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National Nanotechnology Investment in the FY 2009 Budget Request

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The emerging fields of nanoscale science, engineering, and technology —the ability to measure and restructure matter at the atomic and molecular levels to create materials, devices and systems with fundamentally new properties and functions—are leading to unprecedented understanding and control over the basic building blocks and properties of all natural and manmade things. The fiscal year (FY) 2009 funding request for nanoscale science, engineering and technology (in brief, *nanotechnology*) research and development (R&D) in 13 federal departments and agencies is $1.5 billion (Table I-9). This investment is known as the National Nanotechnology Initiative (NNI) and began in FY 2001, with a budget of $494 million.[2] The NNI is a collaborative program among 26 federal departments and agencies with a long-term strategic plan to accelerate discovery, development and deployment of nanotechnology.[3] The budget increase is justified by the

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[2] See the NNI's website http://nano.gov

[3] Federal agencies with budgets dedicated to nanotechnology R&D are: U.S. Department of Agriculture, Cooperative State Research, Education, and Extension Service (USDA/CSREES); Forest Service (USDA/FS); Department of Defense (DOD); Department of Energy (DOE); Department of Homeland Security (DHS); Department of Justice (DOJ); Department of Transportation (DOT); Environmental Protection Agency (EPA); National Aeronautics and Space Administration (NASA); National Institute of Standards and Technology (DOC/NIST); Centers for Disease Control and Prevention, National Institute for Occupational Safety and Health (HHS/CDC/NIOSH); National Institutes of Health (HHS/NIH); and National Science Foundation (NSF). Other participating agencies are: Bureau of Industry and Security (DOC/BIS); Consumer Product Safety Commission (CPSC); Department of Education; Department of Labor (DOL); Department of State (DOS); Department of the Treasury; Food and Drug Administration (HHS/FDA); International Trade

current results and potential to expand fundamental knowledge and contribute to national priorities such as economic competitiveness and public health. Because of the NNI: federal agencies have initiated major new nanotechnology R&D activities under a common vision that support national goals and agency missions; an extensive infrastructure of nanotechnology research and educations centers has been established; and participating agencies are working together to maximize the effectiveness of their individual and collective investments on society.

The NNI vision is a future in which understanding and control of matter at the nanoscale will lead to a revolution in technology and industry. The four goals of the NNI are to: 1/ Advance a world-class nanotechnology research and development program; 2/ Foster the transfer of new technologies into products for commercial and public benefit; 3/ Develop and sustain educational resources, a skilled workforce, and the supporting infrastructure and tools to advance nanotechnology; and 4/ Support responsible development of nanotechnology.

The supported R&D is grouped into eight program component areas (PCAs) whose proposed FY 2009 funding levels for all NNI agencies are as follows: (1) Fundamental nanoscale phenomena and processes, $551 million; (2) Nanomaterials, $227 million; (3) Nanoscale devices and systems, $327 million; (4) Instrumentation research, metrology, and standards for nanotechnology, $82 million; (5) Nanomanufacturing, $62 million; (6) Major research facilities and instrumentation acquisition, $161 million; (7) Environmental, health and safety (EHS), $76 million; and (8) Education and societal dimensions, $41 million.

Funding generally is provided on a competitive basis with other programs and within NNI. The President signed on December 3, 2004, the "21st Century Nanotechnology R&D Act" (Public Law 108-153) with recommend funding levels for five agencies—NSF, DOE, NASA, NIST and EPA—for fiscal years 2004-2008. NSET updated its long-term strategic plan in December 2007.[4] The President's Council of Advisors on Science and Technology (PCAST), which was assigned as the National Nanotechnology Advisory Panel (NNAP) called for by the Act,

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Commission (ITC); Intelligence Technology Innovation Center (ITIC); Nuclear Regulatory Commission (NRC); U.S. Geological Survey (USGS); and U.S. Patent and Trademark Office (DOC/USPTO).

