

National Nanotechnology Initiative

Overview (II)

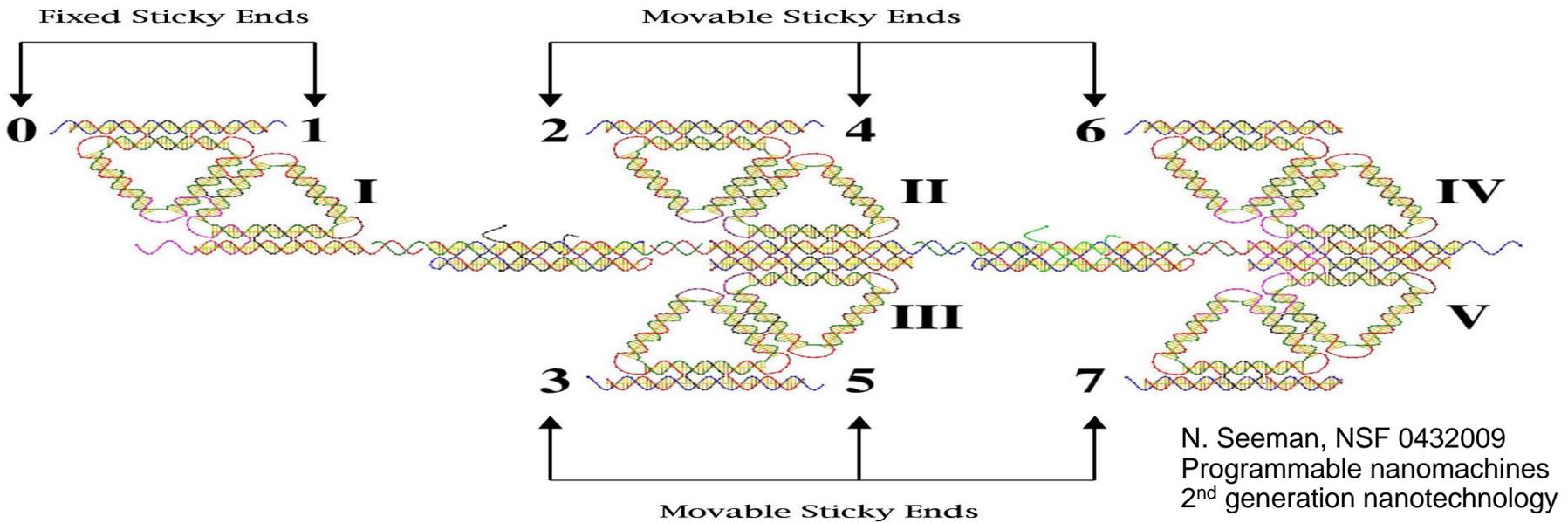
NNI investments and partners

Scientific accomplishments

Technology transfer mechanisms

Panel 1. National Research Council, Washington, D.C., June 27, 2005

General background material (I) was presented at the NRC review on March 23, 2005



