Guide to FY2014 Research Funding

Advanced Manufacturing Initiative

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Summary and Index

Advanced manufacturing capabilities are essential for turning research discoveries, inventions, and new ideas into better or novel products—our nation’s ability to innovate. Innovation, in turn, drives U.S. economic growth and growth of U.S. productivity. The White House / Office Science and Technology Policy (OSTP) continue the national effort addressing Advanced Manufacturing which has significant research, development, demonstration and training opportunities. The focus of this guide is mainly on research programs open to Universities rather than industrial efforts.

Participating Federal agencies with significant programs, each having its own particular focus, are:
- DOD (DARPA) - disruptive manufacturing technologies with military impact
- DOD (MIPB) - manufacturing technologies and processes for defense systems
- DOE - energy and cost benefits of energy-efficient processes and materials
- Dept. of Labor (DOL) / Dept. of Education (ED) - innovative workforce solutions – training
- NASA - manufacturing requirements for space transportation systems
- NIST - standards, metrology, calibration, manufacturing extension partnerships
- NSF - fundamental research leading to transformative advances in manufacturing

Descriptive of Advanced Manufacturing Federal Programs

Participating Agency Program  
1. Initiative Overview  
2. Participating Agency Program  
3. Resources

FY2013/14 New Program and/or Significant Funding Opportunities

University lead

NSF Cyber-Enabled Materials, Manufacturing, and Smart Systems  
Advanced Manufacturing (Engineering Directorate)  

Industry Oriented (with academic contribution)

NIST National Network for Manufacturing Innovation  
DOE EERE Advanced Manufacturing R&D Projects  
DOE EERE Clean Energy Manufacturing innovation Institutes  
DOE EERE Innovations in Manufacturing Competitiveness  
DOE ARPA-E Stationary Power Systems  
DOD Lightweight and Modern Metals Manuf Innovation  
DOD Digital Manufacturing and Design Innovation Inst  
DOD DARPA Living Foundries

Projected FY14 ($M)  

Appendix 1: FY2014 New Basic Research Programs and/or Significant Change  
Appendix 2: Data Sheets on Key Advanced Manufacturing Leaders  
Appendix 3: Acronym Glossary, including Manufacturing Readiness Levels
**Initiative Overview**

Advanced manufacturing capabilities are essential for turning research discoveries, inventions, and new ideas into better or novel products—our nation’s ability to innovate. Innovation, in turn, drives U.S. economic growth and growth of U.S. productivity. There are many interrelated elements of an innovation ecosystem—entrepreneurs, workers, tax policies, to name a few—but without manufacturing, the economic power and dynamism of innovation fade.

The 2012 National Strategic Plan for Advanced Manufacturing recommends meeting five objectives:

- Accelerate investment in advanced manufacturing technology, especially by small and medium-sized manufacturing enterprises, by fostering more effective use of Federal capabilities and facilities, including early procurement by Federal agencies of cutting-edge products.
- Expand the number of workers who have the skills needed by a growing advanced manufacturing sector and make the education and training system more responsive to the demand for skills.
- Create and support national and regional public-private, government-industry-academic partnerships to accelerate investment in and deployment of advanced manufacturing technologies.
- Optimize the Federal government’s advanced manufacturing investment by taking a portfolio perspective across agencies and adjusting accordingly.
- Increase total U.S. public and private investments in advanced manufacturing research and development (R&D).

Funding for advanced manufacturing research is distributed among several Federal agencies, each having its own particular focus:

- DHS - security of manufacturing facilities
- DOD (DARPA) - disruptive manufacturing technologies with military impact
- DOD (MIPB) - manufacturing technologies and processes for defense systems
- DOE - energy and cost benefits of energy-efficient processes and materials
- DOL / ED - innovative workforce solutions – training
- NASA - manufacturing requirements for space transportation systems
- NIST - standards, metrology, calibration, manufacturing extension partnerships
- NSF - fundamental research leading to transformative advances in manufacturing
- SBA – Entrepreneurial Mentor Corps

The Federal effort is coordinated by the Advanced Manufacturing National Program Office (AMNPO, http://www.manufacturing.gov/amnpo.html). The AMNPO, housed by NIST, is staffed by representatives from federal agencies with manufacturing-related missions (DOD, DOE, NASA, and NSF) as well as by fellows from manufacturing companies and universities. As recommended in the President’s Council of Advisors on Science and Technology (PCAST) advanced manufacturing report, the AMNPO is charged with:

- Convening and enabling industry-led, private-public partnerships focused on manufacturing innovation and engaging U.S. universities, and
• Designing and implementing an integrated advanced manufacturing initiative to facilitate collaboration and information sharing across federal agencies. Its director is NIST's Mr. Michael Molnar (see data sheet in Appendix 2).

**Participating Agency Programs**

1. **National Network for Manufacturing Innovation (NNMI)**
   http://manufacturing.gov/amp/nnmi.html
   A total of 15 NNMI centers are projected; funding for those centers will be in the NIST budget line (~$1B in the requested NIST budget). The National Network for Manufacturing Innovation (NNMI) initiative will:
   
   • Induce industry and non-federal co-investment to rapidly seize innovation opportunities that lead to industrial capabilities
   • Promote direct collaboration on industry-relevant research and development to address emerging technology areas where market failures are causing U.S. innovations to be scaled and manufactured elsewhere
   • Facilitate the adoption of new manufacturing technologies, tools, and methodologies that will make U.S. manufacturers more competitive
   • Support identification and diffusion of "best practice" approaches to governance structure, IP management, partnering, facilities access, etc.

   The Center research, development and demonstration efforts will focus on Technology Readiness Levels 4-7, i.e., from component and/or breadboard validation in the laboratory environment through system prototype demonstration in an operation environment. The Institutes will bring together industry, universities and community colleges, federal agencies, and regional and state organizations to accelerate innovation by investing in industrially relevant manufacturing technologies with broad applications. The Federal contribution is estimated at ~$70M over five years, to be matched 1:1 by other sources.