[4] The NNI Strategic Plan, NSET, Washington, D.C., December 2007

reviewed NNI in the report *NNI at Five Years (2005)* and another report is expected in Spring 2008. The National Research Council published two reviews of NNI, in 2002 and 2006, and another study focused on environmental, health and safety aspects covered by NNI is under way. Nanotechnology is highlighted by the American Competitiveness Initiative providing support to NSF, DOE (Office of Science) and NIST.

SUMMARY FOR ALL AGENCIES

- The FY 2009 President's request of about $1.5 billion for federal investment in nanoscale science provides a 2.4 percent increase over the current FY 2008 estimate. The FY 2009 increases are at NSF, DOE, NIST, EPA and USDA. The budget decreases at DOD and NASA may be explained by the reassignment of applied nanotechnology projects to other areas of relevance, as well as by overall budget constraints. Approximately 65 percent of the total NNI funding supports academic research. The balance funds R&D at government laboratories (about 25 percent) and in industry (about 10 percent to industry, of which 7 percent is small business).

- The 2009 NNI budget provides increased support for research on fundamental nanoscale phenomena and processes, from $481 million in 2007 to $551 million in 2009.

- The proposed budget reflects substantial growth in funding for instrumentation research, metrology, and standards (from $53 million in 2007 to $83 million in 2009) and in nanomanufacturing research (from $48 million in 2006 to $62 million in 2009). NNI agencies are gathering input and feedback from industry and the research community on these growing investments through a series of workshops.

- EHS R&D funding in 2009 ($76.4 million) is over double the level of actual funding in 2005 ($34.8 million). The steady growth in EHS R&D spending follows the NNI strategy of expanding the capacity to do high quality research in this field. For tables in this document, EHS R&D is defined as research whose primary purpose is to understand and address potential risks to health and to the environment posed by nanotechnology. Therefore the proposed $76.4 million for 2009 does not include substantial research reported under other PCAs, *e.g.,* on instrumentation and metrology and on fundamental interactions between biosystems and engineered nanoscale materials, both of which are

important in the performance and interpretation of toxicological research. The interagency Nanoscale Science, Engineering, and Technology (NSET) Subcommittee published a draft report for public comment prepared by its Nanotechnology Environmental and Health Implications (NEHI) Working Group entitled *Prioritization of Environmental, Health, and Safety Research Needs for Engineered Nanoscale Materials* in August 2007, and a *Strategy for Nanotechnology-Related Environmental, Health, and Safety Research* in February 2008. This data in 2006 showed that the total funding for nanotechnology-related research in 2006 was about $68 million, 80 percent higher than that reported for "primary purpose research."[5] An FDA task force released a report in 2007 addressing scientific questions related to the application of its regulatory authorities to nanotechnology-enabled products. EPA issued a white paper on nanotechnology in 2007, and has initiated a Nanoscale Materials Stewardship Program under the Toxic Substances Control Act (TSCA) in January 2008 to gather and develop information from manufacturers, importers, processors and users of engineered chemical nanoscale materials. NIOSH continues to update its guidance document on best practices for safe handling of nanomaterials in the workplace, and has posted a draft document providing interim guidance on medical screening of workers potentially exposed to engineered nanoparticles. Two joint interagency solicitations for research projects addressing potential environmental and health implications of nanotechnology continue. One (led by EPA, with NSF) addresses environmental implications, while another (led by NIH, with EPA and NIOSH) focuses on human health implications. NSF will fund a new Center for Environmental Implications of Nanotechnology (CEIN) in 2008, and plans to form a network around it in 2009 with collaboration from EPA and other agencies. NNI agencies are coordinating this research internationally as well, with outreach to the European Union and Japan in particular, both bilaterally and through international organizations.

NNI has created an extensive network of over 65 large research centers, user facilities and other infrastructure for nanotechnology research. Table 2 lists key R&D networks and user facilities.