National Nanotechnology Initiative: Investments and Partners

M.C. Roco

NSF and NSTC/NSET Subcommittee

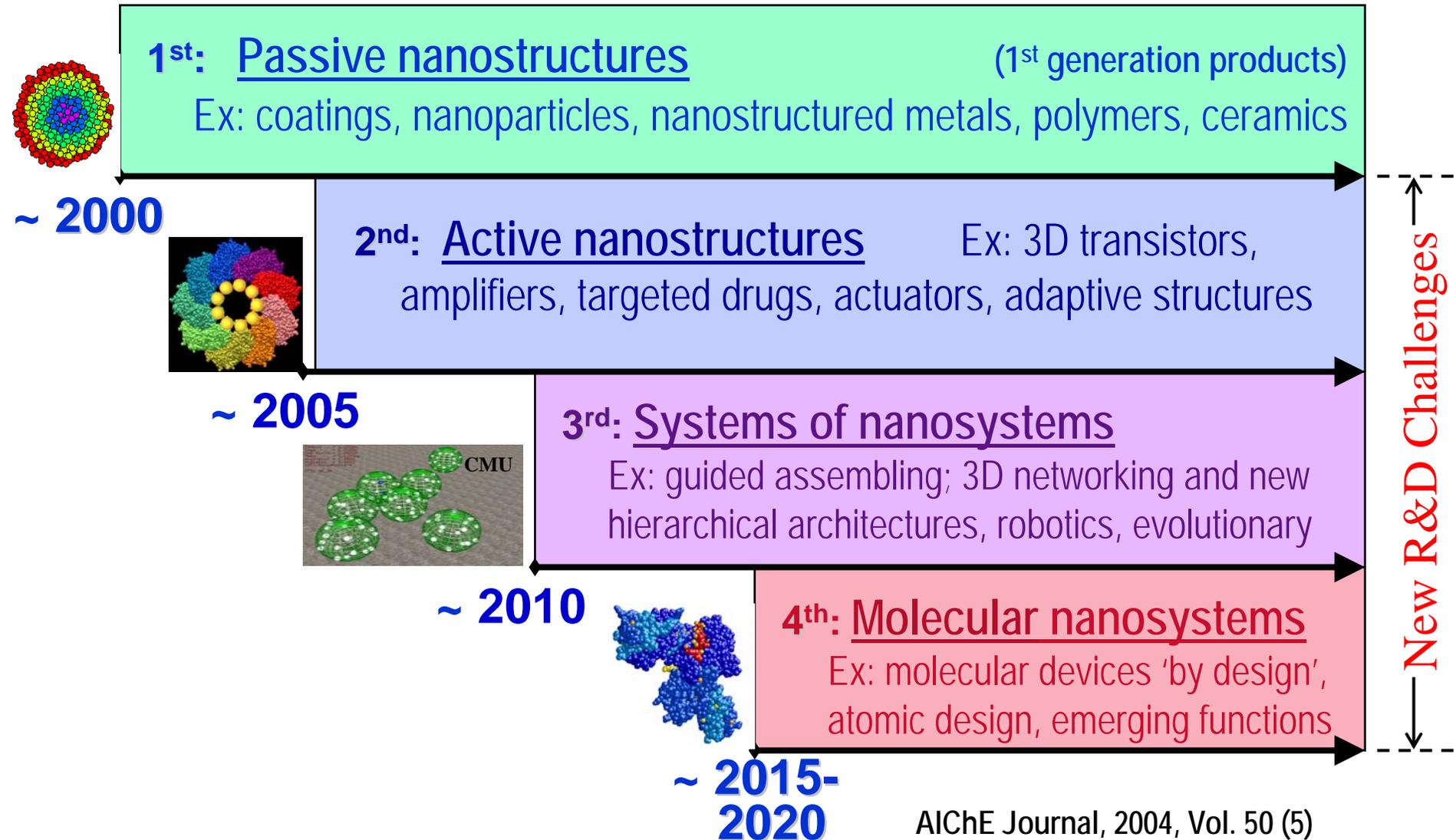
NRC, Washington, D.C., June 27, 2005

Defining Nanotechnology

Definition on www.nano.gov/omb_nifty50.htm (see report NS&T)

- Working at the atomic, molecular and supramolecular levels, in the length scale of approximately 1 – 100 nm range, in order to understand and create materials, devices and systems with fundamentally new properties and functions because of their small structure
- **NNI definition encourages new contributions that were not possible before.**
 - novel phenomena, properties and functions at nanoscale, which are nonscalable outside of the nm domain
 - the ability to measure / control / manipulate matter at the nanoscale in order to change those properties and functions
 - integration along length scales, and fields of application

Timeline for beginning of industrial prototyping and nanotechnology commercialization: Four Generations