   While waiting for the requested NNMI appropriation, “pilots” have been initiated using reprogramed agency funds. In August 2012, the National Center for Defense Manufacturing and Machining (NCDMM) was selected to lead the National Additive Manufacturing Innovation Institute (NAMII, http://namii.org/). NAMII (funded by DOD, DOE, NIST, NSF and NASA) provides the innovation infrastructure needed to support new additive manufacturing technology and products. Three additional pilot competitions were announced in 2013:
   
   • Lightweight and Modern Metals Manufacturing Innovation (LM3I)
     ONR BAA 13-019
   • Digital Manufacturing and Design Innovation (DMDI)
     AMRDEC ACC-RSA BAA 13-01DMDI
   • Clean Energy Manufacturing Innovation Institute (CEMI)
     DOE EERE DE-FOA-0000683

2. **NSF**
   a. Advanced Manufacturing Cluster (in the CMMI Division, Engineering Directorate)
   http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503287&org=CMMI&from=home
   Dr. Steven McKnight, Division Director (see Appendix 2 for a data sheet)
   The Advanced Manufacturing Cluster supports fundamental research leading to transformative advances in manufacturing and building technologies across size scales from nanometers to kilometers, with emphases on efficiency, economy, and minimal environmental footprint.
Research is supported to develop predictive and real-time models, novel experimental methods for manufacturing and assembly of macro, micro, and nanoscale devices and systems, and advanced sensing and control techniques for manufacturing processes.

b. Cyber-enabled Materials, Manufacturing, and Smart Systems (CEMMSS)
This is an NSF interdisciplinary program that includes investments by four NSF Directorates – Computer and Information Science and Engineering (CISE), Biological Sciences (BIO), Mathematics and Physical Sciences (MPS) and Engineering (ENG). The goal is to establish a scientific basis for the discovery, design development and production of new materials, and to develop and deploy advanced manufacturing methods to produce artifacts and systems with superior functionality, including embedded intelligence to make them smart, response, and adaptive.

c. Adv. Manufacturing Technologies in the Advanced Technological Education (ATE) program
http://atecenters.org/advanced-manufacturing-technologies/
Division of Undergraduate Education, Education and Human Resources Directorate
The Advanced Technological Education (ATE) program endeavors to strengthen the skills of technicians, whose work is vitally important to the nation’s prosperity and security. In ATE centers and projects, community colleges have a leadership role and work in partnership with universities, secondary schools, business and industry, and government agencies to design and carry out model workforce development initiatives. The publication “ATE Centers Impact 2011” describes the effort and impact of the ATE centers.

3. National Institute of Standards and Technology (NIST)
Providing technical support to the nation’s manufacturing industries as they strive to out-innovate and outperform the international competition has always been one of NIST's top priorities.

a. Measurement Science and Engineering (MSE) Research Grant Programs
http://www.nist.gov/director/ocfo/grants/grants.cfm
The Engineering Laboratory grant program operates within three major goals: Disaster-resilient buildings, infrastructure and communities; sustainable and energy-efficient manufacturing, materials, and infrastructure; and smart manufacturing, construction and cyber-physical systems.

1. The Systems Integration Division: Pursues state-of-the-art, information technology-based solutions to manufacturing systems integration problems. The contact person for this division is Vijay Srinivasan, (301) 975-3508 or vijay.srinivasan@nist.gov.

2. The Intelligent Systems Division: The primary objective is to collaborate with or conduct research consistent with NIST laboratory programs and research in manufacturing process and equipment interoperability, industrial control system security, intelligent systems and robotics, and intelligent control of mobility systems; machine tool and machining process metrology; smart manufacturing systems; and sensor networking and integration. The contact person for this division is Albert Wavering (301) 975-3418 or albert.wavering@nist.gov.
b. Advanced Manufacturing Technology Consortia (AMTech)
http://www.nist.gov/ampo/about.cfm
The AMTech Program is new in FY2013 and is located in the AMPO. AMTech’s aim is to catalyze partnerships between U.S. industry, academia, and government that will support efforts to meet the long-term research needs of U.S. industry. More specifically, the AMTech Program will help to establish, or strengthen existing, industry-led technology consortia for the purpose of identifying and prioritizing research projects that reduce barriers to the growth of advanced manufacturing in the United States.

c. Hollings Manufacturing Extension Program (MEP)
http://www.nist.gov/mep/index.cfm
The MEP works with small and mid-sized U.S. manufacturers to help them create and retain jobs, increase profits, and save time and money. The nationwide network provides a variety of services, from innovation strategies to process improvements to green manufacturing. MEP also works with partners at the state and federal levels on programs that put manufacturers in position to develop new customers, expand into new markets and create new products.

4. Department of Energy (DOE)

https://www1.eere.energy.gov/manufacturing/about/index.html
The AMO (formerly the Industrial Technology Program, ITP) works with diverse partners to develop and deploy technologies and practices that will help U.S. manufacturers succeed in global markets. AMO R&D funding moves innovative, pre-competitive projects along the technology pipeline - bridging the traditional "Valley of Death" for emerging technologies. Dr. Robert Ivester is Acting Director; Dr. Dev Shenoy is Chief Engineer (see Appendix 2 for data sheets).

i. Next Generation Manufacturing Processes
Novel processing concepts can open pathways to double net energy productivity, enabling rapid manufacture of energy-efficient, high-quality products at competitive cost. Four funded process technology areas are expected to generate large energy, carbon, and economic benefits across the manufacturing sector.

- Reactions and Separations
- High-Temperature Processing
- Waste Heat Minimization and Recovery
- Sustainable Manufacturing

ii. The Innovative Manufacturing Initiative (IMI)
The IMI leads AMO’s public-private R&D partnership activities. IMI supports the development of advanced manufacturing process and materials technologies that will transition scientific innovations into clean-energy manufacturing capabilities. Cost-shared projects are selected through a competitive process. Initial awards (2011 solicitation DE-FOA-0000560) have been announced - thirteen in 2012, and 5 in 2013.

iii. Manufacturing Demonstration Facilities (MDF)
https://www1.eere.energy.gov/manufacturing/rd/mdf.html
MDFs are collaborative manufacturing communities that share a common RD&D infrastructure. This shared infrastructure provides affordable access to advanced physical and virtual tools for rapidly demonstrating new manufacturing technologies and optimizing critical processes. Oak Ridge National Laboratory is home to AMO’s only MDF;
it is focused on Additive Manufacturing and Low-cost Carbon Fiber. No new MDFs are projected; the CEMI Institutes will be created instead.

iv. Clean Energy Manufacturing Initiative (CEMI)
http://www1.eere.energy.gov/energymanufacturing/index.html
CEMI is a strategic integration and commitment of manufacturing efforts across the Office of Energy Efficiency & Renewable Energy’s (EERE) clean energy technology offices and Advanced Manufacturing Office, focusing on American competitiveness in clean energy manufacturing. A 2013 announced solicitation will focus on wide bandgap semiconductor technology. A possible three CEMI Institutes are projected for FY2014.

b. Solar Manufacturing Technology Program (in EERE)
Innovations in Manufacturing Competitiveness
In FY 2012 and FY 2013 SUNPATH awards were fully funded and require no additional resources in FY 2014; assessment of the impacts of these awards is pending. Instead, a SolarMat solicitation (DE-FOA-0000862, due date May 2013) was run to support research and development of manufacturing technologies that will assist industry in the United States to be competitive globally.

c. ARPA-E
http://wwwarpa-e.energy.gov/
ARPA-E catalyzes transformational energy technologies that could create a more secure and affordable American future. There are no programs specifically focused on manufacturing, but a number of projects do address the topic.

d. Basic Energy Sciences (BES, in the Office of Science)
http://science.energy.gov/bes/
BES does not have any manufacturing science program per se, but a number of the programs are important to manufacturing, e.g., synthesis and processing, catalysis, and separations and analysis.

