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Information Sciences Institute

TITLE PAGE

Input to NIST NNMI RFI

National Need on Manufacturing Innovation

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

15 October, 2012

In Response to Solicitation: NIST NNMI RFI Issued 4 May, 2012

Submitted to:

National Institute of Standards and Technology (NIST)
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LIST OF ACRONYMS

AMPO	Advanced Manufacturing Program Office
DOD	Department of Defense
DOE	Department of Energy
LCC	Life-Cycle-Cost
NIST	National Institute of Standards and Technology
NNMI	National Network for Manufacturing Innovation
NRE	Non-Recurring Engineering
NSF	National Science Foundation
PCAST	President's Council of Advisors on Science and Technology
R&D	Research and Development
RE	Recurring Engineering
RFI	Request for Information
ROI	Return on Investment
SME	Small-Medium-Size Manufacturing Enterprise
TRL	Technical Readiness Level
USC	University of Southern California

National Network for Manufacturing Innovation (NNMI)

Abstract

This white paper provides input to NIST's Advanced Manufacturing Program Office (AMPO) regarding the establishment of NNMI Centers as recommended by the President's Council of Sciences and Technology (PCAST) report published in July, 2012. This white paper addresses the specific questions published by NIST's AMPO in its desire to obtain focused advise in the structure of the program. The white paper is organized in two sections. First, a brief overview of the NNMI program goals/objectives is provided as documented in [1]. And second, the response to every NIST-solicited question is given.

1. NNMI Program Objectives and Attributes Summary [1]

According to NIST RFI solicitation [1] on NNMI, the NNMI program will be managed collaboratively by the Department of Defense (DoD), the Department of Energy (DOE), the Department of Commerce's NIST, the National Science Foundation (NSF), and other agencies. Industry, state, academic and other partners will co-invest in the NNMI-established Institutes. Should the NNMI program be funded in FY 2013, the Federal government will make a $1 billion, one time investment, through the NNMI program, in a series of competitive solicitations staged over several years. This start-up investment will help support initial expenses for up to **15 Institutes**. Participating agencies will oversee the solicitations, select award recipients, provide technical assistance to applicants, and manage the awards from the NNMI program funding.

Each Institute will integrate capabilities and facilities required to reduce the cost and risk of commercializing new technologies, and to address relevant manufacturing challenges on a production-level scale. Each will have a well-defined technical focus and will be selected through a competitive process. Additional attributes at each NNMI Institute will include:

- Long-term partnership between industry (including small, medium, and large firms), educational institutions, non-government organizations, and state, regional and local economic development authorities;
- Flexibility to form integrated teams of industrial and academic experts from multiple disciplines to solve difficult problems and to develop the future workforce;
- Adaptability for education and workforce development at multiple levels, including K-12, professional credentialing, undergraduate and graduate education, and mentoring and professional development;
- Involvement of industry associations, professional societies, and economic development organizations for validation and linkages to broader industry and regional activities;
- Analytical capability to identify critical emerging technologies with transformational impact and operational capacity in translating these technologies into products and businesses for the market;
- Ability to engage and assist SMEs to effectively deploy technologies; and
- A sustained focus on innovation with a strong reputation for quality and success.

Each Institute will have a clear focus area that does not overlap with those of the other Institutes. The focus area could be an advanced material, a manufacturing process, an enabling technology, or an industry sector. The Federal government does not intend to create or provide a complete

[1] National Program Office for the Advanced Manufacturing Partnership Established at NIST, December, 19,2011

list of focus areas for the NNMIs. The NNMI solicitation will invite applicants to propose such areas.

2. Response to RFI Request

A response is given to each of the questions solicited by NIST's AMPO:

A. Technologies with Broad Impact

Assumption: It is assumed that each NNMI Institute will be established in a geographic area having strength in certain industry types. For example, mid-west in U.S. is focused on heavy machinery (industry's characteristic landscape), while electronics are mostly concentrated in California, Massachusetts, and Texas. Generally, industry types, very often, are concentrated in more than one geographic location (e.g., Information Technology -- California, Virginia, and Massachusetts, green energy -- California and Arizona, etc.), but nothing should prevent an NNMI Institute focusing on a specific industry type prominent in a geographic area, to cooperate synergistically with same industry types located in other geographic areas; in fact, *this should be encouraged*. Based on these assumptions, the following answers are in order:

1. **What criteria should be used to select technology focus areas**?
    a. Regional industry focus and concentration. For example, an Institute focused on "electronics" should be in a location surrounded by such industry types.
    b. Regional educational system and areas of excellence within these educational institutions.
    c. Availability of Community Colleges and Vocational Schools supporting this Industry for workforce development.
    d. Value/focus of a technology in terms of addressing not only technical excellence, but also whether the technology, and Institute's proposed technology portfolio at large, address the cultural changes/needs within the society (e.g., the *iPhone or iPAD* uses mundane electronic technology, but, its functionality addresses the shift in society cultural preferences).
    e. Mix of available labor pool including its educational level. For example, establishing a software-focused Institute, a consideration should be given if the local workforce talent can support such industry at large. The reason is that a goal of the NNMI Institutes is to stimulate local economies; for example, spinning-off start-ups or strengthening through growth existing SMEs (see further related comments below).
    f. Improvements in strengthening the supply chain-making of products. This includes, but not limited to, reliable supply-chain, **trusted** supply-chain, records-keeping of participating vendors within the supply-chain, *just-in-time* delivery of items for inventory minimization, etc.
    g. Policies of local county, city, and state governments regarding the support of SMEs for future growth.
    h. Workforce-related factors driving corporate strategies (see Ref. [3]).
2. **What technology focus areas that meet these criteria would you be willing to co-invest in**?
    a. Nanotechnology – wide spread applications (flexible electronics, bio-informatics, sensors, etc.).
    b. Electronics assemblies leading to integrated subsystems.

c. Bio-inspired electronics applied to specific domain applications for manufacturing (e.g., reducing power requirements in servers, performing intelligent processing in robots (e.g., cognitive-based), cognitive processing (e.g., machine-learning, Bayesian inferences), automated testing of complex systems, etc.).

d. Complex systems that Information Technology and Reliable Electronics/Nano-electronics are key components. This includes Photonics, MEMS, and Beyond CMOS Electronics:

- Intelligent, self-adaptive, self-tested and self–repaired Complex Systems.

e. New material and meta-material

- **All topic areas should be structured not only to provide the required technical skills, but also the associated processes, like system engineering, supply-chain management, etc.**

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

a. Timely and cost-effective transition from R&D to Prototyping to Production.

b. Use of TRL measure to qualify maturity levels, and time taken to progress from one TRL value to the next (e.g., 1 year to increase TRL maturity level from TRL 4 to TRL 5).

c. R&D cost; also, the NRE and RE costs to set-up production including anticipated ROI (Return-on-Investment).

d. Number and impact to the manufacturing community of trained personnel that understands *system engineering in their bones*, as this is one of the most critical discipline in the success of advanced manufacturing.

e. Number of potential jobs (at all levels) to be created as part of Institute activities.

f. Type and frequency of consulting performed by the Institute to Industry including the number of joint projects between the Institute and Industry.

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

a. Workforce Development measures:

- Number of college students involved in the program, and those absorbed by the industry after graduation.
- Number of pre-college students (e.g., K-12), community college students, and vocational schools students involved in the program. Also, those absorbed by the industry after graduation or completion of training.

b. Number of technologies brought by the Institute to national manufacturing effort, adopted by the Industry, and successfully transitioned to Industry for production of manufactured products.

c. Timing and cost to take an Institute-developed technology from the TRL of 3 to TRL of 7 (ready for technology transition and production).

d. IP portfolio and number of patents created as a result of Institute activities, number of Companies using the IP/patents and associated revenue generation.

e. Number of start-ups and number of SMEs impacted positively by the Institute in their operations (e.g., produced new products) as a result of Institute activities.

f. Number of joint engagements between personnel supported by the Institute and Industry (joint projects, *in-residence* engagements of Industry or Institute's personnel, investment of Industry in the Institute's activities, etc.).

g. Number and funding size of projects, other from NNMI funds, that the Institute received (and/or receiving) after 3-4 years.

h. Number of technical events (symposia, lectures, etc.) that Institute-sponsored personnel organized for the Industry at large to disseminate its technology base.

i. Number of professional distinctions that Institute personnel received (and/or receiving annually) from peers.

B. Institute Structure and Governance

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

a. Technical merits of an Institute-sponsored project associated with ROI. ROI should be measured by the project team in terms of two components: **a)** ability to raise complimentary funds from other sources for technology transition after the Institute's initial investment for proof-of-principle and possibly prototyping; and **b)** ability to raise other funds to continue the enhancement of the end product developed in the project.

b. Business plan for any Institute-funded project. Plan should contain a detailed elaboration of the project schedule, critical milestones, associated costs, milestone-driven costs, and technology transition to Industry.

c. Two types of funding to be provided by the Institute:

1. Highly-speculative (high-risk and high-payoff) technologies. For example, technologies less than TRL of 3-4.
2. Applied technology projects associated with well-thought and -constructed business plans as described above. For example, projects leading to TRL 6-7 in a 2-year period.

d. Progress based on technology-driven and cost-driven milestones. Critical milestones could be spaced on a 6-month or 12-month period.

e. Comprehensive technology transition plan associated with milestone-driven events regarding Industry participation in the project (the sooner the better).

