ADVANCED MANUFACTURING

Few areas of research hold as much potential for significant short-term and long-term economic impact as research in advanced manufacturing. Rather than a "refinement" of traditional manufacturing processes, advanced manufacturing involves new methodologies, new systems, new processes, and entirely new paradigms for translating fundamental raw materials into finished products. In many cases, advanced manufacturing promises entirely new classes and families of products having previously unattainable properties and functionalities.

Summary

NSF supports a diverse research portfolio providing basic research discoveries that benefit advanced manufacturing. In recent years, significant investments have been made in areas of importance to advanced manufacturing, and for FY 2012, additional investment in these as well as new areas is a principal focus for NSF.

Within the Foundation, major areas of emphasis include:

- Manufacturing enterprise systems, manufacturing and construction machines, and materials processing and manufacturing;
- Advanced semiconductor and optical device design, fabrication and processing, for application in biomedical, alternative energy, communications, computing and sensing systems, pursued both through support of the National Nanotechnology Infrastructure Network (NNIN) and other ongoing programs;
- The National Nanotechnology Initiative (NNI) Signature Initiative: Nanoelectronics for 2020 and Beyond, supporting innovations on novel paradigms representing departures from traditional architectural practices of computing, including reconfigurable, evolvable, adaptive hardware architectures and the use of heterogeneous systems that can dynamically change via software mechanisms and architectures capable of combating error-prone devices at the nanoscale;
- Capabilities for the 21st century, specifically those associated with complex engineering systems design and manufacturing, such as materials and surface engineering, sensors and sensing systems, engineering design and innovation, control systems, and dynamical systems;
- Cyber–physical systems and advanced robotics research; and
- A variety of activities aimed at bolstering industry/university interactions, such as forums and networks that connect fundamental research developments with regional and national innovation ecosystems, and related activities through the Industry/University Cooperative Research Centers (I/UCRC) program.

Ongoing Investments: Advanced Manufacturing

National Nanotechnology Initiative (NNI): Investments include nanoscale processing and materials science, as well as reconfigurable, evolvable, adaptive hardware architectures and the use of heterogeneous systems that can dynamically change via software mechanisms and architectures capable of combating error prone devices at the nanoscale. Support for nanomanufacturing research is aimed at the manufacture of materials devices and systems through manipulation and assembly of materials at the atomic and molecular levels. In addition, NSF's participation in the NNI Signature Initiative on Sustainable Nanomanufacturing includes cutting-edge research aimed at overcoming key roadblocks to the scale-up of nanotechnology to the commercial level.

NSF also supports centers, interdisciplinary projects, and investigator-initiated research projects related to manufacturing processes and manufacturing enterprises, as well as education and workforce development.

Center-scale Activities: The Foundation supported four NSECs (Nanoscale Science and Engineering Centers), with a budget of about $12.7 million for FY 2010, that focus on manufacturing at the nanoscale. These centers have strong partnerships with industry, national laboratories, and international centers of excellence, which puts in place the necessary elements to bring discoveries in the laboratory to real-world, marketable innovations and technologies. The NSECs with a focus on nanomanufacturing are:

- The Center for Hierarchical Manufacturing at the University of Massachusetts Amherst;
- The Center for Scalable and Integrated Nanomanufacturing (SINAM) at the University of California, Berkeley (formerly at UCLA);
- The Center for High-rate Nanomanufacturing (CHN) at Northeastern University; and
- The Center for Nano-Chemical-Electrical-Mechanical Manufacturing Systems (Nano-CEMMS) at the University of Illinois at Urbana-Champaign.

NSF also supports the National Nanomanufacturing Network (NNN), which includes the NSF NSECs and non-NSF centers in collaboration with the Department of Defense (DoD), National Institute of Standards and Technology (NIST), and industry partners in an alliance to advance nanomanufacturing strength in the U.S.

