

Survey of Federal Manufacturing Efforts

MIT Washington Office
820 1st St. NE, Ste. 610
Washington, DC 20002
202.789.1828 || 617.324.9981

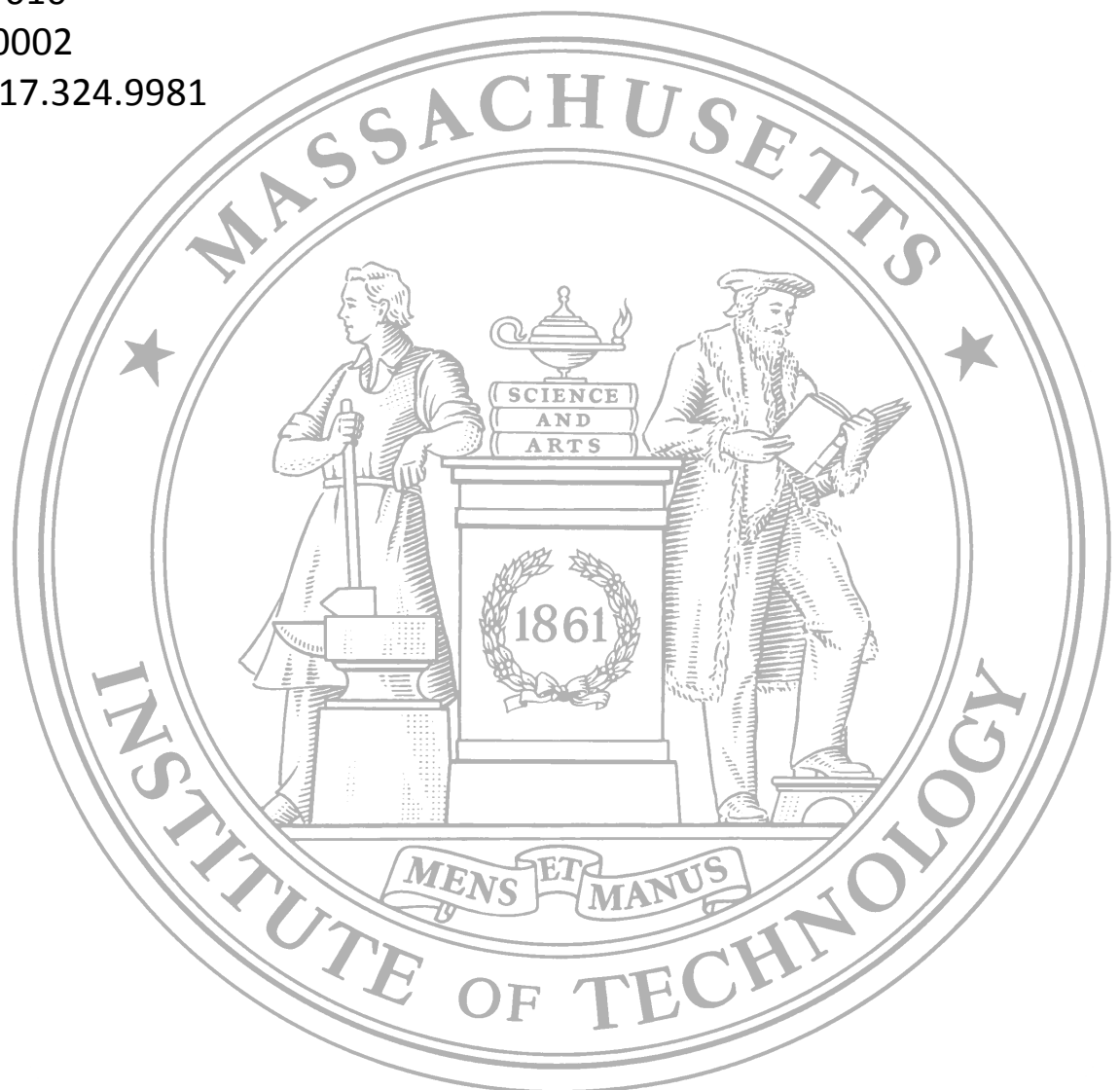


Table of Contents

INTRODUCTION	3
HELPFUL ACRONYMS	3
DEPARTMENT OF DEFENSE	4
DARPA	4
<i>Adaptive Vehicle Make</i>	4
<i>Disruptive Manufacturing Technologies Program</i>	5
MANTECH	6
<i>Air Force ManTech</i>	11
<i>Army ManTech</i>	12
<i>Navy ManTech</i>	13
<i>Joint Defense Manufacturing Technology Panel</i>	14
DEPARTMENT OF ENERGY	16
INDUSTRIAL TECHNOLOGIES PROGRAM.....	16
1. <i>Energy Intensive Industries</i>	18
2. <i>Crosscutting Technologies</i>	19
3. <i>BestPractices</i>	19
4. <i>Industrial Assessment Centers (IAC) and "Save Energy Now"</i>	19
5. <i>Superior Energy Performance Plant Certification Program</i>	20
NATIONAL INSTITUTE FOR STANDARDS AND TECHNOLOGY	21
MANUFACTURING EXTENSION PARTNERSHIP	21
MANUFACTURING ENGINEERING LABORATORY.....	23
1. <i>Precision Engineering Division (PED)</i>	23
2. <i>Manufacturing Metrology Division (MMD)</i>	24
3. <i>Intelligent Systems (ISD)</i>	25
4. <i>Manufacturing Systems Integration (MSID)</i>	26
5. <i>Fabrication Technology (FTD)</i>	26
NATIONAL SCIENCE FOUNDATION	28
CIVIL, MECHANICAL AND MANUFACTURING INNOVATION (CMMI) ORGANIZATION.....	29
<i>Advanced Manufacturing</i>	29
<i>Mechanics and Engineering Materials</i>	30
<i>Resilient and Sustainable Infrastructures</i>	32
<i>Systems Engineering and Design</i>	33
PRESIDENT'S COUNCIL OF ADVISORS ON SCIENCE AND TECHNOLOGY – PENDING STUDY	36
CONCLUSION	37
APPENDIX A – LIST OF CONTACTS BY PROGRAM.....	38
APPENDIX B – SUMMARY OF FEDERAL MANUFACTURING FUNDING AT FOUR LEADING AGENCIES:.....	39

Introduction

The purpose of this survey is to answer the question of “What is the federal government currently undertaking to further advances in American manufacturing?” It highlights and summarizes the offices, programs, clusters and divisions within federal agencies that are in some way focused on manufacturing, and includes the Departments of Defense and Energy, the National Institute for Standards and Technology, the National Science Foundation and the President’s Council of Advisors on Science and Technology.

This report attempts a summary of those efforts. Grouped by agency or office, funding information is printed when available. All information came from the agencies themselves; as a result, the level of detail varies between them. The contact information for each agency or program is listed in the text and at the end in Appendix A; most contacts are the head/director/chief of that particular group. Whenever possible, language describing manufacturing program elements is drawn directly from those programs. This survey does not attempt to cover every agency with manufacturing efforts, only a number of the major programs at four leading agencies.

If you are reading this on a computer: the page numbers in the table of contents are hyperlinked to the page, enabling the reader to jump to an office of interest.

Sources are included in footnotes and sometimes in the body of the paper. Any comments, questions, or concerns can be addressed to Eliza Eddison, MIT undergraduate and Washington Office intern, at eddison@mit.edu.

Helpful Acronyms

A few helpful acronyms used in this report:

- ARRA = American Recovery and Reinvestment Act
- RD&D = Research, Development and Deployment

Department of Defense

The Department of Defense (DoD) performs manufacturing research, prototype and implementation work, in the Office of the Secretary and in the services. This summary reviews work in two major areas: through the Defense Advanced Research Projects Agency (DARPA) and the Manufacturing Technologies Program (ManTech).

DARPA

DARPA has historically focused on research and technology where risk and payoff are both very high, and success provides opportunities for potentially revolutionary advances. Historically, its support of the collaborative semiconductor industry effort, Sematech, led by Robert Noyce, Bill Spencer and other noted technology leaders, stands as a seminal manufacturing success.¹ Sematech focused on revamping the efficiency of and process for manufacture of semiconductor equipment, and thereby helped restore U.S. global leadership of semiconductor production, which was, in turn, considered a critical defense technology. Although two particular programs are highlighted below, currently a number of DARPA projects have potentially significant manufacturing aspects, such as its effort to sharply accelerate the time required for vaccine production and its gradient optics manufacturing program.²

Adaptive Vehicle Make

On September 14, 2010, DARPA announced a major new manufacturing thrust, under consideration for a number of months.³ It will include a portfolio of programs organized around its Adaptive Vehicle Make (AVM) program. These will be, “aimed at dramatically compressing development timelines for complex defense systems” by altering “the way systems are designed, built and verified, significantly improving the capacity to handle complexity – which has been rapidly outpacing 1960’s vintage approaches to managing it.”⁴

¹ Larry D. Browning and Judy C. Shetler, *Sematech – Saving the U.S. Semiconductor Industry* (Texas A&M Press 2000).

² See, DARPA’s Accelerated Manufacture of Pharmaceuticals program, <http://www.darpa.mil/dso/thrusts/bwd/act/amp/index.htm> ; and its Gradient Optics Manufacturing program, <http://www.darpa.mil/sto/programs/mgrin/index.html> .

³ Talk by DARPA Dep. Dir. Ken Gabriel, March 29, 2010 at MIT Innovation/Mfg. Roundtable <http://alum.mit.edu/news-views/alumni-news-features/alumni-news-archive/focus-innovation> (video at: 22:51).