Priorities. The initiative focuses on long-term research to understand the manipulation of matter at the atomic, molecular and supramolecular levels. Applications areas include electronics for information technology; high-performance, lower-maintenance materials and design for

[5] NNI FY 2009 Budget and Highlights, NNCO, 2008.

manufacturing, defense, transportation, space, and the environment; applications in medicine, health care, and agriculture; and extending the limits of sustainable development. In FY 2009, priority in R&D funding will continue be given to research on: (1) advancing the knowledge frontiers of nanoscale phenomena and processes to extend systematic control over matter at the nanoscale, and in particular to quantum phenomena and selfassembling processes; (2) materials with emerging behavior, including activities related to the hydrogen economy; (3) active nanostructures and complex nanosystems; (4) enabling the design of hierarchically structured materials and efficient nanomanufacturing from the molecular scale; (5) nano-biosystems and medicine; (6) silicon nanoelectronics and beyond; (7) development of instrumentation, metrology and standards; and (8) environmental, health and safety (EHS) issues. It will also support: (1) the education and training of the new generation or workers for the future industries; (2) addressing ethical and other social issues raised by the development of nanotechnology; (3) establishing and operating major scientific user facilities with advanced instrumentation; and (4) partnerships to enhance industrial participation in the nanotechnology revolution. The convergence of nanotechnology with information technology, modern biology and social sciences will reinvigorate discoveries and innovation in almost all areas of the economy.

Key areas of growth are nanotechnology research for nanomedicine (particularly at NIH), nanoscale systems and their manufacturing (particularly at NSF and NIST), energy conversion (particularly at DOE and NSF), agriculture and forestry products (at USDA), and EHS (particularly at EPA, NIOSH, NIH, DOE and NSF). The detailed NNI priorities per PCA and agency are presented elsewhere.[6] The Department of Education and Department of Labor have become NNI participants.

***Collaborative activities*:** The National Science and Technology Council (NSTC) Subcommittee on Nanoscale Science, Engineering and Technology (NSET) will coordinate joint activities that create synergies between the individual agencies in a variety of topics and modalities of collaboration. NSET will identify the most promising research directions; fund complementary/synergistic fields of research that are critical for the advancement of the nanoscience and engineering field; develop a balanced infrastructure (portfolio of programs, development of

[6] Details are in NNI Supplement to the President's FY 2009 Budget, Washington, D.C., est. March 2008.

new specific tools, instrumentation, simulation infrastructure, standards for nanoscale); correlate funding activities for centers and networks of excellence; cost-share high cost R&D activities; develop a broad workforce trained in the many aspects necessary to nanotechnology; study the diverse, complex implications on society such as the effect of nanostructured material manufacturing on the environment and the effect of nanodevices on health; and avoid unnecessary duplication of efforts. NSET will also address NNI management issues, the interaction with nanotechnology regional alliances, and international activities.

Several NSET working groups (Nanomaterials Environmental and Health Implications, Nanotechnology Industrial Liaison and Innovation, Nanomanufacturing, Nanotechnology Public Engagement, and Global Issues in Nanotechnology) provide support for partnerships.

Examples of specific coordination efforts are:

- National Nanomanufacturing Network (key partners NSF, DOD, and NIST; the main node of the network is at the University of Massachusetts, Amherst).
- Environmental and health issues (two joint solicitations are planned involving EPA, NIOSH, NIH, NSF, DOE and USDA, and a partnership with European Community is explored in FY 2009; NIH, FDA and NIOSH continue to collaborate in the National Toxicology Program that involves the toxicological evaluation of specific engineered nanomaterials; NSF and EPA will establish the Center for Environmental Implications of Nanotechnology.)
- NIH, FDA and NIOSH continue to collaborate in support of the Nanotechnology Characterization Laboratory (NCL) established by the National Cancer Institute.
- Infrastructure development (such as among R&D centers—NSECs, NNIN, NCN, and centers and networks with DOE, DOD, NASA, NIH, and NIST).
- Particle characterization and standards development (NIST, FDA, NIH, NSF and other agencies); Modeling and simulation and nanoelectronics (DOD, DOE-Sandia National Laboratory, NASA and NSF).
- Collaborating with the Semiconductor Research Corporation to develop the next generation of nanometer-scale lithography technology (NSF and DOD); Cooperative efforts between DOD (ARO) and DOE (Sandia National Laboratory) to develop monolithic absorber/bolometric sensors for terahertz detectors.