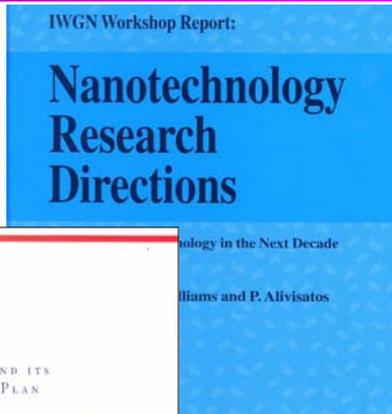


Defining the vision for the *first strategic plan (I)*

National Nanotechnology Initiative

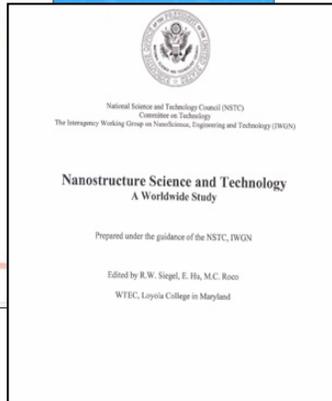
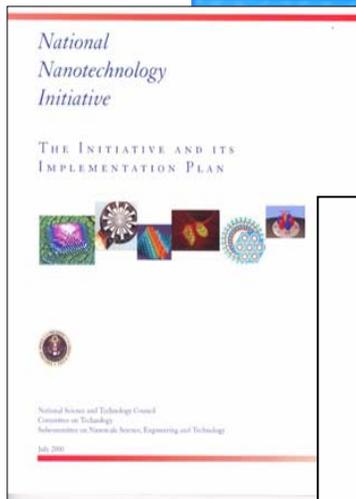
1999-2000

1999:
10-year
vision

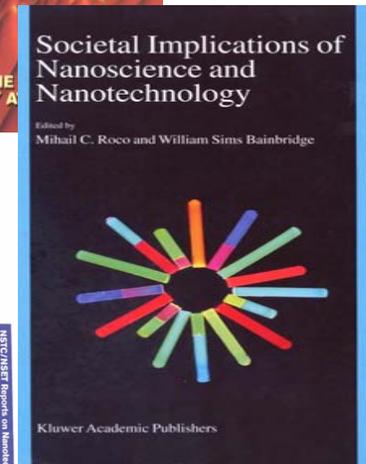
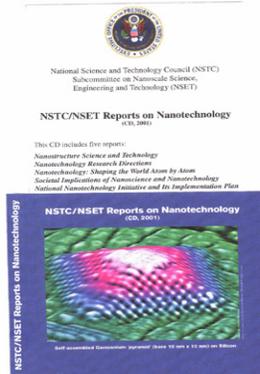
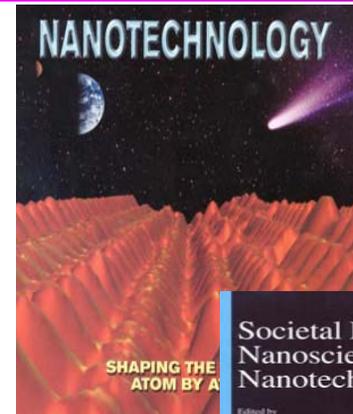