⁴ DARPA, DARPA Aims to Revolutionize Defense Manufacturing (Sept. 14, 2010) <http://www.darpa.mil/news/2010/AdaptiveVehicleMakeNewsRelease.pdf> .

The portfolio will be composed of four synergistic efforts: *META*, *iFAB* (Instant Foundry Adaptive through Bits), *FANG* (Fast Adaptive Next Gen Ground Combat Vehicle) and *MENTOR* (Manufacturing Experimentation and Outreach). These efforts will support a practical project – a next generation infantry combat vehicle. The goal is to compress the development timeline by five times. According to Program Manager Paul Eremenko, “DARPA’s goal is to replicate the success of the integrated circuit industry in coping with rapidly growing product complexity by moving to higher levels of abstraction in design, introducing design automation and model-based verification and decoupling the design and build phases of the development process.”

META is a program to develop metrics, a representation metalanguage, design tools, and verification techniques to enable the synthesis of vehicle designs that are “correct-by-construction.” It will create a toolset to enable the development of a complex military vehicles and avoid the design-build-test-redesign loop that disrupts schedules and costs as unanticipated interactions within that system are chased down.

iFAB will complement *META*’s “fab-less” design capability with a “foundry-style” production approach. Eremenko says that the vision for the project is “for a bitstream-programmable manufacturing facility that can be rapidly configured to produce a new design or design variation with nearly zero learning curve.” He refers to this as “large scale manufacturing in quantifies of one.”

META and *iFAB* will support the evolution of *FANG*. Through *vehicleforge.mil*, DARPA will attempt to multiply the number of contributors in the *FANG* design process by orders of magnitude – called “democratizing innovation.” DARPA will develop a collaborative infrastructure for crowdsourcing vehicle designs, called *vehicleforge.mil*, with the site employing the *META* metalanguage to represent designs that include version control and “branching” features similar to opensource software forge sites, and new credentialing technology, in an effort to enable thousands of contributors to participate in the design process.

Contact: Paul Eremenko|| paul.erenko@darpa.mil

Disruptive Manufacturing Technologies Program

Until its new portfolio of manufacturing efforts around AVM in its Tactical Technologies office, perhaps DARPA’s leading effort in manufacturing has been the Disruptive Manufacturing Technologies Program (DMT),⁵ within the Defense Sciences Office.

⁵ The initial DMT solicitation can be found at:
<http://www.darpa.mil/dso/solicitations/DMT.pdf>.

The Disruptive Manufacturing Technologies Program's purpose, in DARPA's words, is to "develop and demonstrate manufacturing capabilities that are affordable at small volumes and with reduced delivery times. These concepts will be extended to polymer matrix composites, advanced metallic turbine blades and ceramic body armor upgrades." Metrics for the DARPA Disruptive Manufacturing Technologies program are significant and pervasive cost savings for multiple platforms or systems and/or decreases in cycle time for manufacturing of components for existing Defense systems and future military procurements.⁶

Examples of specific objectives include the following:

- Developing and demonstrating non-autoclave manufacturing technology for production of polymer matrix composites aerospace components and establishing a robust process for full-size components.
- Demonstrating elimination of costly mold-making steps in manufacturing 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.

The focus of this program is on manufacturing process development. Challenge problems for manufacture are parts/materials now bought by DoD that provide benchmarks for cost, performance, and production time.⁷

The different program focus areas are listed below. They have different phases with different funding (FY08), listed where available:

- Integrated Circuits (\$4.85 million)
- Software Producibility (\$3.4 million)
- Advanced Materials (\$3.33 million, \$986,000)

For more information:

- Integrated Circuits - <http://www.darpa.mil/MTO/Programs/dmt/index.html>
- Software Producibility - <http://www.darpa.mil/ipto/programs/dmt/dmt.asp>
- Advanced Materials -
<http://www.darpa.mil/dso/thrusts/materials/novelmat/disman/index.htm>

Contact: William Coblenz || william.coblenz@darpa.mil || 571.218.4647

The funding dimensions for the new DARPA manufacturing portfolio around AVM are still unfolding, with draft solicitations pending. However, a very rough estimate of the new portfolio along with existing DARPA manufacturing programs, could be in the \$60 million/year range.

ManTech

⁶ See, www.darpa.mil/Docs/disrupt_manuf_fs2_200807180942214.pdf and <http://www.darpa.mil/dso/thrusts/materials/novelmat/disman/index.htm>

⁷ <http://www.darpa.mil/dso/thrusts/materials/novelmat/disman/>

Manufacturing, in ManTech’s words, “is so important to the nation that the ManTech community is sometimes looked to as the champion for not only defense manufacturing technologies, but for the entirety of the defense manufacturing enterprise or even for enhancing US global manufacturing competitiveness.”

It also claims as its mission, “to anticipate and close gaps in defense manufacturing capabilities makes the program a crucial link between technology invention and industrial applications—from system development through sustainment” which gives ManTech “a unique identity within the extended defense enterprise.” Mantech programs at DOD are located in the Office of the Secretary of Defense (OSD), in the office of the Director of Defense Research and Engineering, as well as in each of the military services.

According to the information available on their website, the OSD ManTech Director and the members of the Joint Defense Manufacturing Technology Panel (JDMTP) follow four tenets in making policy and resource allocation decisions:

1. Address the highest priority defense manufacturing needs in the window of opportunity to make a difference.
2. Transition manufacturing R&D processes into production applications.
3. Attack pervasive manufacturing issues and exploit new opportunities across industry sectors.
4. Address manufacturing technology requirements beyond the normal risk of industry.

The available resources of the combined ManTech offices, in OSD and the services, total about \$200 million annually, and the details are shown below, in Table 1.

Program	FY09 Approved	FY09 PB			
		FY 10	FY 11	FY 12	FY 13
DoD MS&T	18.4	14.9	19.9	19.9	24.8
Army ManTech	91.1	69.6	70.2	71.7	73.4
Navy ManTech	61.9	58.6	56.5	60.0	60.6
AF ManTech	56.5	40.5	40.8	41.6	42.5
DLA ManTech	55.3	20.8	21.3	21.7	22.0
MDA*	33.3	38.6	47.6	44.8	45.5
Total**	283.2	204.4	208.7	214.9	223.3

*MDA line is the total for all Manufacturing and Producibility

**This total does not include MDA’s budget for Manufacturing and Producibility

Table 1: ManTech funding, by program element. Amounts shown in millions of dollars.

ManTech’s five-year plan issued in December 2009, the main source for the information in this survey, states that its strategy “balances its traditional emphasis on processing and fabrication technology solutions with active support for broader defense manufacturing needs.” This strategy is broken down into “strategic thrusts” and lower level “enabling goals.” The graphics used in that report are inserted below. Figure 1 shows the overall strategy.

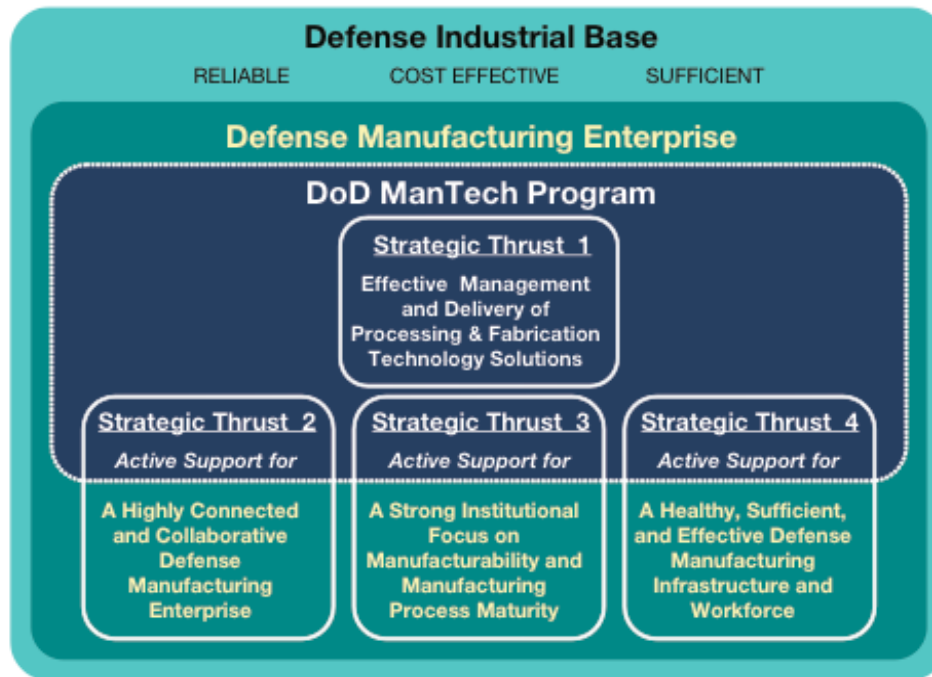


Figure 1: Overview of ManTech's Strategic Thrusts from Five Year Plan

Within each Strategic Thrust are Enabling Goals. The graphics from the five year plan for the enabling goals for Strategic Thrusts 1-4 are shown in Figures 2-5, respectively:

Strategic Thrust 1 in many ways is the heart of the program – it represents the core focus of ManTech and drives the majority of program investment activity. The key, direct-line recipients or customers of these delivered manufacturing technology solutions are the acquisition and logistics program managers responsible for transitioning acquisition programs from development into production and for the repair, maintenance, and overhaul of fielded systems, as well as multiple manufacturing stakeholders across the broader defense industrial base.



Figure 2: Detailed graphic for ManTech's Strategic Thrust 1



Figure 3: Detailed graphic for ManTech's Strategic Thrust 2

Strategic Thrust 3 points to the “strategic need for a pervasive culture of manufacturing that embodies a cradle- to-grave focus, across DoD and industry, that persistently considers weapon system manufacturability and aggressively resolves associated production and sustainment issues over the Acquisition life cycle.” Which, in turn, is meant to “maximizes opportunities to positively influence weapon system cost, schedule, and performance through manufacturing reviews appropriate for each phase of research, development and acquisition.”