5. Department of Defense (DOD)

a. Office of Manufacturing and Industrial Base Policy (MIBP)
http://www.acq.osd.mil/mibp/
MIBP supports the Office of the Secretary of Defense and Service Acquisition by providing detailed analyses and in-depth understanding of the increasingly global, commercial, and financially complex industrial supply chain essential to our national defense. MIBP supports responsible investment to advance industrial productivity through a variety of authorities and programs, including the Defense Production Act and Manufacturing Technology (ManTech). MIPB is working through ONR and the Army Material Command to implement the two DOD pilot NNMI announced in 2013.

DOD ManTech Centers of Excellence
http://www.dodmantech.com/index.asp
The manufacturing centers of excellence (COEs) sponsored by the ManTech Programs of the Army (1 COE) and Navy (10 COEs) provide a focal point for the development and transfer of new manufacturing processes and equipment in a cooperative environment with industry, academia, and DOD activities. The COEs:
Develop and demonstrate manufacturing technology solutions for identified defense manufacturing issues;
Serve as corporate residences of expertise in their particular technological areas;
Provide consulting services to defense industrial activities and industry;
Facilitate the transfer of developed manufacturing technology.

b. DARPA

- Defense Science Office (DSO) Disruptive Manufacturing Technologies Program
  The Disruptive Manufacturing Technologies (DMT) program will develop manufacturing capabilities that are affordable at small volumes and with reduced delivery times. Specific objectives include:
  - Developing nonautoclave manufacturing technology for production of polymer matrix composites for aerospace components and establishing a robust process for full-size components.
  - Eliminating costly mold-making steps in the manufacture of precision airfoils through digital fabrication.
  - Demonstrating low-cost synthesis of boron carbide armor for personnel and vehicles via plasma synthesized nanoscale powder and pressureless sintering.

- Microsystems Technology Office (MTO)
  http://www.darpa.mil/Our_Work/MTO/Focus_Areas/Manufacturing.aspx
  MTO seeks to develop techniques that will provide system developers the ability to determine the function of digital, analog and mixed-signal ICs non-destructively. Additionally, the office seeks revolutionary circuit design methodologies combined with hybrid lithography tools to enable cost-effective, low-volume fabrication of application specific integrated circuits (ASICs) for DoD applications. Existing programs are:
  - Carbon Electronics for RF Applications
  - Chip-Scale Vacuum Micro Pumps
  - Gratings of Regular Arrays and Trim Exposures
  - Integrity and Reliability of Integrated Circuits
  - Leading Edge Access Program
  - Maskless Nanowriter
  - Nano Electro Mechanical Computers
  - Self HEALing Mixed Signal Integrated Circuits
  - Tip Based Nanofabrication
  - Trusted Integrated Circuits

- Tactical Technology Office (TTO) Adaptive Vehicle Make (AVM) Program
  AVM is a portfolio of programs that address revolutionary approaches to the design, verification and manufacturing of complex defense systems and vehicles. The portfolio consists of three primary programs: META, Instant Foundry Adaptive through Bits (iFAB), and Fast Adaptable Next-Generation Ground Vehicle (FANG). The FANG program encompasses vehicleforge.mil, three AVM Prize Challenges, and the Manufacturing Experimentation and Outreach effort.
c. Each OXR (the three service research funding offices) has selected manufacturing opportunities at the program officer level. In particular, the Office of Naval Research has a specific manufacturing component in its ManTech program (Code 03TMT), including a program on Cyber-enabled Manufacturing Systems (CeMS, BAA 11-003).

6. NASA
National Center for Advanced Manufacturing (NCAM)
http://mafspacemsfc.nasa.gov/tenants_ncam.html
NCAM combines education, research, and manufacturing to provide leadership in technology. It is located in New Orleans, Louisiana on NASA’s Michoud Assembly Facility. NCAM is a partnership between NASA, the State of Louisiana, and The University of New Orleans, which leads a consortium of 7 Universities. The purpose of the partnership is to:
- Address NASA’s needs in research and technology development,
- Build the technology base for manufacturing next generation launch vehicle systems.

7. Department of Labor (DOL) - Education and Training Administration (DOLETA)
http://www.doleta.gov/BRG/Indprof/Manufacturing.cfm
The U.S. Department of Labor has announced a series of investments totaling more than $100M to address the workforce needs of the advanced manufacturing industry (“Job Training for Employment in High Growth Industries” and “Work Information, Electronic Tools, System Building”). The grants are intended to provide genuine solutions, leadership, and models for partnerships that can be replicated across the country.
- Trade Adjustment Assistance Community College and Career Training Grant Fund (TAACCCT)
http://www.doleta.gov/taaccct/
TAACCCT provides community colleges and other eligible institutions of higher education with funds to expand and improve their ability to deliver education and career training programs that can be completed in two years or less, are suited for workers who are eligible for training under the TAA for Workers program, and prepare program participants for employment in high-wage, high-skill occupations. Through these multi-year grants, the Department of Labor is helping to ensure that our nation’s institutions of higher education are helping adults succeed in acquiring the skills, degrees, and credentials needed for high-wage, high-skill employment while also meeting the needs of employers for skilled workers. The Department is implementing the TAACCCT program in partnership with the Department of Education.

The FY2014 budget request has a FY2015 program as follow-on to TAACCCT. It would split $8B funding for a proposed Community College to Career Fund between the U.S. Departments of Labor and Education over three years. The Community College to Career Fund will advance skill building through funding a number of priority areas:
- Developing community college partnerships to train skilled workers for unfilled jobs
- Instituting “Pay for Performance” in job training
- Bringing jobs back to America
- Training the next generation of entrepreneurs

- Job Training for Employment in High Growth Industries
http://www.doleta.gov/brg/jobtraininitiative/
The Department’s ongoing dialogue with employers in demand sectors such as information technology, communication and broadband technology, advanced manufacturing, and health care and health information technology has confirmed that there are jobs in the United States that are going unfilled. The Department’s long-term goal is to decrease the need for visas by helping American workers develop the high level skills needed by these employers.

- Work Information, Electronic Tools, System Building
  Programs funded through the Workforce Information/E-Tools/System Building budget line item assist working-age individuals, employers, government entities, and non-profit organizations. The resources supported through this line item are foundational to creating innovative workforce strategies to ensure a skilled workforce for renewable energy, energy efficiency, health care, broadband and telecommunications, advanced manufacturing, and other high demand and emerging industries and occupations providing good jobs for workers.

**Resources**

1. Interagency Working Group on Advanced Manufacturing
   [http://www.whitehouse.gov/administration/eop/ostp/nstc/committees/cot](http://www.whitehouse.gov/administration/eop/ostp/nstc/committees/cot)
   The interagency working group (IAWG) focused on Advanced Manufacturing (IAM) as a subcommittee of the National Science and Technology Council’s (NSTC) Committee on Technology in the President’s Office of Science and Technology Policy (OSTP).