Brochure for
public

Societal
implications



Reports



Government
plan

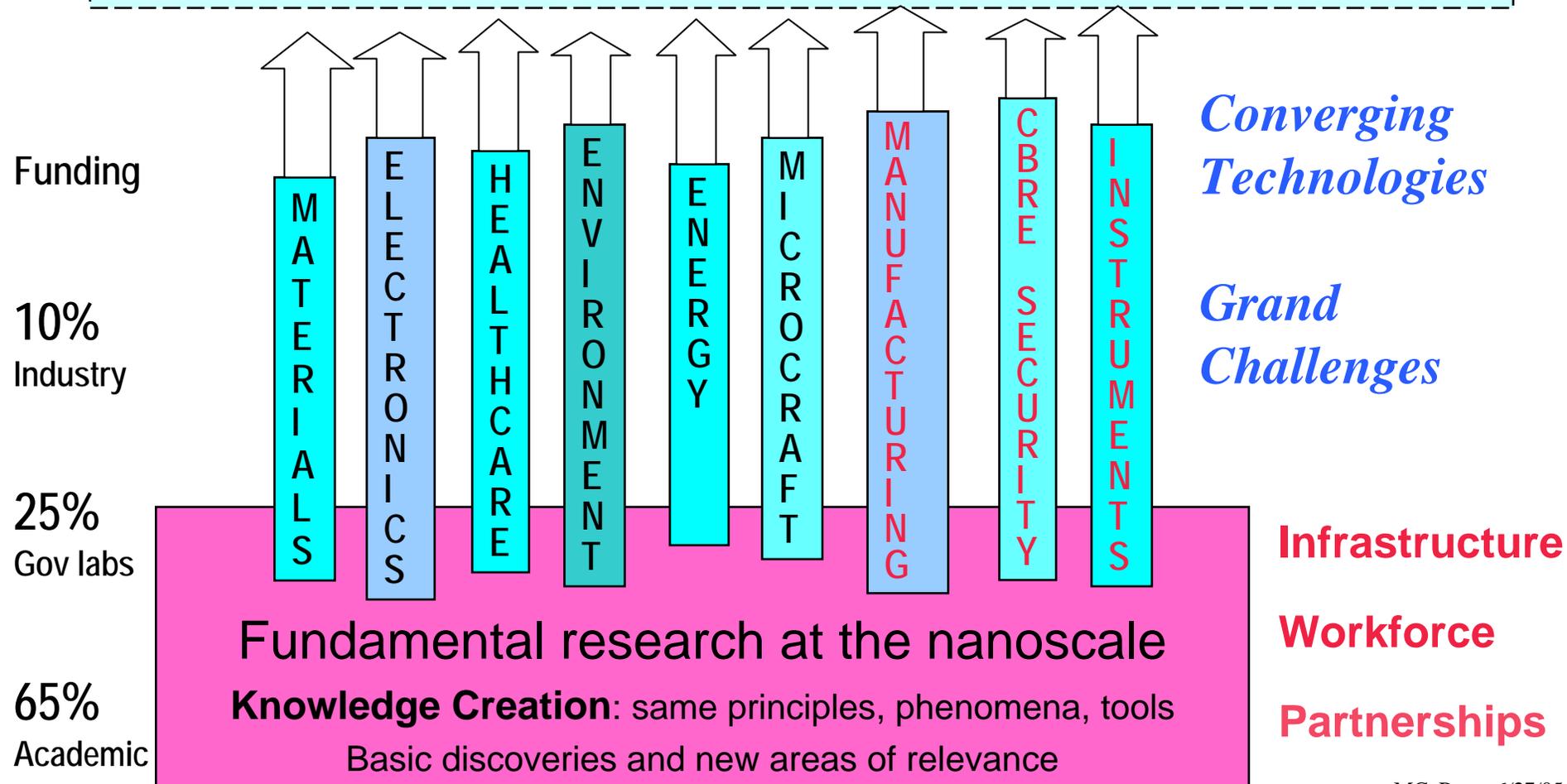
Worldwide
benchmark

Focus on Knowledge Creation (same principles, phenomena, tools, architectures) to support innovation in various areas of relevance

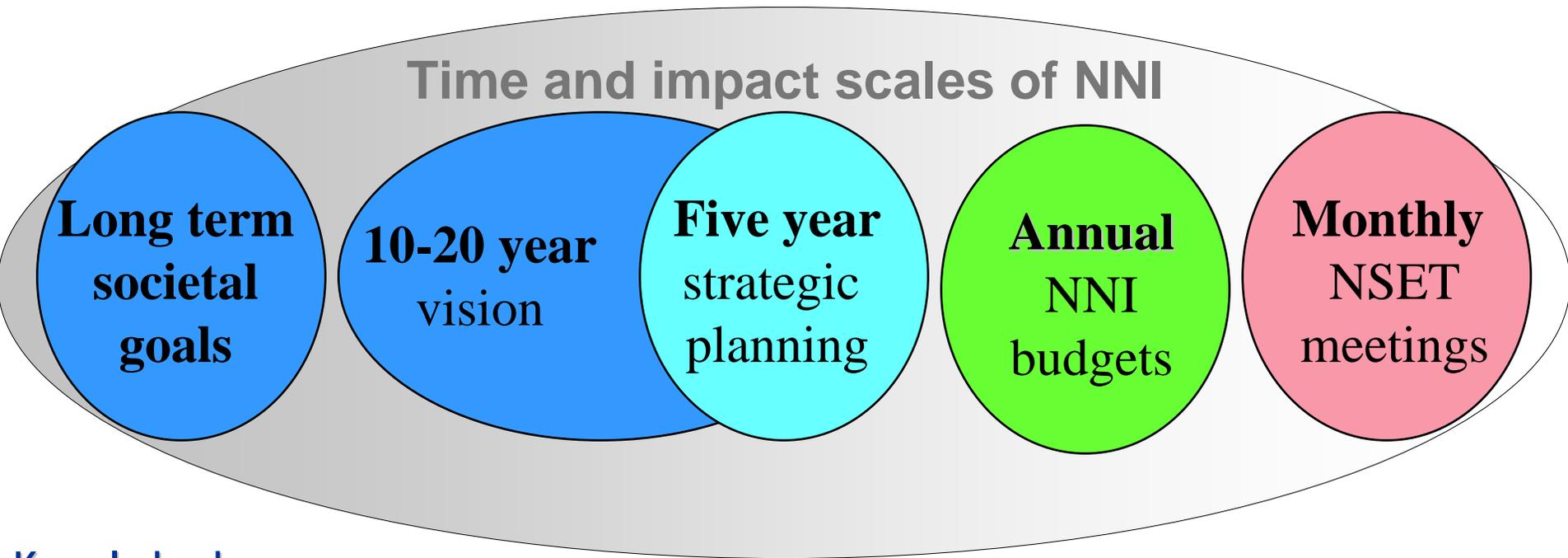
Planning with Feedback: after each 5(3) years, 1 year, 1 month;
and 4 levels: national / NSET, agency (24), R&D program, partnerships