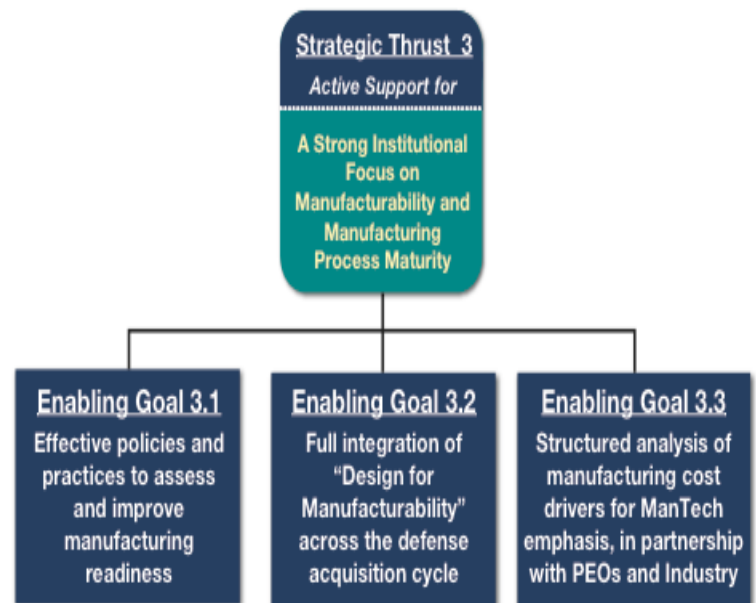


Figure 4: Detailed graphic for ManTech's Strategic Thrust 3



Figure 5: Detailed graphic for ManTech's Strategic Thrust 4

Strategic Thrust 2 is the first of three program strategies applying to the broader defense manufacturing base and is founded on the premise that “21st century defense manufacturing will rely on a networked, collaborative and increasingly global supply base, with capabilities that can be linked within and among the nodes to respond rapidly to dynamically changing defense needs.”

ManTech is not structured to be solely responsible for meeting the broader industrial base needs in Strategic Thrust 4, however it is a key player in developing a “highly effective defense manufacturing enterprise, and DoD policy requires the ManTech Program to promote the key attributes supporting these needs.”

Adele Ratcliff, the director of ManTech, gave a presentation to the National Defense Industrial Association (NDIA) quarterly meeting in May 2009 which included a slide on the Standing Technology Focus Team (TFT) Proposal. It can be found below, in Figure 6, and is a good overview of various projects that ManTech undertakes:

Standing Technology Focus Team (TFT) Proposal

- **Standing TFTs on big areas**
 - Provide the top 5-6 objectives for respective technology areas in the 1st year
 - Target date for reaching objectives is 5-10 years out
 - Revalidate the objectives and deep dive in 1 or 2 areas, each subsequent year
 - Brief results to the DSTAG

Big Areas

- **Advanced Electronics (\$520M)**
- **Advanced Materials (\$340M)**
- **Information Systems (\$1.870B)**
- **Robotics & Autonomous Systems (\$100M)**
- **Human Systems (\$440M)**
- **Sensors & Surveillance (\$980M)**
- **Energy & Power (\$620M)**
- **Space?**
- **Directed Energy?**

Assessments:

- ✓ **Electronics**
- ✓ **Materials (Meta/Thermal Mgmt/Energetic Mat)**
- ✓ **Info Systems (Info Assurance/Networks/SW)**
- ✓ **Robotics/Autonomy**
- ✓ **Human Systems (Accel Learning)**
- ✓ **Sensors (Thru the Wall and IRFPAs)**
- ✓ **Energy & Power (Thermal Mgmt)**

We have performed assessments in big areas. We need to continue to populate websites and get info out.

17

Figure 6: Standing TFT Proposal from presentation by ManTech director in May 2009.⁸

This slide indicates “Big Areas” of major DoD technology thrusts, with associated DoD funding, and the responsive manufacturing assessments at Mantech to support those efforts. Information included in this section of this survey was found in the DoD Mantech Strategic Plan, available along with other publications on the program’s website.⁹

Each branch of the military also has its own branch of ManTech. Details of the programs within the services are outlined below.

⁸<http://www.ndia.org/Divisions/Divisions/Manufacturing/Documents/919C%20presentations/12%20Ratcliff%2014%20May%202009%20OSD%20NDIA%20ManTech%20Presentation.pdf>

⁹ <https://www.dodmantech.com/pubs/pubs.asp?main=publink>

Air Force ManTech

The Air Force ManTech program plans, manages, and advocates programs providing advanced manufacturing processes, techniques and technologies for timely, high quality, economical production and sustainment of Air Force systems. Affordability is addressed by programs focusing on acquisition reform, business practices/policies, supplier practices/relationships, and the implementation of lean principles to reduce cost and cycle time while improving the quality of weapon systems and their components.¹⁰

It is divided into three branches:

- 1. Electronics**

Key programs: ALON and Spinel Optical Ceramics · Beryllium Industrial Base Production Initiative · Coal Based Carbon Foam · High Performance Thermal Battery Production Initiative · High Temperature Flexible Aerogel Material Supplier Initiative · Thin Silicon-On-Insulator Wafers · Integrated Advanced Composite Fiber Placement · Light-weight Ammunition and Armor Initiative · Lithium Ion Battery Production · Low Cost Military GPS Receivers · Methanol Fuel Cell Components · Military Lens System Fabrication and Assembly · Miniature Compressors for Electronics & Personal Computing · Next Generation Radiation Hardened Microprocessors · Polyhedral Oligomeric Silsesquioxane (POSS) Nanotechnology Scale-up Initiative · Radiation Hardened Microelectronics Capital Expansion · Reactive Plastic CO2 Absorbent Production Initiative · Silicon Carbide Monolithic Microwave Integrated Circuit (MMIC) Devices · Silicon Powder & Ceramic Armor Manufacturing · Photovoltaic Solar Cell Encapsulant · Steel to Titanium Transformation, Non-Aerospace Titanium · Titanium Metal Matrix Composites for Aircraft · Traveling Wave Tube Amplifiers for Space · Vacuum Induction Melting-Vacuum Arc Remelting Furnace Capacity

- 2. Processing and Fabrication**

Split into metals and non-metals teams.

- 3. Integration and Technology**

- *Key programs:* Micro-Electro-Mechanical Systems (MEMS) for munitions Inertial Measurement Units (IMUs) · Manufacturing Readiness · Joint Programmable Fuze scale-up · Flash LADAR · Unmanned Aerial Systems (UAS) · High Accuracy Robotic Drilling · Advanced Manufacturing Enterprise · Integrated Cost Modeling

More information is available on the program's website.

¹⁰ <http://www.ml.afrl.af.mil/mlm/default.html>

Army ManTech

In its words, “The Army Manufacturing Technology (ManTech) Program supports the reduction of costs and risks to manufacturing technologies that enable the affordable production and sustainment of future weapon systems, as well as the affordable transition of new technologies that can enhance capabilities of Current Force systems.”

Its projects fall into three categories:

1. **Army Technology Objectives for Manufacturing (ATO-M)**
Normally large efforts (\$3M to \$5M per year for one to three years) or efforts that address critical manufacturing technology
2. **Tracked Efforts**
Normally smaller efforts or efforts that address specific manufacturing opportunities
3. **Combined with Science and Technology (S&T) Research for Demonstration (ATO-R or ATO-D)**
Addresses manufacturing and producibility aspects of those technologies and improve transition.

Generally, the Army ManTech Program “supports process prototyping and pilot demonstration to develop or modify manufacturing technologies for the Army’s use. The Army ManTech Program does not acquire off-the-shelf capital equipment unless it is a minor portion of the investment and is required to establish the first-case application integral to the ManTech project. Before Army ManTech funds are committed to an effort, the Program Manager must demonstrate that their Acquisition Strategy includes a realistic plan to implement the technology in the industrial base.”¹¹

The program is divided into six investment areas. Examples of the projects within each area is included within the items:

1. **Aviation Systems** - to include investing in aviation ManTech lightweight helicopter structures, drive train housings, embedded sensors for composite structures, and low cost rotorcraft cabin floors.
2. **Armor and Armaments** - to include affordable lightweight structural and B(x) armor, next generation helmets, an transparent armor.
3. **Sensors**- to include next generation infrared (IR) and focal plane array (FPA) systems, low cost laser designator modules, and micro-displays.
4. **Electronics and Power Systems** - to include compact power and energy storage, high current silicon carbide switches, software defined radios, and chip scale atomic clocks.

¹¹ <http://www.armymantech.com/overview.html>

5. **Precision Munitions** - to include grenade initiation modules, multi-purpose warheads, seeker domes for missiles, and insensitive munitions processes.
6. **Flexible Displays**- to include flexible electronics and displays.

For a list of Army ManTech project highlights, see:
<http://www.armymantech.com/highlights.html>

Navy ManTech

Managed within the Office of Naval Research (ONR), the Navy ManTech Program provides for the development of enabling manufacturing technology and the transition of this technology for the production and sustainment of Navy weapon systems to support the Fleet. Navy ManTech is currently focused on shipbuilding affordability. Reducing the acquisition cost of current and future platforms is a critical goal of the Navy, and ManTech aids in achieving this goal by developing and transitioning key manufacturing technology.

