molnar	*NIST/Advanced Manufg National Program Office (AMNPO)*
Kevin Moore	*Colorado School of Mines*
Naseem Munshi	*CTD*
Walt Natzic	*Grace Technologies*
George Newman	*Front Range Community College*
Gregory O'Connor	*Amalgam Industries, Inc.*
Ron Ott	*Oak Ridge National Laboratory*
Sun Pak	*iComputer*
Joseph Pentlicki	*Oliver Manufacturing Co., Inc.*
Eric Peterson	*Idaho National Laboratory*
Zoya Popovic	*University of Colorado*
David Prawel	*Colorado State University*
Donald Radford	*Colorado State University, Mechanical Engineering*
Douglas Ramsey	*Alcoa Inc.*
Patricia Rankin	*University of Colorado, Boulder Campus*
Adele Ratcliff	*OSD(MIBP)*
Joe Razum	*GE*
Kathay Rennels	*Colo State University - Community & Economic Development*
Matthew Reyes	*NASA Ames Research Center*
Mike Rinker	*Pacific Northwest National Laboratory*
Ethan Rojhani	*PwC*
Sarah Ruen Blanchard	*ASERTTI*
Selma Salihagic	*Ball Aerospace & Technologies*
L. Rafael Sanchez	*University of Colorado Denver*
Bhima Sastri	*Department of Energy*
Michael Schen	*NIST/Advanced Manufacturing National Program Office*
Steven Schmid	*NIST/Advanced Manufacturing National Program Office*
Jeffrey Sczechowski	*University of Colorado Boulder*
Aleta Sherman	*CAMT*
Larry Shipers	*Sandia National Laboratories*
Scott Smith	*NIST/Advanced Manufacturing National Program Office*
Marina Sofos	*U.S. Dept. of Energy/Advanced Manufacturing Office*
Sumer Sorensen-Bain	*CAMT*
Michelle Sosa-Mallory	*NREL*
Girish Srinivas	*TDA Research, Inc.*
Rose Ann Sullivan	*TechVision21*
Karla Tartz	*State of Colorado*
LaNetra Tate	*NASA*

Alan Taub	*University of Michigan*
David Teter	*Los Alamos National Laboratory*
Daryl Thompson	*Salt Lake Community College*
Dave Thompson	*AlloSource*
Gary Thompson	*NIST MEP*
Wade Troxell	*Colorado State University*
Cameron Turner	*Colorado School of Mines*
Michael Ulsh	*National Renewable Energy Laboratory*
John Vickers	*NASA*
Kelly Visconti	*A.A.A.S. Fellow at U.S. Department of Energy*
Lynn Vosler	*Front Range Community College*
Ben Webster	*University of Colorado Boulder*
Alan Weimer	*Univ. of Colorado and ALD NanoSolutions, Inc. and Sundrop Fuels*
Chauncey Wenner	*United Launch Alliance*
Christian White	*iComputer*
Sarah Wilson	*Workforce Boulder County*
Kyle Winslow	*McAllister & Quinn*
Christopher Wolf	*ITN Energy Systems, Inc*
Thomas Wunsch	*Sandia National Laboratories*
Mark Yoss	*Lockheed Martin*
Paul Ziehl	*U. South Carolina*

Appendix C: October 18, 2012 Workshop Agenda

7:30am	**Sign-In and Continental Breakfast Opens**
8:30am	**Call to Order and Start of Plenary Session** *Welcome Remarks* ▪ Kathleen Hogan - Deputy Assistant Secretary Energy Efficiency, U.S. Department of Energy ▪ William Farland - Senior Vice President for Research, Colorado State University ▪ Patricia Rankin - Associate Vice Chancellor for Research, University of Colorado Boulder *Keynote Addresses* ▪ **Why Manufacturing Matters to Colorado** Ken Lund - Director, Colorado Office of Economic Development and International Trade ▪ **Innovation and Economic Impact** Phillip Singerman - Associate Director for Innovation and Industry Services, NIST/U.S. Department of Commerce ▪ **Framing the Challenge** Mike Molnar - Director, Advanced Manufacturing National Program Office
10:20am	**Break**
10:35am	**Workshop Period I - Designing for Impact Dialogues** Featuring: ▪ Technologies with Broad Impact ▪ Institute Structure and Governance ▪ Strategies for Sustainable Institute Operations ▪ Education and Workforce Development
11:40am	**Lunch Program.** Pick up boxed lunch.
12:00pm	**Regional Perspectives - A Panel of Regional Leaders:** ***Focus on Education and Workforce Development*** *Discussion followed by Q&A. (Invited panel members)*

- Drew Crouch - Vice President, Technology, Ball Corporation
- Jason Gies - Vice President, Firehole Technologies
- Naseem Munshi - President and CEO, Composite Technology Development, Inc.
- Kathy Rowlen - CEO, InDevr
- John Vukich - Dean, Economic and Workforce Development, Pueblo Community College

Facilitated by:

- Tim Heaton - President, Colorado Advanced Manufacturing Alliance

1:10pm **Workshop Period II - Designing for Impact Dialogues**

Featuring:

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

2:10pm **Break, Rotate to next Dialogue Session**

2:20pm **Workshop Period III - Designing for Impact Dialogues**

Featuring:

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

3:20pm **Networking Session**

3:50pm **Concluding Session**

Report Out from Dialogue Team Leaders

Closing Remarks and Next Steps

- Dana Christensen - Deputy Laboratory Director for Science & Technology, National Renewable Energy Laboratory
- Mike Molnar - Director, Advanced Manufacturing National Program Office

4:30pm **Adjourn**