2. Advanced Manufacturing Partnership (AMP)
   This private-sector-led effort is guided by a Steering Committee, which operates within the framework of PCAST and comprises leading experts from industry and academia. AMP’s mission is to identify opportunities for investments in R&D, precompetitive collaboration, and shared facilities and infrastructure that have the potential to transform advanced manufacturing in the United States.

3. Advanced Manufacturing Portal (AMP)
   This site is a “one-stop shop” for news and information on advanced manufacturing programs and related activities under way in federal agencies with science and technology missions. These include interagency initiatives, such as the proposed National Network for Manufacturing Initiative coordinated by the Advanced Manufacturing National Program Office, as well as agency-specific programs.

4. Data.gov - Manufacturing
   The Federal datasets on this site contain information on manufacturing. It will be enhanced with the addition of new datasets, and new apps using these datasets, as they are developed.

5. National Nanotechnology Initiative (NNI)
   [http://www.nano.gov/node/831](http://www.nano.gov/node/831)
   The NNI has instituted a signature initiative on sustainable manufacturing.
6. Materials Genome Initiative (MGI)  
http://manufacturing.gov/amp/materials_genome_initiative.html  
The MGI aims to double the speed at which we discover, develop, and manufacture new materials.

7. National Robotics Initiative (NRI)  
The NRI is to accelerate the development and use of robots in the United States that work beside, or cooperatively with, people.

8. National Center for Manufacturing Sciences (NCMS)  
http://www.ncms.org/  
The National Center for Manufacturing Sciences fuels innovative solutions for manufacturers. A nonprofit, member-based consortium, the organization's objective is to drive the global competitiveness of North American Manufacturers through collaboration, innovation, and advanced technologies.

9. For access to the information on the Research Advancement’s Central Desktop website Mission Agency Program Site (MAPS), contact NLWalker@usc.edu for user name and password.

The MAPS site has:  
Under “Wiki” Tab - how to use the site  
Under “Files/Discussion” Tab  
Mission Agency (DHS, DOD, DOE, DoEd, EPA, NASA, NIST, NOAA, USDA and cross agency programs in Adv Manuf, Sustainability, STEM Education)  
Guide to Agency Funding for FYXX  
Agency Research Program Charts  
Agency Planning Documents  
Program Officer Data sheets (with contact info, biosketch, program descriptive, personal pubs)  
Program Officer presentations (when available)  
Proposal Writing Guides  
Under “Database” Tab  
USC MAPS - table of all program officers / programmatic interests

**Assistance in Locating Funding and Preparing Proposals**  
Dr. James S. Murday  
DC Office of Research Advancement  
Tel: 202 824 5863  
Email: Murday@usc.edu
Appendix 1: New Project or Significant Growth in FY2014

NSF

Cyber-Enable Materials, Manufacturing, and Smart Systems from $142M in FY2013 to $300M

The CEMMSS focus will be on evolving a comprehensive, integrated program across the focus areas to encourage new connections, discoveries, and/or emerging fields of science and engineering. Investments will be made in advanced manufacturing ($160M), including investments in:

- scalable nanomanufacturing ($10M);
- cyber-physical systems ($50M);
- core programs that integrate materials science and engineering with processing, design, and manufacturing research ($36M);
- Designing Materials to Revolutionize and Engineer our Future/MGI ($42M); and
- National Robotics Initiative ($32M).

A workshop is planned to bring together communities engaged in materials research on sensors and detectors with those in manufacturing and cyber-physical systems. This will enhance community building and identify science and engineering challenges for this new community. In addition, CEMMSS will conduct a round of challenges and contests.

Advanced Manufacturing (Engineering Directorate) from $48M in FY2012 to $78M

ENG will strategically invest additional funds across the directorate in advanced manufacturing to support innovations in multi-scale modeling for simulation-based design and manufacturing across the supply chain, nanomanufacturing, innovative materials and manufacturing processes, energy systems manufacturing, and complex engineering systems design and manufacturing.

NIST Advanced Manufacturing Initiatives

AMTech from 0 in FY2013 to $21M

AMTech will provide grants to leverage existing consortia or establish new industry led consortia to develop road-maps of critical long-term industrial research needs as well as fund research at leading universities and government laboratories directed at meeting these needs. In FY 2014 the number of planning awards ($500,000 or less) may be commensurate with or exceed the number of large ($1-5 million) implementation awards to established consortia for targeted research following their technology roadmap.

National Network for Manufacturing Innovation (NNMI) from 0 in FY2013 to $1B

Launch a network of up to 15 manufacturing innovation institutes across the country. Each institute would bring together companies, university and community colleges, and government to co-invest in the development of cutting-edge manufacturing technologies and capabilities that U.S. manufacturers can apply in production. The NNMI will fill a gap in the innovation infrastructure, allowing new manufacturing processes and technologies to progress more smoothly from basic research to implementation in manufacturing. A network leadership council will disseminate best practices and facilitate collaboration among the institutes.

Hollings Manufacturing Extension Partnership (MEP) from $129M in FY2013 to $153M

MEP is a Federal-State-industry partnership that provides U.S. manufacturers with access to technologies, resources, and industry experts. The program consists of 60 MEP Centers that work directly with their local manufacturing communities to strengthen the competitiveness of
our Nation's domestic manufacturing base.

**DOE EERE**

**Advanced Manufacturing R&D Projects:** from $60M in FY2012 to $120M

Focuses on foundational manufacturing processes and materials. The additional funding will provide strengthened support to address core technical issues for foundational technologies that will enable U.S. manufacturers to realize significant gains in energy productivity, environmental performance, product yield, and economic growth. This will allow the program to increase the number of targeted Advanced Manufacturing Project funding opportunities to at least 3 in FY 2014. Each FOA will provide between $20 million and $40 million to support projects in different foundational technology areas, which includes a FOA to support the AMO Incubator Activity. This represents a strategy to focus on high priority foundational technologies through targeted investments based on analyses of impact and alignment with U.S. competitive advantages, versus the one broad FOA for Innovative Manufacturing Initiative projects, which closed in FY 2012.

**Clean Energy Manufacturing Innovation Institutes** from 15M in FY2012 to $193M

The program’s facilities focus on the development – through targeted and innovative shared facilities and capabilities – of new materials and associated production technologies that can reduce costs, reduce energy use, improve product quality, and enhance productivity for U.S. manufacturers. The first Institute for the program will target wide bandgap semiconductor power electronics devices, a foundational technology for power conversion-dependent clean energy technologies.

**Solar Energy**

**Innovations in Manufacturing Competitiveness** from 0 in FY2013 to $50M

In FY 2014 introduce SolarMat II - A solicitation will be run to support research and development of manufacturing technologies that will assist industry in the United States to be competitive globally.

**DOE ARPA-E**

**Stationary Power Systems** from $115M in FY2013 to $148M

As part of the proposed increase, ARPA-E may investigate opportunities in novel materials and manufacturing for energy applications including further advances in low-cost semiconductor materials, magnetics and motors, and low-cost/light-weight materials and manufacturing technology to improve energy efficiency.