- Interdisciplinary research at the intersection of nanotechnology, biotechnology and information technology (NSF, NASA, EPA). Cooperative efforts between DOD, DOE, NASA, and NSF on materials, and device development and modeling for direct thermal-to-electrical energy conversion will be undertaken in areas of thermoelectric, thermophotovoltaics, and thermionics.
- DOE, NSF, NIH, and NIST will collaborate on development and use of neutron and synchrotron facilities.
- NIH (NCI) and NIST will collaborate on nanobiotechnology, including novel opto-immunoassays for probing the molecular pathology of prostate cancer.
- DOD collaborates with NSF in the NSF-Navy Civilian Service Fellowship/Scholarship program.
- NIH and NSF are actively exploring ways to expand the scope of the institutional NCI-NSF Integrative Graduate Education and Research Traineeships (IGERT) awards initiated in FY 2005 in support of nanobiotechnology training.
- Industry liaison and technology transfer activities are given a high priority in the new NNI Strategic Plan released in December 2007. NNI agencies are working with various industry sectors to gather input on their nanotechnology-related activities, and are funding increasing numbers of nanotechnology-related SBIR and STTR awards to promote technology transfer to industry. Industry liaison groups with the electronics, forest products, and chemical industries, and with the industry research management community are continuing, while formation of comparable groups with other sectors such as constructions and predictive nanomaterials is under consideration. One successful example is the collaboration between NSF, NIST, and the industry-led Nanoelectronics Research Initiative, where industry and government representatives collaborate in reviewing proposals and in supporting pre-competitive research. In another example, NIH is formulating a "NanoHealth Enterprise," which will be a partnership with other federal agencies, private industry, and international partners to address research needs for safe development of nanoscale materials and devices.
- International collaborations in nanotechnology are progressing, with strong NNI agency participation. The Organization for Economic Cooperation and Development (OECD) Working Party on Manufactured Nanomaterials, chaired by the United States, has begun its work addressing health and safety issues. A second OECD

working party formed under the Committee for Scientific and Technological Policy is addressing broader issues such as economic impact, education and training, and public communication. With respect to standards development, the National Nanotechnology Coordination Office and several NSET member agencies represent the United States on the International Organization for Standardization (ISO) Technical Committee on Nanotechnologies (ISO TC 229), and the United States leads the ISO TC 229 working group on EHS aspects of nanotechnology.

A detailed Budget Supplement will be released after agencies have allocated funds received under 2009 appropriations, and when data become available on funding for nanotechnology under the Small Business Innovation Research (SBIR) and Small Business Technology Transfer Research (STTR) programs.

NATIONAL SCIENCE FOUNDATION (NSF)

The FY 2009 request is $396.8 million, an $8.1 million increase over the FY 2008 current estimate (see Table 1).

Table 1. NSF Directorate Budgets for NNI Funding
(in millions of dollars)

NSF Directorate	FY 2007 Current Plan	FY 2008 Estimate	FY 2009 Request
Biological Sciences	54.71	55.55	56.60
Computer and Info. Sci. and Eng.	12.89	12.22	11.00
Engineering	137.02	137.02	140.02
Geosciences	9.65	9.65	6.33
Mathematical and Phys. Sci.	169.48	169.48	178.07
Social, Behavioral and Econ. Scis.	1.67	1.67	1.67
Subtotal, R&RA	385.42	385.59	393.69
Education and Human Res.	3.27	3.10	3.10
Total National Nanotech. Initiative	$388.69	$388.69	$396.79

The Nanoscale Science and Engineering (NSE) Group coordinates the NNI activities at NSF. The NSF investment will be expanded to develop and strengthen critical fields and to establish the science and engineering infrastructure and workforce needed to exploit the opportunities

presented by new capabilities. NSF supports fundamental knowledge creation, education and infrastructure across all disciplinary areas at the nanoscale. Nine networks for research, education and user facilities will be operating in 2009. The Major Research Instrumentation Program and other programs will continue to support the creation of smaller academic nanoscale science and engineering facilities.