Interdisciplinary "horizontal" Knowledge Creation with "vertical" transition from basic concepts to Grand Challenges and technology integration - Converging Technologies

Revolutionary Technologies and Products



The long-term vision drives NNI: 4 time scales



Knowledge base

Economy

Quality of life

Responsible NT

World context

1999 Research Directions I

2004 Research Directions II

10 topical reports in 03-04

Evaluation PCAST, NRC

Annual budgets

FY 2001, .. , 2005

EOP evaluation,
OMB, GPRA, COV

Tactical decisions

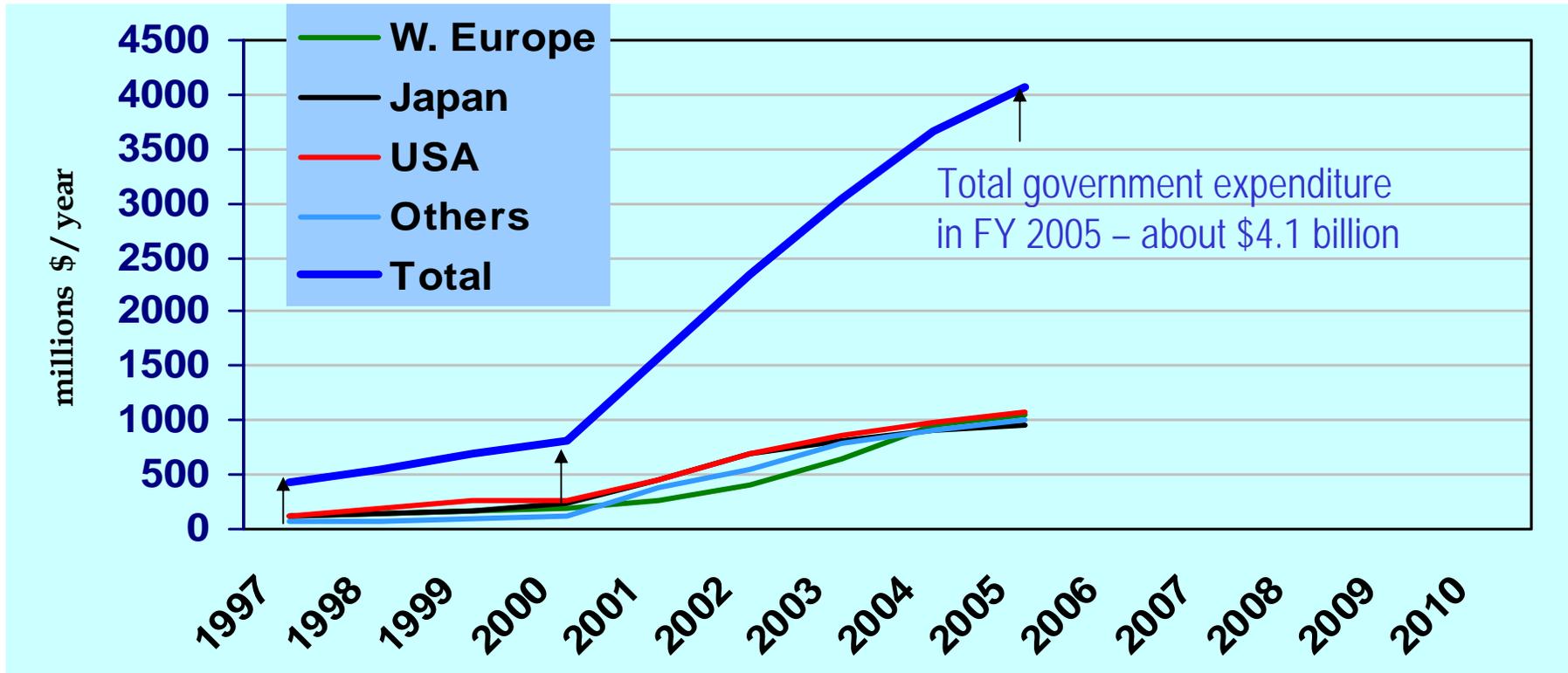
Programs

Partnerships

Safety issues

Long term view in the international context

Past national government and EC investments 1997-2005 (est. NSF)