**DOD**

**Lightweight and Modern Metals Manuf. Innovation (LM3I)** from 0 in FY2013 to $17M

MIBP program, via its Manufacturing Technology Program and the Office of Naval Research. $70M Federal funding over 5 years to be matched 1:1 by other sources. The purpose of the Institute is to accelerate advances in lightweight and modern metals processing and fabrication technologies (in the target range of MRL 4-7) and facilitate technology transition to U.S. manufacturing enterprises. These manufacturing advancements, in-turn, will spur the development, demonstration, and integration of new material, component, and system designs, for DOD and commercial applications. The DOD vision for this Institute is to bring together large and small businesses, academia, and federal and state agencies to accelerate innovation by investing in industrially relevant advanced manufacturing technologies.
Digital Manufacturing and Design Innovation Inst. (DMDI) from 0 in FY2013 to $17M
MIBP program, via its Manufacturing Technology Program and the Army Materiel Command.
$70M in Federal funding over 5 years to be matched 1:1 by other sources. The DMDI Institute
will initiate a paradigm shift in the development, production and sustainment of complex
systems by accelerating the design to production timeline at reduced costs. The institute will
develop and execute opportunities to mature technologies from research executable in a lab
environment or prototype to that which is ready for industry acceptance as a standard business
practice, making a step-function improvement in the manufacturing capabilities in the U.S. This
research activity generally falls within a manufacturing readiness level (MRL) range of 4 to 7.

DOD/DARPA
Transformative Sciences – Open Manufacturing from $10M in FY2013 to $12M
The Open Manufacturing program will reduce barriers to manufacturing innovation, speed, and
affordability of materials, components, and structures. This will be achieved by investing in
technologies to enable affordable, rapid, adaptable, and energy-efficient manufacturing and to
promote comprehensive design, simulation and performance-prediction tools, and exposure to
best practices.

Living Foundries from $10M in FY2013 to $18M
The goal of Living Foundries is to create a revolutionary, biologically-based manufacturing
platform to provide new materials, capabilities, and manufacturing paradigms for the DOD and
the Nation. With its ability to perform complex chemistries, be flexibly programmed through
DNA code, scale, adapt to changing environments and self-repair, biology represents one of the
most powerful manufacturing platforms known. Living Foundries aims to provide game-
changing manufacturing paradigms for the DOD, enabling distributed, adaptable, on-demand
production of critical and high-value materials, devices, and capabilities in the field or on base.

Instant Foundry Adaptive Through Bits from $20M in FY2013 to $26M
Formerly part of the META Program, Instant Foundry Adaptive Through Bits (iFAB) will lay the
groundwork for the development of a foundry-style manufacturing capability--taking as input a
verified system design specified in an appropriate metalanguage--capable of rapid
reconfiguration to accommodate a wide range of design variability and specifically targeted at
the fabrication of military ground vehicles.
Appendix 2: Key Program Leader Data Sheets

Dr. Charles (Chuck) E. Thorpe
Asst. Director for Advanced Manufacturing and Robotics
Office of Science and Technology Policy, White House
CThorpe@ostp.eop.gov

Biosketch:
Chuck Thorpe is Assistant Director for Advanced Manufacturing and Robotics OSTP. Named ASME Foundation Swanson Fellow in 2011. He is on loan from Carnegie Mellon University, where he is Professor of Robotics, and has been the Director of The Robotics Institute and Dean of Carnegie Mellon Qatar. His technical expertise is in intelligent vehicles, ranging from automated military vehicles in rough terrain to crash-avoidance technologies for highway driving.

Education
BS, in Natural Science from North Park College, Chicago, in 1974
Ph.D. in Computer Science from Carnegie Mellon in 1984

Illustrative Papers Reflecting Personal Research Interests:
Subgraph-preconditioned Conjugate Gradients for Large Scale SLAM
Dellaert Frank; Carlson Justin; Ila Viorela; et al.
IEEE International Conf on Intelligent Robots and Systems, 2566-2571 2010

EM, MCMC, and chain flipping for structure from motion with unknown correspondence
Dellaert F; Seitz SM; Thorpe CE; et al.
MACHINE LEARNING 50(1-20), 45-71 JAN-FEB 2003

Adaptive vehicle motion estimation and prediction
Zhao L; Thorpe CE

POINT-COUNTERPOINT - BIG ROBOTS VS SMALL ROBOTS
THORPE CE
Editor(s): Harmon J
PROC OF THE SPIE 1838, 78-88 1993

OUTDOOR VISUAL NAVIGATION FOR AUTONOMOUS ROBOTS
THORPE CE
INTELLIGENT AUTONOMOUS SYSTEMS 2, VOLS 1 AND 2, 530-544 1989
Mr. Michael F. Molnar
Chief Manufacturing Officer
NIST
301 975 3673
mike.molnar@nist.gov

Biosketch:
Michael F. Molnar was recently named as the first Chief Manufacturing Officer for the Commerce Department’s National Institute of Standards and Technology (NIST). The new position includes responsibility for planning and coordinating the Institute’s broad array of manufacturing research and services programs. It also includes serving as NIST’s central point of contact with the White House and other agencies on policy issues and initiatives related to manufacturing.

Molnar has extensive industrial experience and leadership roles including advanced manufacturing, metrology, manufacturing systems, quality, technology development, sustainability, and industrial energy efficiency. He served as Director of Environmental Policy and Sustainable Development at the Columbus, Ind., headquarters of Cummins Inc. Cummins is a $14 billion international company that designs and manufactures commercial engines and power generation systems. His credentials include service as a Federal Fellow in the White House Office of Science and Technology Policy, and election as Fellow of both the American Society of Mechanical Engineers and the Society of Manufacturing Engineers. He is a licensed Professional Engineer, a Certified Manufacturing Engineer, and a Certified Energy Manager. He is an active member of professional societies, consortia, and volunteer organizations.

Education
Master of Business Administration from the University of Notre Dame
MS in Manufacturing Systems Engr. and a BS in Mechanical Engr. from the Univ. of Wisconsin

Illustrative Papers Reflecting Personal Research Interests:
Paving the Way Through Recognition
Molnar Michael F.; Bohlander Ronald A.; Kurfess Thomas R.; et al.
MANUFACTURING ENGINEERING 142(2), 16-17 FEB 2009

Development of a standard reconfigurable assembly cell for agile manufacturing
Molnar M. F.; Fernandez R.; Huff B.
RECONFIGURABLE MANUFACTURING SYSTEMS AND TRANSFORMABLE FACTORIES, 273-294 2006

Hey, where’s MY personal robot?
Molnar MF; Borchelt RD
MANUFACTURING ENGINEERING 129(1), 74-79 JUL 2002
Dr. Steven H. McKnight
Director, Division of Civil, Mechanical, and Manufacturing Innovation
Engineering Directorate
National Science Foundation
smcknigh@nsf.gov
703 292 8360

Biosketch:
Appointed to NSF CIMMI August 17, 2009. He left the Army Research Laboratory, where he directed a comprehensive interdisciplinary materials research program that encompasses materials science and engineering, chemistry, applied physics, process and manufacturing technology, and engineering mechanics. He oversaw both in-house research and an extramural collaborative research program with 42 academic and 38 industrial partners.