DEPARTMENT OF DEFENSE (DOD)

The FY 2009 request is $431 million, which is less than the FY 2008 estimate in the current plan, which includes congressionally directed funds (see Table I-9). Since DOD is a mission-oriented agency, its nanotechnology programs are simultaneously focused on scientific and technical merit and potential relevance to DOD. The overall objective for DOD is to discover and exploit unique phenomena at material structures in the range of 1 to 100 nanometers to enable novel applications enhancing war fighter and battle systems capabilities. The principal DOD participants in the NNI are the Directorate for Defense Research and Engineering (DDR&E), the Defense Advanced Research Projects Agency (DARPA), the Air Force, the Army and the Navy. The Defense Threat Reduction Agency (DTRA), the U.S. Army Medical Research and Materiel Command and the DOD Manufacturing Technology (MANTECH) program are evaluating nanotechnology as an investment area. DOD supports nanoscale science and technology in order to meet the national security mission. The DOD structures its S&T investment into basic research ("6.1"), applied research ("6.2") and advanced technology development ("6.3"); the latter two focus on transitioning science discovery into innovative technology.

DEPARTMENT OF ENERGY (DOE)

The FY 2009 request is $311 million, a $60 million increase. The FY 2009 request includes a substantial increase in funding for research at the nanoscale for activities related to the solar energy, hydrogen fuel, advanced nuclear energy systems, fundamental studies of materials at the nanoscale, instrumentation for characterizing materials at the nanoscale, and research relevant to environmental and ecological aspects of nanomaterials. In addition, the FY 2009 request includes a large investment for all five Nanoscale Science Research Centers (NSRC). Support for fundamental scientific research on nanoscale phenomena will be by grant programs and DOE National Laboratory research efforts.

HHS: NATIONAL INSTITUTES OF HEALTH (NIH) AND NATIONAL INSTITUTE FOR OCCUPATIONAL SAFETY AND HEALTH (NIOSH)

The total FY 2009 request by the Health and Human Services (HHS) department is $232 million, which would support nanotechnology activities in NIH and NIOSH.

The FY 2009 NIH request is $226 million, the same as the 2008 estimate. NIH has several roadmap initiatives.[7] NIH's priority for nanotechnology research continues to be creating novel diagnostic and therapeutic approaches and devices, and operating research capabilities to understand fundamental biomedical mechanisms. A consortium of 17 NIH institutes re-released the solicitation, "Nanoscience and Nanotechnology for Biology and Medicine," both for regular research grants and feasibility projects. Large centers and related programs at the NCI, NHLBI, and Nanomedicine Roadmap Initiative will continue in 2009. The National Institute of Dental and Craniofacial Research (NIDCR) issued in 2006 a request for applications (RFA) to encourage research leading to the development of nanostructured dental composite materials. There is a continued ramp-up of nanotechnology R&D funding for programs including implementing the Nanomedicine Roadmap Initiative, the National Cancer Institute's Nanotechnology Platform Partnerships and Nanotechnology Characterization Laboratory, the National Heart, Lung, and Blood Institute's Programs of Excellence in Nanotechnology, and the Nanotechnology Program Area at the National Institute of Biomedical Imaging and Bioengineering.