The Navy ManTech Program works with defense contractors, the Naval Research Enterprise, Navy acquisition Program Offices, and academia to develop improved processes and equipment. Project success is measured by implementation of these technologies on the factory floor and rapid transition to the Fleet to support Navy warfighters. It is structured to provide maximum dissemination of the results of ManTech projects and to promote early implementation to strengthen the defense industrial base. With their expertise in specific technology areas, the Navy ManTech Centers of Excellence (COEs) play a key role in the definition and execution of the Navy ManTech Program.

There are many customers of the Navy ManTech Program. They range from the acquisition Program Managers (PMs) and industry responsible for transitioning major Navy weapon systems from development into production, to the logistics managers at the naval depots and shipyards responsible for repair, overhaul, and remanufacture of major weapon systems. Additional beneficiaries of the Navy ManTech Program include the other Services and academia.¹²

Comparable to the other service programs, Navy ManTech's goals (under DoD 4200.15) are as follows:

1. Aid in the economical and timely acquisition and sustainment of weapon systems and components.
2. Ensure that advanced manufacturing processes, techniques, and equipment are available for reducing DoD materiel acquisition, maintenance, and repair costs.
3. Advance the maturity of manufacturing processes to bridge the gap from research

¹² <http://www.onr.navy.mil/Science-Technology/Directorates/Transition/Manufacturing-ManTech.aspx>

- and development advances to full-scale production.
4. Promote capital investment and industrial innovation in new plants and equipment by reducing the cost and risk of advancing and applying new and improved manufacturing technology.
 5. Ensure that manufacturing technologies used to produce DoD materiel are consistent with safety and environmental considerations and energy conservation objectives.
 6. Provide for the dissemination of Program results throughout the industrial base.
 7. Sustain and enhance the skills and capabilities of the manufacturing work force, and promote high levels of worker education and training.

Specific projects are described in the Navy ManTech *2010 Project Book*,¹³ including funding details.

Note: Two other DoD Mantech programs, at the Missile Defense Agency and Defense Logistics Agency, are not summarized here, but information is available on their websites.

Joint Defense Manufacturing Technology Panel

The Joint Defense Manufacturing Technology Panel (JDMTP) is designed to coordinate ManTech efforts and maximize leverage of ManTech funding across the Services, Defense Logistics Agency (DLA), and Missile Defense Agency (MDA)

The JDMTP is composed of the manager of the Army, Navy, Air Force, DLA, and MDA ManTech Programs. This panel also includes an ex-officio representative from the Office of the Secretary of Defense and representatives for the Department of Commerce (DOC), and Department of Energy (DOE)

The JDMTP defines a taxonomy under which DoD components coordinate technical projects that optimize the investment of funds for manufacturing process development. To meet its challenges, the JDMTP is structured around three technical subpanels to support the planning, execution, and implementation of both joint and Service-unique projects. Service ManTech projects are aligned within the JDMTP technical subpanels. They are as follows:

- **Metals Processing and Fabrication Subpanel** projects provide manufacturing technology to develop affordable, robust processes and capabilities for evolutionary metals and special materials, joining and inspection.

¹³ http://www.onr.navy.mil/en/Science-Technology/Directorates/Transition/Manufacturing-ManTech/~/_media/9334B4DE93CB4FCD99B97EC8815BC56C.ashx

- **Composites Processing and Fabrication Subpanel** coordinates manufacturing technology projects that improve the processes used to produce composite structures in aircraft, ground vehicles, ships and Soldier protective systems.
- **Electronics Processing and Fabrication Subpanel** addresses manufacturing technology for electronic materials, devices, integrated circuits, subassemblies, and subsystems. The scope includes digital electronics, analog microwave and millimeter wave electronics, and photonic and electro-optic technologies.

Contacts:

DoD OSD ManTech's director, Adele Ratcliff (adele.ratcliff@osd.mil) is spending the year at the Army War College, and will not return until June 2011. The following following contacts are available in her stead:

- Steve Linder || steve.linder@osd.mil || 703-607-5319
- Mike Dunn || michael.dunn.ctr@osd.mil || 571.226.8761
- Cynthia Gonsalves || cynthia.gonsalves@osd.mil || 703.607.5315

Additional staff can be reached at the following two numbers for more information on ManTech:

- 703.695.0598
- 703.614.2079

Department of Energy

Within the Department of Energy (DoE) is the Energy Efficiency & Renewable Energy Office (EERE), which has a budget request of \$2.4 billion for FY11, and focuses on applied energy research, prototyping, demonstration and commercialization activities, working largely with the private sector. The mission of EERE, “is to strengthen America’s energy security, environmental quality, and economic vitality through R&D and public-private partnerships that diversify the Nation’s sources of energy, increase efficiency and productivity of the existing energy infrastructure, bring clean, reliable, and affordable energy technologies to the marketplace, and make a difference in the everyday lives of Americans by productively enhancing their energy choices and quality of life.”¹⁴ The Industrial Technologies Program (ITP) is a subdivision within EERE.

Industrial Technologies Program

The ITP seeks to “improve industrial energy efficiency and environmental performance by partnering with U.S. industry in a coordinated program of research and development, validation and dissemination of energy efficiency technologies and operating practices.”

ITP focuses on reducing manufacturers’ energy requirements while stimulating economic productivity and growth by investing in technologies and practices that provide clear public benefit and addressing market barriers that prevent adequate private sector investment. Opportunities exist in process specific, energy-intensive industries; others target crosscutting technologies that are common to many industrial processes. Still others provide near-term benefits by improving industrial systems and practices, today.

The Industrial Technology Program seeks to reduce the intensity of energy use of the U.S. industrial sector through the targeted research, development, and deployment of next-generation manufacturing technologies, and the leveraging of collaborative industry partnerships for the adoption of efficient technologies and process improvements.

In 2006, the most recent year for which complete data is available, ITP states it directly contributed to industrial energy savings of almost 500 trillion BTUs. ITP estimates that technologies developed and activities undertaken since 1977 have cumulatively saved more than 103 million metric tons of carbon equivalent (MMCTe) and over 5.6 Quads of energy.¹⁵

¹⁴ http://www1.eere.energy.gov/ba/pba/pdfs/fy10_budget_brief.pdf, at 3.

¹⁵ Ibid, at 33.

According to the ITP: “At the heart of ITP’s success is a spirit of collaborative problem-solving, involving vigorous outreach to voluntary industry partners.” This effort is exemplified by ITP’s *Save Energy Now* initiative (SEN). “Since its inception in 2006, over 2,000 SEN industrial energy assessments have identified ways to save over 131 trillion BTUs of natural gas, roughly equivalent to that used by 2 million average U.S. homes.”

ITP works with industry in an effort to save energy and money, increase productivity, and reduce environmental impacts by:

- Conducting R&D on new energy efficient technologies
- Supporting commercialization of emerging technologies
- Providing plants with access to proven technologies, energy assessments, software tools, and other resources
- Promoting energy and carbon management in industry

Its mission is to have U.S. industry lead the world in energy efficiency and productivity, and its budget is summarized below in Table 2.

Activity	FY2008 Appropriation	FY2009 Appropriation	FY2010 Appropriation
Industries of the Future (Specific)	10,969	15,575	12,122
Industries of the Future (Crosscutting)	52,223	74,425	87,878
Efficiency of Information and Communications Technology	-	50,000*	-
TOTAL	63,192	140,000	96,000

*FY09 Additional Appropriation from ARRA

Table 2: Budget information for the Industrial Technology Program within the EERE. Amounts shown in thousands of dollars.

Figure 7, below, shows the trends in funding for ITP over the last decade, which was a slide in a presentation given by program manager Douglas E. Kaempf in September 2009 entitled “Deep Dive”:

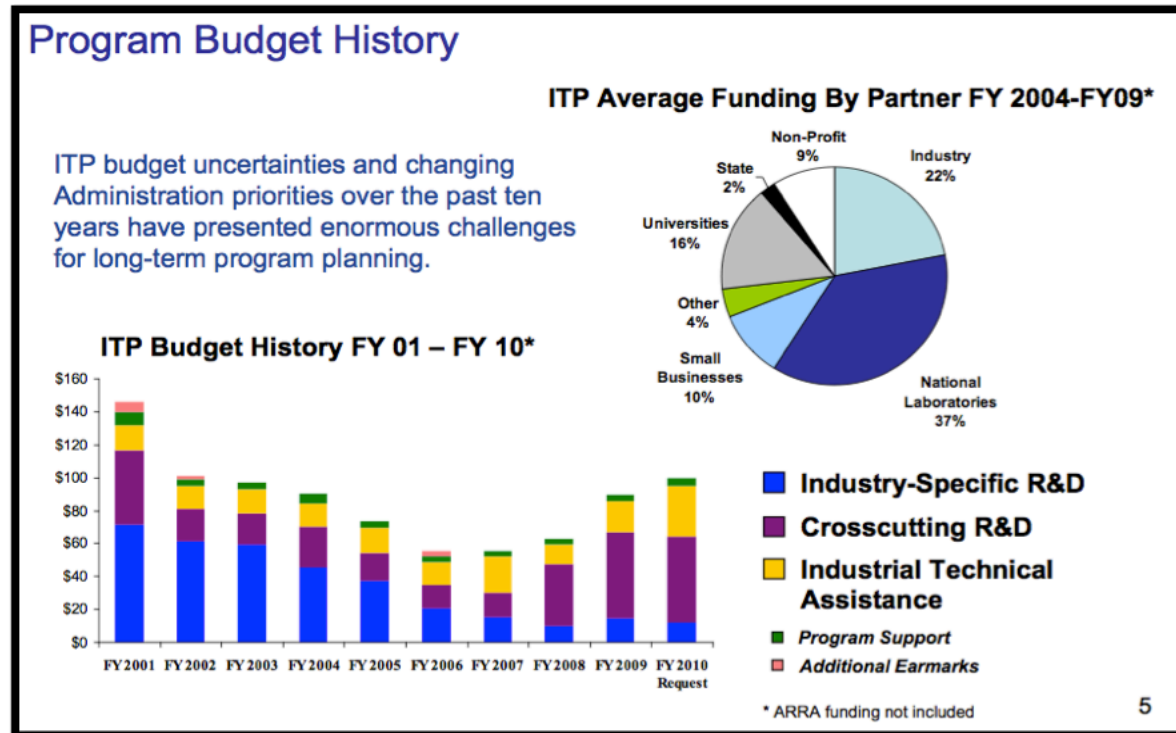


Figure 7: ITP Budget history from 2001-2009, as depicted in a presentation by the ITP manager in Sept. 2009¹⁶

The five program areas within ITP are:

1. Energy Intensive Industries

The Energy Intensive Industries process provides cost-shared support to R&D partnerships that address the needs of eight of the nation's most energy intensive – and most crucial – industries (listed below). These eight industries account for a full 75% of industrial energy consumption and represent the largest opportunity to increase energy efficiency in the industrial sector.