McKnight began at ARL in 1996 as a materials research engineer, and he led the polymer engineering research team, the Polymers Research Branch, and the Multifunctional Materials Branch before becoming division chief. McKnight's personal research focuses on advanced polymer composite materials and polymer adhesion science, including innovative composites manufacturing techniques using non-traditional consolidation and curing methods for structural composite materials and composite material repair, tailored nanoscale engineering of composite fiber reinforcement for ballistic applications, and fundamental studies on the degradation mechanisms of multi-component, high-performance military coating systems.

Education
B.S. in materials engineering from Virginia Tech
Ph.D. in materials science and engineering from the University of Delaware.

Illustrative Papers Reflecting Personal Research Interests:
Effect of colloidal silica on the strength and energy absorption of glass fiber/epoxy interphases
Gao X.; Jensen R. E.; McKnight S. H.; et al.
COMPOSITES PART A-APPLIED SCIENCE AND MANUF 42(11), 1738-1747 NOV 2011

Electrospinning of polymer nanofibers with specific surface chemistry
Deitzel JM; Kosik W; McKnight SH; et al.
POLYMER 43(3), 1025-1029 FEB 2002

Accelerated curing of epoxy paste adhesives for repair of composites using induction heating
McKnight SH; Fink BK; Wells S; et al.
SOCIETY OF PLASTICS ENGINEERS TECHNICAL PAPERS 44, 1084-1088 1998
Dr. Robert W. Ivester  
Acting Director, Advanced Manufacturing Office  
EERE EE-2F, DOE  
202 586 9488  
Robert.Ivester@ee.doe.gov

Biosketch

Robert W. Ivester, Ph.D., currently serves as the Executive Secretary to the Interagency working group on Advanced Manufacturing, which was formed in 2011 under the NSTC Committee on Technology in the Executive Office of the President. The working group's primary purpose is to develop a national strategic plan for advanced manufacturing. Dr. Ivester's research interests include manufacturing process metrology, modeling, and optimization. Dr. Ivester has performed research to quantify uncertainty associated with measurements and model-based predictions of manufacturing process behavior. In particular, Dr. Ivester has performed extensive research on the measurement of temperature and strain during orthogonal cutting of metals. Dr. Ivester has been an instructor for the Johns Hopkins University Engineering for Professionals program for graduate-level studies in manufacturing engineering since 2001, including courses in design for manufacturability, manufacturing systems analysis, and computer-integrated manufacturing. February 2013 Fellow, American Society of Mechanical Engineers

Oct 2012 – Present  
Dept. Program Manager, EERE Adv. Manufacturing Office, DOE

Sep 2000 – Present  
Instructor, Johns Hopkins University

Feb 2010 – Oct 2012  
Manufacturing Engineer, NIST

Feb 2008 – Feb 2010  
Technical Analyst, NIST

Education

PhD, Mechanical Engineering from University of Massachusetts, Amherst  
M.S, and B.S. from the University of Massachusetts

Illustrative Publications Reflecting Personal Research Interests:

Productivity improvement through modeling: An overview of manufacturing experience for the food industry  
Ivester, Robert W.  
COMPREHENSIVE REVIEWS IN FOOD SCIENCE AND FOOD SAFETY 7, 1  JAN 2008

Comparison of measurements and simulations for machining of aluminum  
Ivester, RW; Whitenton, E; Deshayes, L  
TRANSACTIONS OF THE NORTH AMERICAN MANUFACTURING RESEARCH INSTITUTION OF SME 33, 429-436  2005

Accelerated wear tests for the Assessment of Machining Models calibration data  
Ivester, RW; Kennedy, M  
MACHINING SCIENCE AND TECHNOLOGY 6(3), 487-494  2002
Dr. Devanand (Dev) K. Shenoy  
Chief Engineer, Advanced Manufacturing Office  
EERE EE-2F, DOE  
202 586 5745  
Devanand.Shenoy@ee.doe.gov

Biosketch:  
Prior to DOE, Dr. Shenoy joined DARPA in August 2005 from the Naval Research Lab (NRL) in Washington, DC. He developed postdoctoral experience in laser light scattering from polymer systems at the Department of Macromolecular Science, Case Western Reserve University and later served as Research Faculty in Physics at the University of Nevada, Las Vegas. There, his fundamental contributions to the understanding of the polyethylene oxide/water system led to publications in high-impact journals such as Nature. As a research physicist at NRL, he led and contributed to several DoD projects including nanopore-based DNA sequencing, dispersion and alignment of single-walled carbon nanotubes for electronics and sensing, uncooled IR sensor based on pyroelectric liquid crystals, underwater acoustic detection utilizing high birefringence complex fluids, artificial muscles with nematic polymers, and noncontact photo-alignment of liquid crystal alignment layers.

Dr. Shenoy served on the DoD Display Technology Panel. He is a member of multiple scientific and technical societies, has more than 50 scientific and technical publications, a book chapter and an issued patent on molecular nanopores for DNA sequencing.

Education:  
B.Sc. in Physics, Chemistry and Mathematics at Bangalore University, Bangalore, India  
M.Sc. in Physics from the same University specializing in Solid State Physics  
Ph.D. in Physics from the Indian Institute of Science at Bangalore, India.

Illustrative Publications Reflecting Personal Research Interests:  
Supramolecular surface plasmon resonance (SPR) sensors for organophosphorus vapor detection  
Daly, Susan M.; Grassi, Michele; Shenoy, Devanand K.; et al.  
JOURNAL OF MATERIALS CHEMISTRY 17(18), 1809-1818  MAY 14 2007

Functional reconstitution of protein ion channels into planar polymerizable phospholipid membranes  
Shenoy, DK; Barger, WR; Singh, A; et al.  
NANO LETTERS 5(6), 1181-1185  JUN 2005

Nonideal elasticity in liquid crystal elastomers  
Shenoy, DK; Thomsen, DL; Keller, P; et al.  
JOURNAL OF PHYSICAL CHEMISTRY B 107(50), 13755-13757  DEC 18 2003
Appendix 3: Acronym Glossary