The FY 2009 NIOSH request is $6 million, unchanged from the previous year. The Institute will operate the Center of Excellence for Nanotechnology Research, with the role of coordinating nanotechnology-related activities across the institute and addressing critical occupational health issues. NIOSH will continue to develop partnerships with stakeholders and other organizations to enable the translation of agency activities into appropriate workplace practices. NIOSH will establish a suite of instruments and protocols for characterizing nanomaterials in the workplace environment. This budget will allow intramural and extramural projects targeted to addressing critical research gaps around occupational safety and health of nanotechnology and nanomaterials.

[7] http://nihroadmap.nih.gov/

NATIONAL AERONAUTICS AND SPACE ADMINISTRATION (NASA)

The FY 2009 NASA request for nanotechnology programs is approximately $19 million, an increase of $1 million from the FY 2008 estimate (see Table I-9). The budget reflects the competition with other NASA priorities. In addition to basic nanoscience and nanotechnology research, NASA plans to invest in various application areas. The basic NASA nanoscience program includes bio-molecular systems research, which is a joint NASA/NCI (National Cancer Institute) initiative. The Office of Advanced Technology Program integrates nanotechnology development in three areas: (1) Materials and structures, (2) Nanoelectronics and computing, and (3) Sensors and spacecraft components. A major focus at NASA is to advance and exploit the zone of convergence between nanotechnology, biotechnology, and information technology. Areas to be emphasized include: ultrahigh strength and multi-functional materials; high density, low power electronics; ultra-small and sensitive sensors; and highly miniaturized spacecraft systems (from microelectromechanical systems (MEMS) to nanoelectromechanical systems (NEMS)).

NATIONAL INSTITUTE OF STANDARDS AND TECHNOLOGY (NIST)

The FY 2009 NIST request is $110 million, a $21 million increase (see Table I-9). The Center for Nanoscale Science and Technology (CNST, Gaithersburg campus) will focus on collaborative nanotechnology research on cost-effective manufacturing of products made with components the size of atoms and molecules. Additional foci at NIST include the development of standard reference materials for nanotechnology and research related to nanomanufacturing, as well as nanoelectonics. NIST has a large range of collaborations with industry.

The National Nanomanufacturing and Nanometrology Facility (N^3F) was developed at NIST to support the development of new infrastructural metrology and standards for U.S. nanotechnology efforts through centralized access to NIST's nanometrology and nanofabrication resources, including the facilities of the Advanced Measurement Laboratory and NIST's nanometrology experts. Several new programs are developing physical standards and measurement methods for nanoparticles and accelerating their use in new classes of materials, as well as assessing environmental impact.

ENVIRONMENTAL PROTECTION AGENCY (EPA)

The FY 2009 request is $15 million, a $5 million increase. The agency is expanding its research program on potential environmental implications of nanotechnology. In line with EPA's Nanotechnology White Paper (2007), this program includes intramural research within EPA's Office of Research and Development, as well as the extramural program that has been in place for several years. EPA has launched a collaborative process to design a Nanoscale Materials Stewardship Program for voluntary reporting of nanomaterials production under the provisions of the Toxic Substances Control Act (TSCA).

EPA will continue to focus the majority of its research in 2009, as in 2008, on health and environmental implications of nanomaterials. EPA will increase its efforts in the area of risk assessment and risk management needs for nanomaterials. Finally, EPA will research nanoscale technology as potential solutions to environmental problems.

FOOD AND DRUG ADMINISTRATION (FDA)

FDA will be addressing scientific and policy concerns and issues related to nanotechnology use for the entire spectrum of FDA-regulated products under the auspices of the recently established FDA Nanotechnology Task Force and Nanotechnology Interest Group (NTIG), which is comprised of scientists qualified to provide input on product development. Under a tripartite Memorandum of Understanding (MOU), FDA, NIH (NCI) and NIST have agreed to collaborate, share know-how and data on particle characterization and standards development.