- Aluminum
- Chemical
- Forest Products
- Glass
- Metal Casting
- Mining
- Petroleum Refining
- Steel

¹⁶ http://www.eere.energy.gov/industry/about/pdfs/industry_deep_dive_pir.pdf

2. Crosscutting Technologies

ITP's efforts in crosscutting technologies provide cost-shared R&D in several key technology areas common to most energy-intensive industries (listed below). Because of the widespread application of these crosscutting technologies they hope to yield large energy savings with only minor efficiency changes.

- Combustion
- Distributed Energy
- Energy Intensive Processes
- Fuel & Feedstock Flexibility
- Industrial Materials for the Future
- Nanomanufacturing
- Sensors & Automation

For a March 2009 presentation on the nanomanufacturing initiative:
www1.eere.energy.gov/industry/pdfs/webcast_2009_0326_nannomanufacturing.pdf

3. BestPractices

“Through BestPractices, ITP helps industry save energy today, by implementing proven technologies and energy management practices. ITP encourages near-term adoption of these technologies and practices and offers resources such as software tools, training and technical information. BestPractices works with U.S. industry to implement energy management practices in industrial plants. To meet the diverse needs of U.S. industry, BestPractices provides a number of resources for corporate executives, plant managers, technical staff, and the general public.”

4. Industrial Assessment Centers (IAC) and “Save Energy Now”

The Industrial Assessment Centers (IACs), sponsored by the Industrial Technologies Program, have provided eligible small and medium-sized manufacturers with no-cost energy assessments. Additionally, the IACs have attempted to serve as a training ground for the next-generation of energy fluent engineers.

This assessment program has recently been extensively revised with an expanded effort called *Save Energy Now* – see information at:

<http://www1.eere.energy.gov/industry/saveenergynow/partnerships.html>.

Through it, energy assessments have been redesigned and improved. The new assessment process will focus on significantly increasing the implementation of identified savings opportunities - "MMBtus/year in the Ground" - while at the same time trying to ensure that there is significant cost/benefit for the Federal funds used for the assessments. The new assessments aim to provide greater value to industrial plants and better leverage the investment.

The enhanced *Save Energy Now* energy assessments will support two types

of companies and plants:

--Companies/plants who have made the *Save Energy Now* LEADER voluntary commitment to reduce their energy intensity by 25% over a 10-year time period

-- Companies/plants who have not made the *Save Energy Now* LEADER commitment, but do have a high level of annual energy use and significant potential for implementing energy efficiency improvements.

The *Save Energy Now* energy Assessment Application Form is available online at sen.assessments@caes.rutgers.edu. Information about the application process is also available.

The largest, most energy-intensive plants in the United States can apply to receive a 3-day system assessment from a DOE Energy Expert who will use DOE's software tools to analyze energy use and help find ways to improve efficiency.

Small- and medium-sized plants can apply to receive a 1-day assessment from one of DOE's university-based Industrial Assessment Centers.

A list is available online of large plants that have participated in a *Save Energy Now* energy assessment as are available assessment reports. Companies can be recognized for achieving significant energy savings after implementing recommendations from an assessment.

5. Superior Energy Performance Plant Certification Program

In this program, ITP joins the U.S. Council for Energy-Efficient Manufacturing in developing Superior Energy Performance by conducting Energy Management Demonstration projects. This voluntary, industry-designed certification program attempts to will give companies a framework to focus on managing and improving energy performance. This program attempts to make energy management an essential part of a company's standard operating procedure by offering a method to measure and validate plant energy efficiency improvements. The first plants could be certified in 2010, and the national voluntary program launch is planned for 2011.¹⁷

¹⁷ This section does not attempt to summarize the Section 48(c) tax credit program administered by DOE for energy efficiency efforts by manufacturing firms because it has been funded for only one year through the ARRA stimulus program.

National Institute for Standards and Technology

The National Institute for Standards and Technology (NIST) has an annual total budget of \$856 million in FY2010. Its mission is to “promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve our quality of life.”

At the July 16, 2010 President’s Council of Advisors on Science and Technology (PCAST) meeting, NIST Director Patrick Gallagher gave an overview of the programs within NIST and when he touched on manufacturing announced that “advanced manufacturing is my number one priority.”¹⁸

Although NIST officials estimate that between 40 to 60% of NIST’s total budget is spent on manufacturing-related efforts, including product performance, there have been two particular major manufacturing initiatives within NIST, the Manufacturing Extension Partnership and the Engineering Laboratory, which are highlighted here. Details on each can be found below, following the summary table of budget information in Table 3.

Program	Funding Level
<i>Manufacturing Extension Partnership</i>	124.7
<i>Engineering Laboratory (total)</i>	34.2
Precision Engineering Division	10.44
Manufacturing Metrology Division	8.0
Intelligent Systems Division	6.87
Manufacturing Systems Integration Division	8.89
Fabrication Technology	<i>None, see program description</i>

Table 3: Funding for the MEP and MEL within NIST for FY10. Amounts shown in millions of dollars.¹⁹

Manufacturing Extension Partnership

The Manufacturing Extension Partnership (MEP) is a twenty-year-old program focused on helping manufacturers “increase their profit-lines and streamline their processes through the implementation of lean manufacturing techniques.” It is also designed to adapt to the current state of manufacturing technology and business. The focus is on five critical profitable growth areas: continuous improvement, technology acceleration, supplier development, sustainability and workforce.

¹⁸ <http://www.whitehouse.gov/administration/eop/ostp/pcast/meetings/past>

¹⁹ Sherri Diaz in NIST’s Budget Division. 301.975.2669, sdiaz@nist.gov. More budget information is available at http://www.nist.gov/public_affairs/releases/approps-summary2008-2010.cfm.

MEP centers attempt to serve as advisors to small and medium-sized manufacturers and help them to strategically plan and implement business growth opportunities and improve their competitive position in the market. The focus can be short or long-term.

By its own account, MEP's strength is in its partnerships. Rather than creating products, services, and programs from scratch, MEP aims to work with partners to leverage the federal government's investment in other programs through awareness, education, collaboration and implementation and bring those resources to manufacturing clients. The MEP nationwide network, as proven by a number of studies, to be invaluable to numerous federal government partners who utilize the network to distribute valuable, cutting-edge information and resources in areas of workforce, technology adoption, environment and energy, quality, and more.

"Creatively using existing resources and partnering to extend them through the MEP network to the nation's manufacturers puts MEP in a unique position to help the nation's manufacturers access invaluable resources that might otherwise have gone unknown and unutilized."

Its partnerships are found in three primary arenas:

- **Federal:** MEP is engaged in active partnerships with such agencies as the Department of Defense, Department of Labor, Environmental Protection Agency, and the Department of Commerce.
- **State:** MEP partners with each state in the country and with Puerto Rico to host its local MEP-affiliated center and provide direct assistance to the manufacturers in that state. The states also partner with other organizations within the state, including universities, community colleges, and economic development organizations to assist in providing direct assistance to U.S. industry.
- **Associations:** MEP partners with many professional and trade associations--among them, the National Association of Manufacturers, the Society of Manufacturing Engineers, the Association of Machining Technologies and Wood Machinery Manufacturers of America.

The partnerships are focused on three primary areas:

- **Manufacturing resources and opportunities:** Programs in specific areas of interest, including energy and environmental protection and waste reduction, quality, and more.
- **Technology:** Partnerships with federal laboratories help to distribute these technologies to companies who can put these applications to use in the marketplace.
- **Workforce:** The Department of Labor and other related organizations use MEP's reach to the manufacturing workforce to provide grants and other support in workforce development.

State of Manufacturing Data

The MEP also performed a study on the State of Manufacturing, using multiple indicators to measure against: PMI, New Orders, Inventories, Production, Supplier Deliveries, Employment and New Export Orders. Updated when new information is available, the data and its sources are listed on the summary page on the website.²⁰

All of this information was found on the MEP's website, where further information is available.²¹

Contacts:

For more information on the program, contact: mfg@nist.gov || 301.975.5020
To speak with the director, contact: Roger D. Kilmer || roger.kilmer@nist.gov
For more information on the State of Manufacturing, contact: Christopher Carbone || christopher.carbone@nist.gov

Engineering Laboratory

NIST's Manufacturing Engineering Laboratory (MEL), was recently merged (effective Oct. 10, 2010) to also include building and construction R&D efforts (http://www.nist.gov/public_affairs/factsheet/reorg_factsheet.cfm), as part of a consolidation of NIST's eight labs into four, and renamed the Engineering Laboratory; it promotes innovation and the competitiveness of U.S. manufacturing. Its mission is to develop and disseminate "advanced manufacturing and construction technologies, guidelines, and services to the U.S. manufacturing and construction industries through activities including measurement science research, performance metrics, tools and methodologies for engineering applications, and critical technical contributions to standards and codes development." While it is undergoing reorganization, the Lab has had a series of divisions, each of which has projects and initiatives which will be continued. These are listed in outline form below, their budget numbers can be seen above in Table 3.