**General**
- AFOSR  Air Force Office of Scientific Research
- ARO  Army Research Office
- BAA  Broad Agency Announcement
- COE  Center of Excellence
- CFDA  Catalog of Federal Domestic Assistance
- DARPA  Defense Advanced Research Projects Agency
- DOC  Department of Commerce
- DOD  Department of Defense
- DoEd  Department of Education (alternative acronym)
- DOE  Department of Energy
- HHS  Department of Health and Human Services
- DHS  Department of Homeland Security
- DOI  Department of the Interior
- DOT  Department of Transportation
- ED  Department of Education (alternative acronym)
- EPA  Environmental Protection Agency
- FOA  Federal Opportunity Announcement
- HBCU  Historically Black College or University
- IAWG  Inter-Agency Working Group
- IHE  Institution of Higher Education
- NASA  National Aeronautics and Space Administration
- NGA  National Governors Association
- NIFA  National Institute for Food and Agriculture (part of USDA)
- NIST  National Institute of Standards and Technology (part of DOC)
- NIH  National Institutes of Health (part of HHS)
- NOAA  National Oceanic and Atmospheric Administration (part of DOC)
- NSF  National Science Foundation
- NSTC  National Science and Technology Council
- NRC  Nuclear Regulatory Commission
- MAPS  Mission Agency Program Site (USC DC Research Advancement website)
- ONR  Office of Naval Research
- OSTP  Office of Science and Technology Policy
- PCAST  President's Council of Advisors on Science and Technology
- R&D  Research and Development
- RF  Radio Frequency
- S&T  Science and Technology
- USDA  Department of Agriculture
- USGS  United States Geological Survey (part of DOI)

**Specific**
- AVM  Adaptive Vehicle Make (DARPA TTO program)
- AMO  Advanced Manufacturing Office (in EERE, DOE)
- AMNPO  Advanced Manufacturing National Program Office (hosted by NIST)
- AMP  Advanced Manufacturing Program
- AMPO  Advanced Manufacturing Program Office (hosted by NIST)
<table>
<thead>
<tr>
<th>Acronym</th>
<th>Description</th>
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<tbody>
<tr>
<td>AMRDEC</td>
<td>Army Aviation and Missile Defense Research and Development Center</td>
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<tr>
<td>AMTech</td>
<td>Advanced Manufacturing Technology Consortium (NIST program)</td>
</tr>
<tr>
<td>ASIC</td>
<td>Application Specific Integrated Circuits</td>
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<tr>
<td>ATE</td>
<td>Advanced Technological Education (NSF program)</td>
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<tr>
<td>AVM</td>
<td>Adaptive Vehicle Make (DARPA program)</td>
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<tr>
<td>BIO</td>
<td>Biological Sciences (NSF Directorate)</td>
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<tr>
<td>BioMaPS</td>
<td>Research at the Interface of the Bio, Math &amp; Physical Sciences (NSF program)</td>
</tr>
<tr>
<td>BES</td>
<td>Basic Energy Sciences (in Office of Science, DOE)</td>
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<tr>
<td>CEMI</td>
<td>Clean Energy Manufacturing Initiative (DOE EERE AMO program)</td>
</tr>
<tr>
<td>CEMMSS</td>
<td>Cyber-enabled Materials, Manufacturing, and Smart Systems (NSF program)</td>
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<tr>
<td>CeMS</td>
<td>Cyber-enabled Manufacturing Systems</td>
</tr>
<tr>
<td>CEO</td>
<td>Chief Executive Officer</td>
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<tr>
<td>CISE</td>
<td>Computer and Information Sciences (NSF Directorate)</td>
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<tr>
<td>CMMI</td>
<td>Civil, Mechanical, and Manufacturing Innovation Division, NSF</td>
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<tr>
<td>CTE</td>
<td>Career and Technical Education</td>
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<tr>
<td>DMDI</td>
<td>Digital Manufacturing and Design Innovation Institute (DOD program)</td>
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<tr>
<td>DMT</td>
<td>Disruptive Manufacturing Technologies (DARPA program)</td>
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<tr>
<td>DMREF</td>
<td>Designing Materials to Revolutionize and Engineer our Future (NSF program)</td>
</tr>
<tr>
<td>DSO</td>
<td>Defense Science Office (in DARPA)</td>
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<tr>
<td>EERE</td>
<td>Energy Efficiency and Renewable Energy Office (in DOE)</td>
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<tr>
<td>ENG</td>
<td>Engineering (NSF Directorate)</td>
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<tr>
<td>FANG</td>
<td>Fast Adaptable Next-Generation Ground Vehicle (DARPA program)</td>
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<tr>
<td>FOA</td>
<td>Funding Opportunity Announcement</td>
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<tr>
<td>I2O</td>
<td>Information Innovation Office (in DARPA)</td>
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<tr>
<td>IAM</td>
<td>Interagency working group on Advanced Manufacturing</td>
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<tr>
<td>IC</td>
<td>Integrated Circuit</td>
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<tr>
<td>IMI</td>
<td>Innovative Manufacturing Initiative (DOE EERE AMO program)</td>
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<tr>
<td>ITP</td>
<td>Industrial Technologies Program, EERE, DOE – now renamed as AMO</td>
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<tr>
<td>IWG</td>
<td>Interagency Working Group (associated with the NSTC)</td>
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<tr>
<td>LM3I</td>
<td>Lightweight and Modern Metals Manufacturing Innovation (DOD program)</td>
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<tr>
<td>ManTech</td>
<td>Manufacturing Technology (DOD program)</td>
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<tr>
<td>MDF</td>
<td>Manufacturing Demonstration Facility (DOE, EERE, AMO program)</td>
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<tr>
<td>MEP</td>
<td>(Hollings) Manufacturing Extension Program (NIST)</td>
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<tr>
<td>MGI</td>
<td>Materials Genome Initiative</td>
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<tr>
<td>MIBP</td>
<td>Office of Manufacturing and Industrial Base Policy (in DOD)</td>
</tr>
<tr>
<td>MPS</td>
<td>Mathematical and Physical Science (NSF Directorate)</td>
</tr>
<tr>
<td>MSE</td>
<td>Measurement Science and Technology (NIST program)</td>
</tr>
<tr>
<td>MTO</td>
<td>Microsystems Technology Office (in DARPA)</td>
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<tr>
<td>NAMII</td>
<td>National Additive Manufacturing Innovation Institute</td>
</tr>
<tr>
<td>NCAM</td>
<td>National Center for Advanced Manufacturing (NASA)</td>
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<tr>
<td>NCDMM</td>
<td>National Center for Defense Manufacturing and Machining</td>
</tr>
<tr>
<td>NCMS</td>
<td>National Center for Manufacturing Sciences</td>
</tr>
<tr>
<td>NERCC</td>
<td>NanoSystems Engineering Research Center (NSF program)</td>
</tr>
<tr>
<td>NNMI</td>
<td>National Network for Manufacturing Innovation</td>
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<tr>
<td>NNN</td>
<td>National Nanomanufacturing Network</td>
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<tr>
<td>NPO</td>
<td>National Program Office</td>
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<tr>
<td>NRI</td>
<td>National Robotics Initiative</td>
</tr>
<tr>
<td>NSEC</td>
<td>Nanotechnology Science and Engineering Center (NSF funded)</td>
</tr>
</tbody>
</table>
Manufacturing Readiness Levels
Source: Department of Defense, Joint Defense Manufacturing Technology Panel.
*Manufacturing Readiness Assessment (MRA) Deskbook* (version 7.1). 2009