U.S. DEPARTMENT OF AGRICULTURE (USDA: CSREES AND FS)

The FY 2009 request is approximately $8 million ($3 million for Cooperative State Research, Education, and Extension Service (CSREES), and $6 million for Forest Service (FS)), overall about $3 million under the FY 2008 estimate. USDA conducts its research both extramurally through the partnership between the CSREES, the Land Grant Universities (LGUs) and SBIR, and in-house at Agriculture Research Service (ARS) national laboratories. The CSREES also provides leadership and financial support for education and outreach in all the states and territories of the United States through the LGUs.

The USDA nanotechnology program will continue in 2008 through its Nanotechnology Research Initiative for extramural competitive research and education grants. The development of nanotechnology-based sensors for application in the food industry and agriculture is also a priority, and will similarly expand. The Forest Service will focus on applications of nanotechnology to enhanced utilization of forest resources and research on low-cost forest product feedstocks for nanomanufacturing. The Forest Service will carry research to determine the basic nanoscale cell wall architecture of wood and bark, wood-binder interaction, utilization of nano-carbon materials recovered from gasification of woody biomass, as well as characterization of nanoscale structures of chemically and physically altered wood fiber cell wall surfaces.

DEPARTMENT OF JUSTICE (DOJ)

In FY 2009 the budget request for the DOJ is about $2 million. The DOJ National Institute of Justice (NIJ) has two separate project areas that incorporate nanotechnology—DNA Research and Development, and Chemical and Biological Defense. The DNA Research and Development program will continue basic research as well as the demonstration of chip-based or micro-device technologies to analyze DNA in forensic applications. Nanotechnology has or will be a significant part of the device under development that will eventually be integrated into the current crime laboratory processes and protocols to analyze forensic DNA samples. The Chemical and Biological Defense program is developing a wearable, low-cost device to provide warning of exposure to unanticipated chemical and biological hazards in sufficient time for its wearer to take effective protective measures.

DEPARTMENT OF TRANSPORTATION (DOT: FHWA)

The Federal Highway Administration budget of about $1.0 million in FY 2009 is supporting research aimed at improving fundamental understanding of the structure and properties of highway construction materials at the nanoscale, *e.g.,* the use of atomic force microscopy to characterize the morphology of asphaltenes, which are the nanoparticle component of asphalt. The FHWA, in collaboration with the University of Connecticut and W.R. Grace, Inc., and with support from a NSF grant will investigate the nanoscale mechanisms controlling hydration and setting of Portland cement concrete.

Table 2. Key NNI R&D user facilities and networks

Center Name	**Institution**
NSF – nine networks	
National Nanofabrication Infrastructure Network (NNIN) – 13 nodes (user facilities)	Cornell University –central node
Network for Computational Nanotechnology (NCN) – 7 nodes (user facilities)	Purdue University – central node
National Nanomanufacturing Network (NNN)	University of Mass., Amherst – central node
Nanotechnology in Society Network (NCN)	ASU – central node
Nanoscale Center for Learning and Teaching (NCLT)	Northwestern University –main node
Nanoscale Informal Science Education (NISE)	Museum of Science Boston - main node
Nanoscale Science and Engineering Centers (NSEC)	University of Columbia- main node
Materials Science and Engineering Centers (MRSECs)	Distributed
Center for Environmental Implications of Nanotechnology (CEIN)	Distributed
DOE – one network of five user facilities	
Center for Functional Nanomaterials	Brookhaven National Laboratory
Center for Integrated Nanotechnologies	Sandia NL and Los Almos NL
Center for Nanophase Materials Sciences	Oak Ridge National Laboratory
Center for Nanoscale Materials	Argonne National Laboratory
Center for Molecular Foundry	Lawrence Berkeley National Laboratory
NIH - four networks	
NHLBI Program of Excellence in Nanotechnology	Four centers
Nanomedicine Development Centers	Eight centers
Centers of Cancer Nanotechnology Excellence	Eight centers
Nanotechnology Characterization Laboratory (user facilities)	NCI Frederick
NIST – one user facility	
Center for Nanoscale Science and Technology	NIST Gaithersburg