NNI government investment is ~ 1/4 of world (2004)

First NNI strategic plan (2001-2005): R&D funding by Agency

<i>Fiscal year</i> (all in million \$)	2000 Actual	2001 Enact/Actual	2002 Enact/Actual	2003 Enact/Actual	2004 Req./Actual	2005 Req/Est.
National Science Foundation	97	150 /150	199 /204	221 /221	249 /256	305/338
Department of Defense	70	110 /125	180 /224	243 /322	222 /291	276/257
Department of Energy	58	93 /88	91.1 /89	133 /134	197 /202	211/210
Health and Human Services	32	39 /39.6	40.8 /59	65 /78	70 /106	89/145
NASA	5	20 /22	35 /35	33 /36	31 /47	35/45
NIST	8	10 /33.4	37.6 /77	66 /64	62 /77	53/75
EPA	-	/5.8	5 /6	5 /5	5 /5	5/5
Homeland Security (TSA)	-		2 /2	2 /1	2 /1	1/1
Department of Agriculture	-	/1.5	1.5 /0	1 /1	10 /2	5/3
Department of Justice	-	/1.4	1.4 /1	1.4 /1	1.4 /2	1/2
Congressionally-directed to DOD				80	103	150
TOTAL	270	422 /465 +72%	600 /697 +50%	770 /942 +35%	849 /1094 +16%	982/1231 + 13%

- NNI as part of U.S. Federal R&D ~ 0.25% (2000) to 1% (2004)

- Industry (x 1.7) + state and local organizations (x 0.4) = 1.1 NNI budget in 2004

Success rates is lower for nanotechnology proposals: Example for NIRT (interdisciplinary teams), NSF, FY 2005

- Received 521 proposals
With limit of 4 proposals per university
- 116 highly recommended for funding by the panels
- 49 awards - \$61.5 million
(funding requested in proposals is about \$900 million)