- **Exit strategy on each Institute-sponsored project based on technology- and cost-driven milestones performance, as well as project performance as overall. On the later, an exit criterion could be the value-added assessment of an Institute-pursued technology to the advancement of the manufacturing base in U.S.**

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

a. Each Institute should be a consortium of Industry (Small, Medium, and Large Companies) and Academia (3-4 Universities).

- Participating Companies should manufacture products, and not performing R&D only.

b. Each Institute should be governed/managed by a cognizant organization that has very strong association with a University, but it is independent, and it has its own contract and financial system (apart from the University). It is experienced in performing contract work, experienced in managing large consortia

(Universities, Industry, Non-profit Organizations, etc.), experienced in managing and executing Government and Industry awards, performs both applied research (TRL greater than 3-4) and fundamental research (TLR less than 3), invokes students (graduate and under-graduate) in its technology development activities, has joint programs with other academic institutions, and has proven-value programs on training/developing the workforce. This organization should have a demonstrated experience on the above over many years of performance.

c. Each Institute's core mission should be on a broad technology area of a domain (e.g., Effective Manufacturing of Electronics – Electronics (micro to nano to beyond CMOS), MEMS, Photonics, Electronic Assemblies, and Subsystems).

d. Two-tier management structure at the Institute for the day-to-day operations:
   - Lower-level: Project management by a qualified PI for each Institute-sponsored project.
   - Director-level day-to-day management for all Institute's projects.

e. The Institute's Director should report to a *Management Oversight Board* (MOB) overseeing progress and mix of technologies of the Institute's portfolio:
   - MOB should comprise of Industry, Academia, and selected experts relevant and knowledgeable of Institute's core mission.

f. Each Institute should retain a *Technology Advisory Group* (TAG) – Consisting of Sr. Experts, Directors of other NNMI Institutes, and Chief Scientists of Participating Companies in the Institute.

g. Per #8 below, each Institute should receive at least annually a feedback on progress and mix of technologies. The feedback should be given to the Institute's Director by its MOB and TAG. The MOB should monitor progress on the implementation of these recommendations.

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

a. Participating Universities should arrange that whereas IP remains with inventors, the Institute retains the right to provide non-exclusive royalty-free license to participating Companies (those supporting financially the Institute), and fee-based license to non-participating Companies. A compensation scheme should be worked out for the inventor to stimulate innovation and interest.

b. An IP statement could be [2]:

" The Institute encourages awardees to pursue and retain principal legal rights to intellectual property developed under their awards, or under subsequent sub-awards. The Institute is available as a resource, to assist awardees strategically and financially, as appropriate, towards this end. Awardees will be expected to have or to implement policies and agreements whereby the Institute's Participants will be granted world-wide, non-exclusive, royalty-free licenses to all foreground technology, inventions, or other intellectual property developed under the award. The Institute will receive standard U.S. Government intellectual property rights accorded to research and development activities utilizing federal or state funds. It is highly desirable that

[2] This statement is similar to DARPA and MARCO statement used in the FCRP program, Solicitation 2009-S200902, issued by DARPA and MARCO in 2009.

awardees identify and provide access to relevant background intellectual property to Institute Participants under reasonable terms."

c) Arrangements should be made that Companies wanted to sponsor/fund projects within the Institute, they should retain all IP to be developed (foreground IP). The same provision should valid for Companies bringing their own IP to a project within the Institute.

8. How should a network of Institutes optimally operate?

a. The Institutes Directors should participate in the Technical Advisory Groups of the other Institutes (see 6e above).

b. Each Institute should hold an annual meeting inviting a wide audience of academia and industry representatives discussing progress on its projects. The meeting should give the opportunity not only to PIs, but also to participating students to present their projects.

c. Also, each Institute should organize topic-specific workshops and invite Industry, Academia, and members of other Institutes as appropriate. The frequency of these workshops can bi-annually or quarterly.

d. Each Institute should retain a comprehensive, professionally constructed, web-site.

e. Projects involving more-than-one Institute should be considered, as this will increase the cross-fertilization of technologies within each Institute.

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

a. Number of projects transferred to Industry by each Institute or a group of Institutes.

b. IP portfolio generated by each Institute or a group of Institutes together including number of patents. Also, how the Industry uses this IP/patent portfolio (e.g., are there any projects that the Industry is willing to fund a technology to mature it for manufacturing and eventual production ?).

c. Number of start-up Companies generated by each Institute or a group of Institutes.

d. Impact of the Institutes network on local economy, including jobs creation.