1. Precision Engineering Division (PED)

"Seeks to provide the foundation of dimensional measurement that meets the needs of the U.S. industrial and scientific communities by conducting research in dimensional measurements, developing new measurement methods, providing measurement services, developing National and International artifact and documentary standards, and disseminating the resulting technology and length-based standards.

²⁰ <http://www.nist.gov/mep/state-of-mfg/index.cfm>

²¹ <http://www.nist.gov/mep/partners/index.cfm>

Also within the mission of PED is to provide dimensional metrology assistance to other federal government agencies in order to address problems and needs that leverage NIST expertise, facilities, and capabilities.”

Topic areas:

- Atomic Force Microscopy (AFM)
- Calibrations
- Characterization, Nanometrology, and Nanoscale Measurements
- Dimensional Metrology
- Documentary Standards
- Electron Microscopy
- Length
- Nanofabrication, Nanomanufacturing, and Nanoprocessing
- Nanomanufacturing
- Nanostructured Materials
- Optical Metrology
- Optical Microscopy

Groups:

- Large-Scale Coordinate Metrology
- Engineering Metrology
- Surface and Microform Metrology
- Nanoscale Metrology

Contact: Michael Postek || michael.postek@nist.gov || 301.975.3463

2. Manufacturing Metrology Division (MMD)

“Seeks to fulfill the measurements and standards needs of the U.S. discrete-parts manufacturers in mechanical metrology and advanced manufacturing technology by conducting research and development in realizing and disseminating the IS mechanical units, developing methods, models, sensors, and data to improve metrology, machines, and processes, providing services in mechanical metrology, machine metrology, process metrology, and sensor integration, and leading in the development of national and international standards.”

Topic areas:

- Metrology and Standards for Manufacturing Process
- Metrology and Standards for Manufacturing Equipment
- Mechanical Metrology
- Mass

- Force
- Sensors
- Calibrations (Mechanical)
- Measurement Standards
- Measurement Services
- Acceleration
- Acoustical pressure measurement
- Optical Metrology

Groups:

- Mass and Force
- Machine Tool Metrology
- Manufacturing Process Metrology
- Sensor Development and Application

Contact: Kevin Jurrens || kevin.jurrens@nist.gov || 301.975.5486

3. Intelligent Systems (ISD)

“ISD supports a future in which U. S. manufacturing grows more accurate, agile, intelligent, interoperable, and reconfigurable through constant innovation. Our work promotes the development of measurement and interoperability standards that will enhance manufacturing robotics and automation equipment and the underlying industrial control systems. These are key elements of a future in which U. S. manufacturing and competitiveness will be driven by an accelerating pace of technological change that encompasses product and process innovation, as well as reduction in time to market, higher quality and better performance of customized products, increased productivity and reduced costs, and new safety and security challenges.”

Topic areas:

- Metrology
- Metrology and Standards for Manufacturing Equipment
- Robotics
- Simulation
- Nanomanufacturing
- Perception
- Autonomous Navigation
- Homeland Security

Groups:

- Machine Systems
- Control Systems
- Systems Integration
- Perception Systems

- Knowledge Systems

Contact: Elena Messina || elena.messina@nist.gov || 301.975.3510

4. Manufacturing Systems Integration (MSID)

MSID states that it aims to respond to industry priorities for interoperability solutions by helping to define technically sound, neutral integration standards in cooperation with industrial partners. The Division also assists with the development of mechanisms for assessing conformance and interoperability of software implementations of these standards to ensure that these information standards solve the problems they are intended to address. Developing viable information technology standards for manufacturing is particularly challenging given the rapid pace of change in technology. Standards must be developed with an eye toward future extensibility. The Manufacturing Systems Integration Division (MSID) attempts to help make US industry more productive by developing the technologies and standards manufacturers need to share digital business information with their stakeholders --- investors, customers, and partners

Topic areas:

- Supply Chain
- Systems Integration
- Metrology
- Simulation
- Ontologies
- Product Data
- Green Manufacturing
- Lean Manufacturing
- Sustainable Manufacturing

Groups:

- Design and Process
- Enterprise Systems
- Manufacturing Simulation & Modeling
- Manufacturing Standards Metrology
- Systems Integration for Manufacturing Applications (SIMA)

Contact: Vijay Srinivasan || vijay.srinivasan@nist.gov || 301.975.3508

5. Fabrication Technology (FTD)

“The mission of the Fabrication Technology Division (FTD) is to provide high quality, reliable, and cost effective fabrication and technical support services to all NIST staff. FTD assists NIST staff in the design and development of instruments and measurement devices needed to maintain the national and international standards of measurement and measurement services for which NIST has stewardship.

“FTD provides the necessary engineering and manufacturing expertise and equipment needed to produce specialized parts and subassemblies for one-of-a-kind instruments conceived by NIST scientists and engineers. The division performs a wide range of specialized precision fabrication and technical support services required to maintain the accuracy and performance of numerous measurement and testing instruments used by NIST scientists and engineers.”

Since its purpose is to support other NIST staff, it receives no direct funding, only indirect from other NIST areas.

Contact: Mark Luce || mark.luce@nist.gov || 301.975.6504

For a thorough listing of EL programs, visit:
<http://www.nist.gov/mel/upload/melprograms10web.pdf>.

As noted above, much of NIST is engaged in manufacturing-related activities, through additional programs at its other laboratory programs: Material Measurement Laboratory, Physical Measurement Laboratory, Information Technology Laboratory, Center for Nanoscale Science and Technology, and Center for Neutron Research. The President's FY 2011 budget request for NIST included about \$70 million in increased funding for manufacturing-related research and support services. While "manufacturing" does not appear in the names of any of the new laboratories, NIST officials state that research and services supporting manufacturing are a significant element in all six of the newly reorganized laboratory units.

National Science Foundation

The National Science Foundation's mission is to "promote the progress of science; to advance the national health, prosperity, and welfare; to secure the national defense..." Its annual total budget is approximately seven billion dollars (\$6.9B in FY10, \$7.35 budgeted in FY11); with that they fund about twenty percent of all federally supported basic research conducted by America's colleges and universities.²²

The Directorate for Engineering within NSF is home to the following six organizations:

1. Chemical, Bioengineering, Environmental and Transport Systems (CBET)
2. Civil, Mechanical and Manufacturing Innovation (CMMI)
3. Electrical, Communications and Cyber Systems (ECCS)
4. Engineering Education and Centers (EEC)
5. Emerging Frontiers in Research and Innovation (EFRI)
6. Industrial Innovation and Partnerships (IIP)

The Civil, Mechanical and Manufacturing Innovation (CMMI) Organization has four program clusters, each with four to six research programs. They are laid out in outline form beneath the budget summary table below in Table 4. Most of the text is taken directly from the program's website and edited for content.

A conversation with George Hazelrigg, director of the Manufacturing and Construction Machines and Equipment Program within the Advanced Manufacturing Cluster, conveyed some rough numbers for the funding these programs receive, and are stated when available below. He repeatedly stressed that NSF does basic research and not applications, so, depending on how manufacturing is defined, one could conclude that if manufacturing is viewed as inherently applied, zero funding goes toward it from NSF. However, the manufacturing story is obviously more complex, incorporating basic and applied advances. He also said that manufacturing innovations might not occur exclusively within the CMMI program. His estimate for strict manufacturing programs' funding was ~\$150 million.

²² <http://www.nsf.gov/about/glance.jsp>


	FY 2009 Omnibus Actual	FY 2009 ARRA Actual	FY 2010 Estimate	FY 2011 Request	Change Over FY2010 Estimate	
					Amount	Percent
CMMI	\$174.93	\$57.96	\$188.00	\$206.50	\$18.50	9.8%
Research	\$152.06	\$56.20	\$164.10	\$182.10	\$18.00	11.0%
<i>Nanoscale Sci. and Eng. Centers</i>	\$6.01	-	\$5.45	\$5.45	-	-
Facilities	\$22.87	\$1.76	\$23.90	\$24.40	\$0.50	2.1%

Table 4: Budget numbers for CMMI.²³ Amounts shown in millions of dollars.

Civil, Mechanical and Manufacturing Innovation (CMMI) Organization

Advanced Manufacturing

“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.”