Through the Engineering Research Centers Program (ERC), NSF supports the ERC for Compact and Efficient Fluid Power (CCEFP) at the University of Minnesota. The Foundation has also supported workshops for manufacturing innovation such as "Re-Shaping U.S. Manufacturing for Global Competitiveness" held in May 2010 and "Extreme Manufacturing" held at NIST in January 2011.

Core Research in Science and Engineering: Support for manufacturing enterprise systems includes research into the dynamic behavior of manufacturing and supply chain operations for more efficient and responsive production and distribution, for the design and operation of manufacturing and distribution facilities, and effective use of sensor data for improved product and process reliability. Support for operations research focuses on mathematical models that can be used to improve the efficiency of factory operations, connect manufacturing management more closely to dynamically changing customer needs, provide more effective collaboration with suppliers, and management strategies to deal with supply chain disruptions.

Education Activities: Investments are also made (through the CAREER, Research Experiences for Undergraduates (REU), and Research Experiences for Teachers (RET) programs as well as manufacturing engineering education) in the people who will educate, lead, manage, operate and create the new wealth-generating manufacturing enterprises for the 21st century. NSF also supports training of the next generation of product designers and product engineers on the ethical production of products through awards in its Ethics Education for Science & Engineering program.

Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR): NSF's SBIR/STTR investments strongly reflect the 2004 Executive Order on *Encouraging Innovation in Manufacturing* (Executive Order 13329).

- In FY 2010, of roughly 450 SBIR/STTR Phase I awards, 140 had a major manufacturing innovation component.
- Of the current active SBIR/STTR Phase II awards, about 30 percent have a significant manufacturing research component.
- For FY 2011, it is anticipated that more than 80 SBIR/STTR Phase I awards will support manufacturing innovation.

Advanced Manufacturing in FY 2012

While many of the activities described above will continue, NSF's increased investment in FY 2012 will emphasize several emerging opportunities in advanced manufacturing research. FY 2012 resources for advanced manufacturing will be utilized to pursue revolutionary research advances in cyber-physical systems including advanced robotics, sensor and model-based smart manufacturing, multi-scale modeling for simulation-based design and manufacturing across the supply chain, scalable nanomanufacturing and nano-bio manufacturing, energy manufacturing, and complex engineering systems design and manufacturing.

A feature of these efforts will be integrated research and educational initiatives focused on making cyber-based access to design, prototyping, fabrication and manufacturing computational tools and physical resources widely available to innovative small and medium-sized businesses and the U.S. citizenry at large. The aim of these efforts is to unleash the creative energy of the U.S. populace, which may provide a major competitive edge in global competition.

A portion of the new NSF-wide investment in research at the intersections of biological, mathematical, and physical sciences and engineering (BioMaPS) will be invested in advanced manufacturing areas. These interdisciplinary efforts will result in accelerated understanding of biological systems, as well as uncovering of new mathematical and physical principles, leading to innovations in manufacturing in such areas as clean energy systems, bio-based materials, bio-imaging, and bio-inspired sensors.

Building on current efforts, additional resources will be allocated to promoting unique collaborations and alliances between academic researchers and industrial partners to accelerate the translation of basic research discoveries to useful manufacturing processes and methods. Investments will be focused on people who will educate, lead, manage, operate, and create the new wealth generating manufacturing enterprises for the 21st century. NSF will also continue to provide training support for the next generation of product designers and product engineers on the ethical production of products through awards in its Ethics Education for Science & Engineering program.

Advanced Manufacturing Funding

(Dollars in Millions)

	2010 Omnibus Actual	FY 2010 Enacted/ Annualized FY 2011 CR	FY 2012 Request
Biological Sciences	-	-	$10.00
Computer and Information Science and Engineering	15.71	17.15	65.90
Engineering	38.50	38.42	74.50
Mathematical and Physical Sciences	20.00	20.00	40.00
Total, Advanced Manufacturing	**$74.21**	**$75.57**	**$190.40**

Totals may not add due to rounding.