C. Strategies for Sustainable Institute Operations

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

a. Initial funding should be provided by the Federal Government. Funding should be sufficient, so, each Institute has the necessary resources to succeed and eventually be self-sustaining.

b. Allow some of the initial funding (modest in value) to be used for selected cases abroad U.S. to allow for technology transfer to U.S. from foreign entities.

c. Funding should be for the Institutes set-up infrastructure involving administrative personnel, research staff, equipment, facilities, and leadership.

d. Each Institute should have a plan that after 3-4 years to start getting Industry funding contributions. In a 7- or 8-year period (but no more than 10), each Institute should be **almost** self-sufficient getting funding from Industry and/or other Federal/State Government grants.

e. The Government should consider to provide to the Institutes a "*base*" funding during their life-time, which can be used for "*infrastructure sustainment*" and "*seed money*" for advanced manufacturing project ideas that Industry might not immediately participate or fund, but, will participate and fund after proof-of-principle.

f. The NNMI program must fund initially a number of projects demonstrating "*early successes*" that could attract Industry's interest. However, a portion of funding should also be allocated for high-risk, but high-payoff, projects in order not to stifle innovation. A 70/30 funding ratio initially could be workable (70% for early demos, and 30% for more long-term).

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

a. Per 10c above, initial funding should be by the Federal Government with private funding starting in 3-4 years. Within a 7- or 8-year period (but no more than 10), each Institute should be **almost** self-sufficient (see additional and related comments on 10e above).

b. Institutes could seek private or Government/State grants, could offer training courses (with certification) to collect fees, offer consultation to Industry at a fee, collect fees on IP licensing and/or from patents, retaining a share in starting new Companies, and collecting a membership fee of participating Companies in a Consortium.

c. Co-investment proportions could vary, but a viable model could be that initially the Institute funds a project to start (seed funding); this could be for 1 or 2 years. After the 2-year period, Industry participates with funding starting at 25%, but based on progress, Industry's share increases to 50% or better after a 3 to 4 years period. These co-investments arrangements will be project-specific, and may not apply to all projects pursued by the Institute.

d. Federal Government should also consider giving a special status to the NNMI Institutes, renewable after some time period, to ease the contract vehicle for the case the Government (any Government Agency) would like to utilize the expertise and resources of the Institutes via grants or other funding instruments. UARC or FFRDC should be avoided, since these designations may restrict the Institute to compete openly for Government projects.

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

a. Progress to self-sustainment per items 11a-11c above.

b. Number of Companies participating in the Institute including **a)** the number of new Companies joining the Institute each year, and **b)** those cease to participate.

c. Ratio of Institute-seeking and acquired investment with respect to that provided solely by the NNMI program after an initial period of 3-4 years.

d. Ratio of Institute-seeking investment as a goal versus that actually acquired/realized. A high ratio will indicate that the Institute is well focused, and well regarded by potential investors and is on the road of self-sustainment, whereas a low ratio will indicate performance and/or technologies-pursued issues.

e. Evaluate bi-annually the Business Plan of each Institute for progress along all technology and management tenets (per #5 above).

f. Technology transfer to Industry and actual potential revenue that could be generated (or is generated) from these initiatives.

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

a. Allow some funding to be used for selected advanced technologies abroad (better in maturation than in U.S.) that could facilitate the technology "*know-how*" and "*transfer*" from foreign Institutions and/or Companies to U.S. Also, allow some funding to be used at foreign Institutions and/or Companies for using their facilities to realize a technology product, if such facilities are not available in U.S.

b. Encourage funds to be used to support U.S. researchers abroad for education and training purposes, where relevant technologies of interest to the Institute(s) appear to be more advanced in foreign institutions.

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

a. Programs relevant to Institute's core mission should organize join workshops. Also, leadership of those programs could participate in the Institute's Technical Advisory Group per #6e above.

b. Invite in the annual review of the Institutes, and/or Institutes-organized workshops, the leadership of these relevant programs per #6f above.

c. Hold periodic meetings discussing program planning in order to minimize technology overlaps (**Comment** – some overlap might be desirable).