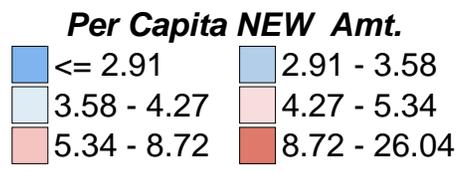
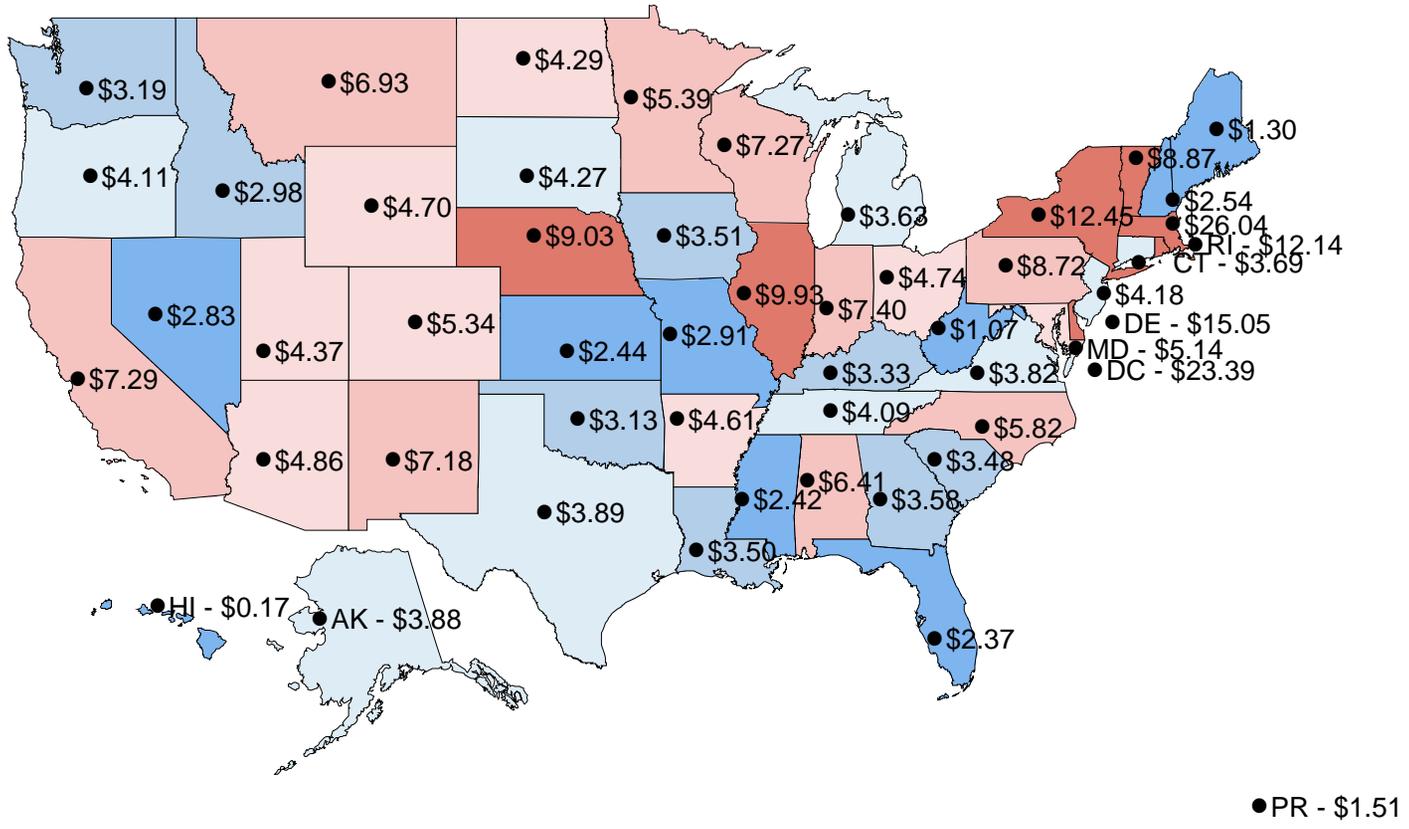
Success rates:

Awarded amount / Requested funds – 7%

Number awards/ Number proposals - 9.4 %

Note: Smaller success rate than NSF average (about 25%)
despite of limitation applied to # NIRT proposals per
university

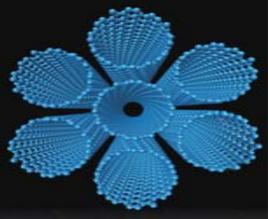
Per Capita NEW NNI Award Amount by State NSF, FY 2001- 2004



2nd Strategic Plan: continue NNI Vision:

a future in which the ability to understand and systematically control matter on the nanoscale leads to a revolution in technology and industry

- Changing the foundation of understanding, control, manufacturing and medicine from the macro and micro domains to the nanoscale, where all fundamental material properties and functions can be efficiently established and changed
- General purpose technology that will affect almost all sectors of the society.
It will disrupt - structural changes - markets, industrial organizations and business models



2nd NNI strategic plan (2006-2010): Goals / Activities

Four main goals (including areas of new focus for next 5 years)

- **Maintain a world-class research and development program** aimed at realizing the full potential of nanotechnology
(Support R&D for active nanostructures and nanosystems)
- **Facilitate transfer of the new technologies into products for commercial and public benefit** *(Increase funding for technological innovation and multidisciplinary R&D platforms)*
- **Develop educational resources, a skilled workforce, and the supporting infrastructure and tools** needed to advance nanotechnology
(Access to research facilities and educational opportunities in nanoscale science and engineering for half of the undergraduate and graduate students by 2010)
- **Support responsible development of nanotechnology** thru societal, environmental and health implications R&D, and interaction with the public
(Address sustainability and life cycle of products)

Areas of NNI investment (Program Component Areas)

- 1. Fundamental Nanoscale Phenomena and Processes**
- 2. Nanomaterials**
- 3. Nanoscale Devices and Systems**
- 4. Instrumentation Research, Metrology, and Standards for Nanotechnology**
- 5. Nanomanufacturing**
- 6. Major Research Facilities and Instrumentation Acquisition**
- 7. Societal Dimensions (EHS, Education, ELSI)**