- *Manufacturing and Construction Machines and Equipment -- \$7.5 million*
 - The MCME program supports fundamental research leading to improved machines and applications for both manufacturing and construction. Key goals are to advance the transition of these industries from skill-based to knowledge-based activities and to develop them as activities with minimal environmental and societal impact. To accomplish these goals the program emphasizes research leading to a fundamental understanding of the relevant physical processes resulting in better predictive models and improved manufacturing and construction decision making. The program also supports research on solid freeform fabrication encompassing scales from microns to meters (nanometer scale additive manufacturing is supported under the Nanomanufacturing program).
 - Contact: George Hazelrigg || ghazelri@nsf.gov || 703.292.7068
- *Manufacturing Enterprise System -- \$5 million*

²³ <http://www.nsf.gov/about/budget/>

- The MES program supports research on design, planning, and control of operations in manufacturing enterprises. Research is supported that impacts the analytical and computational techniques relevant to extended enterprise operations and that offer the prospect of implementable solutions. Topics of interest include analytical and computational tools for planning, monitoring, control, and scheduling of manufacturing and distribution operations, and development of methods for optimization of manufacturing enterprises in the presence of a high degree of uncertainty and risk.
- Contact: Cerry Klein || cklein@nsf.gov || 703.292.5365
- *Materials Processing and Manufacturing -- \$10 million*
 - The MPM program supports fundamental research on the interrelationship of materials processing, structure, performance and process control. Analytical, experimental, and numerical studies are supported covering processing methods such as molding, forging, casting, welding, hydroforming, composite layup, and other materials processing approaches. Emphasis is placed on environmentally benign manufacturing and virtual manufacturing. Research leading to the development of novel processes and novel hybrid processing techniques to achieve net shape products and complex multi-scale, multi-functional products with superior quality and performance is also supported.
 - Contact: Mary Toney || mtoney@nsf.gov || 703.292.7008
- *NanoManufacturing – \$8.5 million*
 - The NM program supports research and education on manufacturing at the nanoscale, and the transfer of research results in nanoscience and nanotechnology to industrial applications. The program emphasizes a systems approach to scale-up of nanotechnology for high rate production, reliability, robustness, yield and cost, and promotes integration of nanostructures to functional micro devices and meso/macro scale systems. Special emphases are on environmental, health, and societal aspects of nanotechnology and nanomanufacturing.
 - Contact: Shaochen Chen || shchen@nsf.gov || 703.292.7557

Mechanics and Engineering Materials

“The Mechanics and Engineering Materials Cluster supports fundamental research aimed at advances in the transformation and use of engineering materials efficiently, economically, and sustainably. The cluster’s programs support research topics relating to the design and use of solid and biological materials that span multiple time scales and length scales from nanometers to meters.”

- *GeoMechanics and GeoTechnical Systems*

- The GEOMM program supports fundamental research on the mechanics and engineering properties of geologic materials including the mechanical properties of soil and rock, mechanically stabilized and biologically modified soil, and on natural processes, such as hydraulic, biological and thermal, that affect the behavior of these materials. The program also funds research on soil-structure interaction and liquefaction. Support is provided for theoretical studies, constitutive and numerical modeling, laboratory, centrifuge, and field-testing.
- Contact: Richard Frigaszy || rfragasz@nsf.gov || 703.292.7011
- *Materials and Surface Engineering -- \$9 million*
 - The MSE program supports fundamental research leading to a better understanding of the effect of microstructure, surfaces, and coatings on the properties and performance of engineering materials; and the ultimate control of these properties through material design. Of particular interest is materials service under conditions such as impact, temperature extremes, corrosion, oxidation, and friction. The program also supports research leading to biomedical applications of materials. Funded research includes both experimental and theoretical approaches.
 - Contact: Clark Cooper || ccooper@nsf.gov || 703. 292.7899
- *Mechanics of Materials*
 - The MOM program supports fundamental research on solid mechanics including theoretical, analytical, and computational approaches, model-based simulation, and the development of constitutive models. Emphasis is placed on the fundamental understanding of existing and emerging material and structural systems behavior across time and length scales, including experimental and analytical research on deformation, fatigue, and fracture. There is significant interest in techniques that address the theoretical basis of multiscale methods.
 - Contact: Glaucio Paulino || gpaulino@nsf.gov || 703.292.7060
- *Nano and Bio Mechanics*
 - The NBM program supports fundamental research in biomechanics and nanomechanics. Research on biomechanics focuses on the mechanical properties and behavior of biological materials and structures, including cells, tissue, muscles, bones, and prosthetic implants. Research on nanomechanics focuses on the unique properties of nano-scale particles and microstructural features and their effects on the macroscopic mechanics and properties of materials, surfaces, and structures that contain them.
 - Contact: Glaucio Paulino || gpaulino@nsf.gov || 703.292.7060
- *Structural Materials and Mechanics*
 - The SMM program supports fundamental research on the behavior of civil infrastructure materials and the mechanics of structural components in the built environment. Of particular interest is

research on structural components consisting of natural and synthetic materials, their response to mechanical, hydrothermal, and time-dependent loads, and their impact on life-cycle performance and sustainable development of the civil infrastructure.

- Contact: Lawrence Bank || lbank@nsf.gov || 703.292.2162

Resilient and Sustainable Infrastructures

The Resilient and Sustainable Infrastructures Cluster supports research to advance fundamental knowledge and innovation for resilient and sustainable civil infrastructure and distributed infrastructure networks. The Cluster funds research on geotechnical, structural, and earthquake engineering, distributed infrastructure systems management and response to hazardous events. Research on social, behavioral, and economic issues related to natural and technological hazards is also invited. The cluster plays a major role in the National Earthquake Hazards Reduction Program (NEHRP), created by Congress by the Earthquake Hazards Reduction Act of 1977.

- *Civil Infrastructure Systems*
 - The CIS program supports research leading to the intelligent engineering of distributed infrastructure systems. Areas of interest include intra- and inter-dependencies in infrastructure design and operation for resilience and sustainability, infrastructure protection, and advanced information technologies for health monitoring, condition assessment, deterioration and asset management. Special emphasis is on risk analysis, life-cycle frameworks, cyber-enabled simulation, and technologies for design, construction, and operation of resilient and sustainable infrastructure networks.
 - Contact: Dennis Wenger || dwenger@nsf.gov || 703.292.8606
- *George E. Brown, Jr. Network for Earthquake Engineering Simulation Research*
 - Designed to advance knowledge discovery and innovation for (1) earthquake and tsunami loss reduction of our nation's civil infrastructure, and (2) new experimental simulation techniques and instrumentation for NEES. NEES comprises a network of earthquake engineering experimental equipment sites available for experimentation on-site or in the field and through telepresence.
 - Contact: Joy Pauschke || jpauschk@nsf.gov || 703.292.7024
- *Geotechnical Engineering*
 - The GTE program supports fundamental research on geotechnical aspects of civil infrastructure, such as foundation engineering, site characterization, underground construction, tunneling, drilling, and mining engineering. Also included is research on geoenvironmental engineering, geotechnical earthquake engineering that does not involve the use of George E. Brown, Jr. Network for Earthquake Engineering Simulation (NEES) facilities, and geohazards such as

tsunamis, landslides, mudslides and debris flows, scour, and erosion. Emphasis is on issues of sustainability and resilience.

- Contact: Richard Fragaszy || rfragasz@nsf.gov || 703.292.7011
- *Hazard Mitigation and Structural Engineering*
 - The HMSE program supports fundamental research on the design and performance of structural systems and on new technologies for improving the behavior, safety, and reliability of structural systems and their resistance to natural hazards such as earthquakes and technological hazards (such as bombs). Also supported by the program are innovations in analysis and model-based simulation of structural behavior and response, design concepts that improve structural performance, reliability, resilience and sustainability, structural health monitoring, and applications of new control techniques for structural systems.
 - Contact: M. P. Singh || mpsingh@nsf.gov || 703.292.7081
- *Infrastructure Management and Extreme Events*
 - The IMEE program focuses on the impact of large-scale hazards on civil infrastructure and society and on related issues of preparedness, response, mitigation, and recovery. The program supports research to integrate multiple issues from engineering, social, behavioral, political, and economic sciences. It supports fundamental research on the interdependence of civil infrastructure and society, development of sustainable infrastructures, and civil infrastructure vulnerability and risk reduction.
 - Contact: Dennis Wenger || dwenger@nsf.gov || 703.292.8606

Systems Engineering and Design

The Systems Engineering and Design Cluster supports fundamental research on the decision-making aspects of engineering, including design, control, and optimization as applied at levels ranging from component to enterprise systems. Supported research examples include sensors, sensing, and the use of sensor data in decision-making and control, and extends to service enterprise systems that address healthcare delivery. Support is provided to enable advances in engineering decision-making, optimization and control, and their application to engineered systems.

- *Control Systems*
 - The CS program supports innovative research on control theory and control technology driven by real life applications. The program accepts proposals on transformative research in established topic areas such as model-based control. However, the program emphasis is on paradigm-shifting ideas for control strategies that may be inspired by nature, unconventional applications, and the combined role of feedback and uncertainty in systems that incorporate large

numbers of sensors and actuators. New sensor and actuator concepts that integrate feedback and signal processing to achieve a sensing or actuation objective are also funded.

- Contact: Suhada Jayasuriya || sjayasur@nsf.gov || 703.292.7014

- *Dynamical Systems*

- This program supports innovative research on the theories of dynamical systems, including new analytical and computational tools, as well as the novel application of dynamical systems to engineered systems. The program is especially interested in transformative research in the area of complex systems, uncertain or stochastic nonlinear dynamical systems, model order reduction of nonlinear or infinite dimensional dynamical systems, discrete nonlinear dynamical systems, and modeling, simulation, analysis and design of multi-scale multi-physics dynamical systems.

- Additional information is available in the "Dear Colleague Letter" NSF 08-079 titled "Unsolicited proposals to the Dynamical Systems program in the Division of Civil, Mechanical and Manufacturing Innovation (ENG) and the Applied Mathematics Program in the Division of Mathematical Sciences (MPS) Addressing Crosscutting Topics in Theory and Application of Dynamical Systems," available at: http://www.nsf.gov/publications/pub_summ.jsp?ods_key=nsf08079.

- Contact: Eduardo Misawa || emisawa@nsf.gov || 703.292.5353

- *Engineering Design and Innovation*

- The EDI program supports research leading to design theory and to tools and methods that enable implementation of the principles of design theory in the practice of design across the full spectrum of engineered products. The program focus is on gaining an understanding of the basic processes and phenomena underlying a holistic, life-cycle view of design where the total system life-cycle context recognizes the need for advanced understanding of the identification and definition of preferences, analysis of alternatives, effective accommodation of uncertainty in decision-making, and the relationship between data and knowledge in a digitally-supported process. The program funds advances in basic design theory, tools, and software to implement design theory and new design methods that span multiple domains, such as design for the environment and for manufacturability.