<table>
<thead>
<tr>
<th>MRL</th>
<th>Definition</th>
<th>Description</th>
<th>Phase</th>
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<tbody>
<tr>
<td>1</td>
<td>Basic Manufacturing Implications Identified</td>
<td>This is the lowest level of manufacturing readiness. Basic research expands scientific principles that may have manufacturing implications. The focus is on a high level assessment of manufacturing opportunities. The research is unfettered.</td>
<td>Pre Materiel Solution Analysis</td>
</tr>
<tr>
<td>2</td>
<td>Manufacturing Concepts Identified</td>
<td>Invention begins. Manufacturing science and/or concept described in application context. Identification of material and process approaches are limited to paper studies and analysis. Initial manufacturing feasibility and issues are emerging.</td>
<td>Pre Materiel Solution Analysis</td>
</tr>
<tr>
<td>3</td>
<td>Manufacturing Proof of Concept Developed</td>
<td>Conduct analytical or laboratory experiments to validate paper studies. Experimental hardware or processes have been created, but are not yet integrated or representative. Materials and/or processes have been characterized for manufacturability and availability but further evaluation and demonstration is required.</td>
<td>Pre Materiel Solution Analysis</td>
</tr>
<tr>
<td>4</td>
<td>Capability to produce the technology in a laboratory environment</td>
<td>Required investments, such as manufacturing technology development identified. Processes to ensure manufacturability, producibility and quality are in place and are sufficient to produce technology demonstrators. Manufacturing risks identified for prototype build. Manufacturing cost drivers identified. Producibility assessments of design concepts have been completed. Key design performance parameters identified. Special needs identified for tooling, facilities, material handling and skills.</td>
<td>Materiel Solution Analysis (MSA) leading to a Milestone A decision</td>
</tr>
<tr>
<td>Phase</td>
<td>Description</td>
<td>Status</td>
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<tr>
<td>5</td>
<td>Capability to produce prototype components in a production relevant environment</td>
<td>Mfg strategy refined and integrated with Risk Mgt Plan. Identification of enabling/critical technologies and components is complete. Prototype materials, tooling and test equipment, as well as personnel skills have been demonstrated on components in a production relevant environment, but many manufacturing processes and procedures are still in development. Manufacturing technology development efforts initiated or ongoing. Productivity assessments of key technologies and components ongoing. Cost model based upon detailed end-to-end value stream map.</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Capability to produce a prototype system or subsystem in a production relevant environment</td>
<td>Initial mfg approach developed. Majority of manufacturing processes have been defined and characterized, but there are still significant engineering/design changes. Preliminary design of critical components completed. Productivity assessments of key technologies complete. Prototype materials, tooling and test equipment, as well as personnel skills have been demonstrated on subsystems/systems in a production relevant environment. Detailed cost analysis include design trades. Cost targets allocated. Productivity considerations shape system development plans. Long lead and key supply chain elements identified. Industrial Capabilities Assessment (ICA) for MS B completed.</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Capability to produce systems, subsystems or components in a production representative environment</td>
<td>Detailed design is underway. Material specifications are approved. Materials available to meet planned pilot line build schedule. Manufacturing processes and procedures demonstrated in a production representative environment. Detailed productivity trade studies and risk assessments underway. Cost models updated with detailed designs, rolled up to system level and tracked against targets. Unit cost reduction efforts underway. Supply chain and supplier QA assessed. Long lead procurement plans in place. Production tooling and test equipment design &amp; development initiated.</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Pilot line capability demonstrated. Ready to begin low rate production</td>
<td>Detailed system design essentially complete and sufficiently stable to enter low rate production. All materials are available to meet planned low rate production schedule. Manufacturing and quality processes and procedures proven in a pilot line environment, under control and ready for low rate production. Known productivity risks pose no significant risk for low rate production. Engineering cost model driven by detailed design and validated. Supply chain established and stable. ICA for MSC completed.</td>
<td></td>
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</table>
8/26/2013

9 Low Rate Production
demonstrated. Capability
in place to begin Full
Rate Production

- Major system design features are stable and proven in test and evaluation. Materials are available to meet planned rate production schedules.
- Manufacturing processes and procedures are established and controlled to three-sigma or some other appropriate quality level to meet design key characteristic tolerances in a low rate production environment. Production risk monitoring ongoing.
- LRIP cost goals met, learning curve validated. Actual cost model developed for FRP environment, with impact of Continuous improvement.

10 Full Rate Production
demonstrated and lean
production practices in
place

- This is the highest level of production readiness. Engineering/design changes are few and generally limited to quality and cost improvements. System, components or items are in rate production and meet all engineering, performance, quality and reliability requirements. All materials, manufacturing processes and procedures, inspection and test equipment are in production and controlled to six-sigma or some other appropriate quality level. FRP unit cost meets goal, funding sufficient for production at required rates. Lean practices well established and continuous process improvements ongoing.

Acronym Glossary

- CDR Critical Design Review
- EMD Engineering and Manufacturing Development
- FRP Full Rate Production
- ICA Industrial Capabilities Assessment
- LRIP Low Rate Initial Production
- MRA Manufacturing Readiness Assessment
- MSA Materiel Solution Analysis
- MS B, MS C MileStone points in the DOD procurement system
- TD Technology Development

Definitions of Terms Found in Manufacturing Readiness Level Definitions

Production relevant environment – An environment normally found during MRL 5 and 6 that contains key elements of production realism not normally found in the laboratory environment (e.g. uses production personnel, materials or equipment or tooling, or process steps, or work instructions, stated cycle time, etc.). May occur in a laboratory or model shop if key elements or production realism are added.

Production representative environment – An environment normally found during MRL 7 (probably on the manufacturing floor) that contains most of the key elements (tooling, equipment, temperature, cleanliness, lighting, personnel skill levels, materials, work instructions, etc) that will be present in the shop floor production areas where low rate production will eventually take place.
Pilot line environment – An environment normally found during MRL 8 in a manufacturing floor production area that incorporates all of the key elements (equipment, personnel skill levels, materials, components, work instructions, tooling, etc.) required to produce production configuration items, subsystems or systems that meet design requirements in low rate production. To the maximum extent practical, the pilot line should utilize rate production processes.

Manufacturability – The characteristics considered in the design cycle that focus on process capabilities, machine or facility flexibility, and the overall ability to consistently produce at the required level of cost and quality. Activities can include some or all of the following activities:
- Design for commonality and standardization- fewer parts
- Perform comprehensive Technology Assessment, including commercial industrial applications and the supplier base
- Design for Multi-Use and Dual-Use applications
- Design for modularity and plug compatible interface/integration
- Design for flexibility, adaptability, and “robust design”
- Utilize reliable processes and materials

Producibility – Is the capability of an item to be produced, including some or all of the following activities:
- Design to specific Cp-CpK process control parameters- six sigma
- Perform material characterization analysis
- Perform variability reduction analysis- Taguchi, DOE
- Develop critical materials and processes before selecting product design
- Utilize pervasive modeling & simulation for product and process design tradeoffs
- Design and deployment of closed-loop process-control on critical items