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

a. Invite representatives of the state and local economic authorities to attend meetings of the governing board and provide suggestions.

b. Create state-funded technology "*hubs-of-excellence*" within the State (or States), where students of Community Colleges and pre-colleges (e.g., K-12) can participate in joint projects with the Institute. Some seed funding could be provided by the Institute, with Federal/State Governments assuming additional funding obligations.

c. Emphasize the creation of these "*hubs-of-excellence*" to support under-privileged and veteran Communities within the State (or States).

d. Consider small pilot projects to under-privileged and veteran Communities funded jointly by the Institute and the State.

e. Develop focused, domain-specific, training courses and associated training practices for workforce development.

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

a. Competiveness:

- Number of innovative products, through technology transfer to industry, produced as a result of Institute activities including patent portfolio.
- Impact of innovative products exported abroad by relevant Industry that were produced as a result of Institute's activities.
- Number of personnel fully trained in manufacturing technology including the systems aspects (i.e., system engineering, processes, etc.).
- Progress on *"market-value"* created by the Institute activities to local, and possibly national, economy.
    - *Market-value* can be defined in terms of many factors. Many of those may include, but not limited to, the number of jobs created, gross revenue from sale of products influenced by the Institute activities, etc.

- Number of Jobs created and sustained after a 5-year period as a result of the Institute activities.
- Number of start-ups created, and became viable after some time period.
- Number and type of civic events performed by the Institute's personnel with respect to *Education* of residents in the local communities. This might include lectures, seminars, talks, etc. given by the Institute to local K-12 schools, Community Colleges, Colleges, Professional Associations (e.g., IEEE), etc.

b. National Security:

- Monitor the number of innovative projects, and rate of their maturity, that have relevance to DoD, and other Government at large, applications to provide military and civil (e.g., police) superiority to armed forces.
- Safeguard such technologies without stifling innovation.
- Number of DoD projects executed in the Institute, and mission successes resulting from DoD projects executed in the Institute.

D. Education and Workforce Development

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

a. Develop/provide domain-specific courses and training programs at all educational levels (vocational, under-graduate, graduate).

b. Use Information Technology to deliver these courses remotely to locations not close to the Institute or to Institutions providing these courses.

- Use technology related to Distance Education Networks (as an example, see USC's Distance Education Network).

c. Provide courses either for degree and/or certification.

d. Develop programs for hands-on training involving teams of people of diverse disciplines and/or specialties.

e. Courses should be tailored to all levels of workforce: Educating/training of Managers, Development Staff, Production, etc.

f. Courses should not only aim to provide technical skills, but also processes, like system engineering, supply-chain management, etc.

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

a. Poll local Industry, and Industry at large, to understand some of the typical factors [3] used by Industry in business decision-making:

- What workforce-related factors are considered when Corporations establish their product development and distribution strategy.
- What are the operational areas the Industry experiences most difficulties in workforce hiring.
- What employee segments have workforce shortages that had a significant impact on a Corporation strategy to locate its operations in a community.

[3] An excellent survey on these issues is provided in reference " Boiling Point: The Skills Gap in U.S. Manufacturing", Deloitte Consulting Corporation.

- What methods/processes Corporations currently use to mitigate existing skill-gaps in workforce.

b. Develop programs chosen/developed jointly with the participating Companies.

c. Provide close cooperation between the NNMI Institutes and appropriate Industry, with industry involvement at all levels of the Institute operations (See also, items #6 and #8 above).

d. Encourage internships of Institutes researchers/students in Industry, also, encourage Industry staff to undertake an "*in-residence*" assignment in the Institute under a term appointment.

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

a. Provide an avenue to integrate relevant on-going manufacturing educational activities within the NNMI structure.

b. In cases, as appropriate, enhance existing educational programs, rather than developing new ones.

c. Provide through the NNMI Institutes consistent updates on existing training programs to keep-up with technology advances. The NNMI Institutes can review these programs and determine updates as needed.

d. Develop an advanced *manufacturing floor* within the Institute to be used as a prototype facility for advanced development of the manufacturing processes and/or products; also, to be used for training. As an example, model this initiative similarly to USC's Space Education & Research Center (SERC), where students, faculty, researchers, and other technical staff, all working together to develop/produce a flight-worthy satellite launched to space under U.S. Government arrangements.

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

a. Number of relevant courses offered by the Universities participating in an NNMI Institute.

b. Number of students involved in those courses including the graduation rate.

c. Number of students employed, upon graduation, by the participating industry in an NNMI Institute, or Industry at large of same technology discipline.

d. Number of technical interactions, or other interaction at large (e.g., internships, in-residence joint developments, etc.), between the participating Industry and the NNMI institutions.

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

a. R&D activities should contain an element of education or results from a project that is a part of the course.

b. Availability of small pilot R&D projects for students, including students from Community Colleges working in a team with other College-level students, initiated on their own and related to their course work aiming to enhance the understanding of the course material.