Guide to FY2014 Research Funding

Advanced Manufacturing Initiative

Contact: James Murday, DC Office of Research Advancement
202 824 5863, murday@usc.edu

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

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).

(http://www.whitehouse.gov/sites/default/files/microsites/ostp/iam_advancedmanufacturing_strategicplan_2012.pdf)

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)
www.nsf.gov/about/budget/fy2014/pdf/34_fy2014.pdf
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)

http://www.nist.gov/manufacturing-portal.cfm
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.srinvasan@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)
a. Adv. Manufacturing Office (AMO, in the Office of Energy Efficiency and Renewable Energy)
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
http://www1.eere.energy.gov/manufacturing/rd/nextgen_manufacturing.html
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)
http://www1.eere.energy.gov/manufacturing/financial/solicitations_detail.asp?sol_id=422
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://www.arpa-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
https://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
  http://www.darpa.mil/Our_Work/DSO/Programs/Disruptive_Manufacturing_Technologies_%28DMT%29.aspx
  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
  http://www.darpa.mil/Our_Work/TTO/Programs/AVM/Adaptive_Vehicle_Make_Program_Overview.aspx
  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://mafspace.msfc.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
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)
http://manufacturing.gov/amp/amp.html
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)
http://www.manufacturing.gov/welcome.html
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
http://www.data.gov/manufacturing/page/manufacturing-data
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
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)
http://www.nsf.gov/funding/pgm_summ.jsp?pims_id=503641&org=CISE
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-Enabled Materials, Manufacturing, and Smart Systems from S142M 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 Engn. 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 FY2103 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
PROCEEDINGS OF THE SPIE 3525, 138-145 1998

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 Engn. and a BS in Mechanical Engn. 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, uncoooled 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)

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

OXR	generic acronym for the three DOD basic research funding offices
PBR	President's Budget Request (submitted to Congress)
RD&D	Research, Development and Demonstration (at meaningful scale)
SBA	Small Business Agency
SBIR	Small Business Innovative Research (program)
STEM	Science, Technology, Engineering and Mathematics (education)
STTR	Small business Technology Transfer (program)
SusChem	Sustainable Chemistry, Engineering and Materials (NSF program)
TIP	Technology Innovation Program (NIST)
TTO	Tactical Technology Office (in DARPA)

Manufacturing Readiness Levels

Source: Department of Defense, Joint Defense Manufacturing Technology Panel. *Manufacturing Readiness Assessment (MRA) Deskbook* (version 7.1). 2009

MRL	Definition	Description	Phase
1	Basic Manufacturing Implications Identified	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.	Pre Materiel Solution Analysis
2	Manufacturing Concepts Identified	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.	Pre Materiel Solution Analysis
3	Manufacturing Proof of Concept Developed	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.	Pre Materiel Solution Analysis
4	Capability to produce the technology in a laboratory environment	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.	Materiel Solution Analysis (MSA) leading to a Milestone A decision

5	Capability to produce prototype components in a production relevant environment	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. Producibility assessments of key technologies and components ongoing. Cost model based upon detailed end-to-end value stream map.	Technology Development (TD) Phase
6	Capability to produce a prototype system or subsystem in a production relevant environment	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. Producibility 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. Producibility considerations shape system development plans. Long lead and key supply chain elements identified. Industrial Capabilities Assessment (ICA) for MS B completed.	Technology Development (TD) phase leading to a Milestone B decision
7	Capability to produce systems, subsystems or components in a production representative environment	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 producibility 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 & development initiated.	Engineering & Manufacturing Development (EMD) leading to Post CDR Assessment
8	Pilot line capability demonstrated. Ready to begin low rate production	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 producibility 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 MS C completed.	Engineering & Manufacturing Development (EMD) leading to a Milestone C decision

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.	Production & Deployment leading to a Full Rate Production (FRP) decision
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.	Full Rate Production/ Sustainment

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