- Contact: Christina Bloebaum || cbloebau@nsf.gov || 703.292.8330

- *Operations Research*

- The OR program supports fundamental research leading to the creation of innovative mathematical models, analysis, and algorithms for optimal or near optimal decision-making, applicable to the design and operation of manufacturing, service, and other complex systems. In addition to the traditional areas of Operations Research which includes discrete and continuous optimization as well as stochastic

modeling and analysis, new research thrusts include simulation optimization and self-optimizing systems that can observe, learn, and adapt to changing environments.

- Contact: Robert Smith || rlsmith@nsf.gov || 703.292.7902
- *Sensors and Sensing Systems -- \$6 million*
 - The SSS program supports research on methods to acquire and use sensor data on civil, mechanical, and manufacturing systems. The program supports fundamental research on advanced actuators, sensors, wireless sensor networks, new materials and concepts for sensing applications, power generation and energy supply for sensors and sensing systems. Also of interest is research on the strategic incorporation of sensors into both natural and engineered systems to achieve effective data acquisition and on processing and transmission of sensor data.
 - Contact: Shih C. Liu || sliu@nsf.gov || 703.292.8360
- *Service Enterprise Systems*
 - The SES program supports research on strategic decision making, design, planning and operation of commercial, nonprofit, and institutional service enterprises with the goal of improving their overall effectiveness and cost reduction. The program has a particular focus on healthcare and other similar public service institutions, and emphasizes research topics leading to more effective systems modeling and analysis as a means to improved planning, resource allocation, and policy development.
 - Contact: Cerry Klein || cklein@nsf.gov || 703.292.5365

President's Council of Advisors on Science and Technology – Pending Study

PCAST is an advisory group of leading scientists and engineers named by the White House as advisors to the President and the Executive Office of the President. PCAST makes policy recommendations in areas “where understanding of science, technology, and innovation is key to strengthening our economy and forming policy that works for the American people.” PCAST is administered by the White House Office of Science and Technology Policy (OSTP).²⁴

PCAST convened a study of advanced manufacturing in March 2010, Chaired by Eric Schmidt, CEO of Google, and, Dr. Shirley Ann Jackson, president of Rensselaer Polytechnic University (RPI). Working sessions of the study group were held on March 19, 2010 and July 16, 2010 with a report likely by the end of the year.

The study is examining a range of topics, including such issues as:²⁵

1. What *scientific and technical developments* apply to a wide range of advanced manufacturing industries? What are the key advanced cutting-edge technologies, relevant across multiple industries, that show the most potential for advanced manufacturing?
2. What are some possible *new concepts* of advanced manufacturing that might apply to a wide range of industries?
3. What is the appropriate *role of government science and technology programs and policies* in advanced manufacturing? At what point is government intervention appropriate? Where is the appropriate line between government and industry actions taking into account timing in the innovation process and leverage points? Does the intervention point vary by industry or sector?
4. What are *historical examples* where federal or state science and technology programs, policies or activities have enhanced advanced manufacturing?
5. What *federal government science and technology programs or policies*, if any, *should be put into place* to accelerate the development and adoption of advanced manufacturing technologies by industry? How might the government encourage increased funding for pre-competitive research by industry?
6. What *broad infrastructural improvements* are critical for new versus existing enterprises? Where do public/private partnerships play a crucial role?

²⁴ <http://www.whitehouse.gov/administration/eop/ostp/pcast/about>

²⁵ Summary from, Science Technology Policy Institute (STPI), “The Role of Government S&T Programs in Advanced Manufacturing. White Papers on Questions Posed for PCAST Study on Advanced Manufacturing - Summaries,” March 5, 2010.

Conclusion

This summary indicates that a series of federal agencies are working towards more efficient, more innovative manufacturing in America. The four leading agencies have a combined FY2010 budget of roughly \$707 million (see Appendix B), predominantly for manufacturing R&D with some implementation (such as through NIST's MEP and aspects of DoD's ManTech). What is also clear, however, is while some of their goals may differ (i.e. programs within the DoD's foci, of course, do not necessarily match up with those of NSF), their work could benefit from further collaboration – not only with each other, but with universities and industry as well, in developing a common technology R&D and implementation strategy,

The strengths of the various organizations could be more complementary; one can contemplate a holistic, cooperative effort. For example, NSF's focus on basic manufacturing research provides a possible complement to DARPA's applied, technology breakthrough approach, which is complemented by NIST's Manufacturing Engineering Lab's emphasis on standards and metrology and by DOE's Industrial Technology Program and its emphasis on energy efficiency. Thus, manufacturing technologies could evolve from basic through applied research, with needed standards and efficiency. On the implementation side, Mantech's programs could provide a critical testbed for evaluating and proving the costs, performance and efficiency of new technologies, and for evolving supporting processes. In turn, NIST's nationwide Manufacturing Extension Program (MEP) could help assure its dissemination to small and mid-size manufacturers. Of course, each agency would have to remain faithful to its underlying mission – DoD will still need to serve its defense manufacturing and industrial mission, for example – but these missions are broad enough to allow a complementary program to evolve to create mutual benefits for each agency's programs.

It would be possible, if the agencies agreed, to treat such a combined effort as a formal interagency collaborative enterprise. For example, the National Nanotechnology Initiative, a complex enterprise involving significant funding and numerous agencies, is coordinated as an interagency body through the Nanoscale Science, Engineering and Technology (NSET) Subcommittee²⁶ with formal status under the executive orders and authorizing statutes allowing such coordination. Given the importance of American manufacturing innovation, cooperation at this level could be considered for agency manufacturing efforts,²⁷ and connected with private and academic sector efforts, to develop a common strategy.

²⁶ http://www.nano.gov/html/about/home_about.html

²⁷ Status as a Subcommittee (like NSET) under the National Science and Technology Council (NSTC), within OSTP, could be considered for a manufacturing initiative.
<http://www.whitehouse.gov/sites/default/files/microsites/ostp/nstc-org-chart.pdf>

Appendix A – List of Contacts by Program

Program	Contact Information
Adaptive Vehicle Make - DARPA	Paul Eremenko paul.erenko@darpa.mil
Civil Infrastructure Systems – NSF	Dennis Wenger dwenger@nsf.gov 703.292.8606
Control Systems – NSF	Suhada Jayasuriya sjayasur@nsf.gov 703.292.7014
Disruptive Manufacturing Technologies – DARPA	William Coblenz william.coblenz@darpa.mil 571.218.4647
Dynamical Systems – NSF	Eduardo Misawa emisawa@nsf.gov 703.292.5353
Engineering Design and Innovation – NSF	Christina Bloebaum cbloebau@nsf.gov 703.292.8330
Fabrication Technology Division – NIST	Mark Luce mark.luce@nist.gov 301.975.6504
GeoMechanics and GeoTechnical Systems – NSF	Richard Fragaszy rfragaszy@nsf.gov 703.292.7011
George E. Brown, Jr. Network for Earthquake Engineering Simulation Research – NSF	Joy Pauschke jpauschk@nsf.gov 703.292.7024
Geotechnical Engineering – NSF	Richard Fragaszy rfragaszy@nsf.gov 703.292.7011
Hazard Mitigation and Structural Engineering – NSF	M. P. Singh mpsingh@nsf.gov 703.292.7081
Infrastructure Management and Extreme Events – NSF	Dennis Wenger dwenger@nsf.gov 703.292.8606
Intelligent Systems Division – NIST	Elena Messina elena.messina@nist.gov 301.975.3510
ManTech - DOD	Mike Dunn michael.dunn.ctr@osd.mil 571.226.8761 Cynthia Gonsalves cynthia.gonsalves@osd.mil 703.607.5315 (for DoD Off. of the Secretary Mantech Program)
Manufacturing and Construction Machines and Equipment	George Hazelrigg ghazelri@nsf.gov 703.292.7068
Manufacturing Enterprise System	Cerry Klein cklein@nsf.gov 703.292.5365
Manufacturing Metrology Division – NIST	Kevin Jurrens kevin.jurrens@nist.gov 301.975.5486
Manufacturing Systems Integration Division – NIST	Vijay Srinivasan vijay.srinivasan@nist.gov 301.975.3508
Materials and Surface Engineering – NSF	Clark Cooper ccooper@nsf.gov 703.292.7899
Materials Processing and Manufacturing – NSF	Mary Toney mtoney@nsf.gov 703.292.7008
Mechanics of Materials – NSF	Glaucio Paulino gpaulino@nsf.gov 703.292.7060
Nano and Bio Mechanics – NSF	Glaucio Paulino gpaulino@nsf.gov 703.292.7060
NanoManufacturing – NSF	Shaochen Chen shchen@nsf.gov 703.292.7557
Operations Research – NSF	Robert Smith rlsmith@nsf.gov 703.292.7902
Precision Engineering Division – NIST	Michael Postek michael.postek@nist.gov 301.975.3463
Sensors and Sensing Systems – NSF	Shih C. Liu sliu@nsf.gov 703.292.8360
Service Enterprise Systems – NSF	Cerry Klein cklein@nsf.gov 703.292.5365
Structural Materials and Mechanics – NSF	Lawrence Bank lbank@nsf.gov 703.292.2162

Appendix B – Summary of Federal Manufacturing Funding at Four Leading Agencies:

Agency	Approximate Funding Level
Department of Defense (DARPA and Mantech), total	~\$264.4 million
Department of Energy, total	~\$ 96 million
NIST, total	~\$158.9 million
NSF, total	~\$188 million
TOTAL, all above agencies	~\$707.3 million