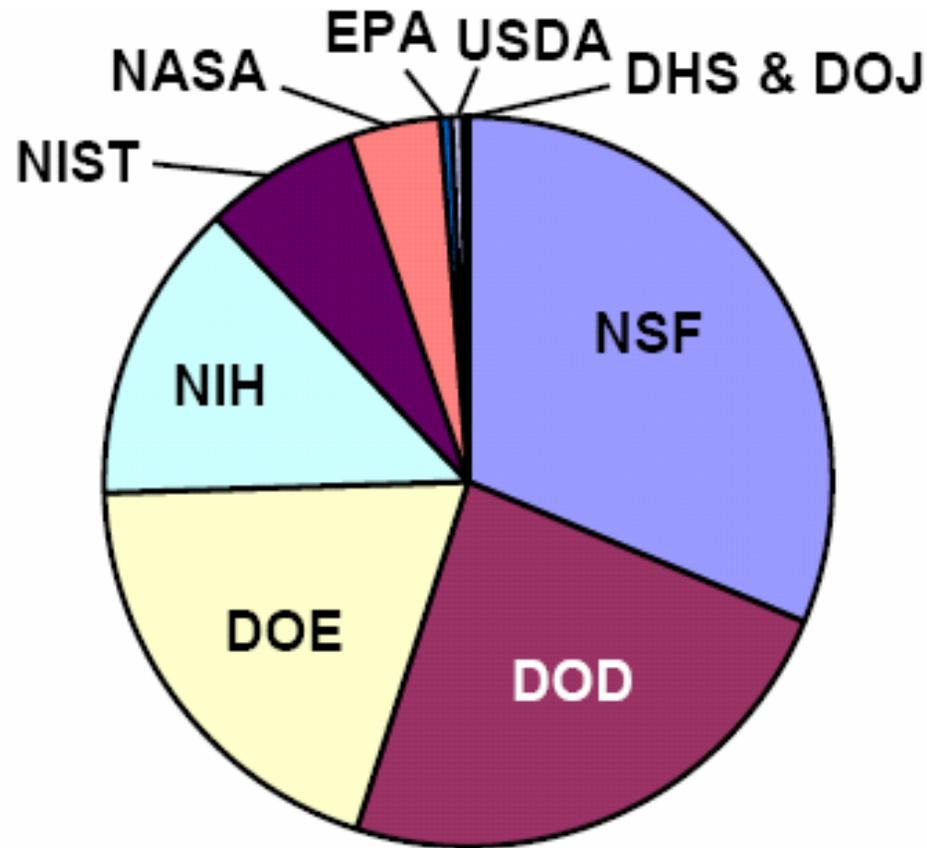
Relationship between PCAs and NNI Agency Missions

● Primary
 Secondary
 Agencies w/
 nano R&D \$\$

	Fundamental Nanoscale Phenomena and Processes	Nanomaterials	Nanoscale Devices and Systems	Instrumentation Research, Metrology, and Standards for Nanotechnology	Nanomanufacturing	Major Research Facilities and Instrumentation Acquisition	Societal Dimensions
CPSC			●	●			●
DHS	●		●	●			
DOC (BIS)		●	●	●			
DOC (NIST)				●	●		
DOC (TA)					●		●
DOC (USPTO)		●	●	●	●		
DOD		●	●		●		
DOE	●	●				●	
DOJ			●				
DOS							●
DOT	●		●		●		
DOTreas		●	●				
EPA		●	●		●		●
HHS (FDA)			●				●
HHS (NIH)	●		●				
HHS (NIOSH)							●
IC		●	●				
ITC		●	●		●		●
NASA		●	●				
NRC			●				
NSF	●	●			●	●	●
USDA		●	●				●

**Ref: Strategic Plan
– p. 18**

NNI FY 2006 Budget Request Total = \$1,054 million



Partnerships

- **NNI inter-agency activities (planning, coordination, evaluation)**
 - NSET Working Groups and Task Forces**
 - Nanomaterials Environmental and Health Implications (NEHI)**
 - Nanotechnology Innovation and Liaison to Industry (NILI)**
 - Nanomanufacturing (MWG)**
 - Nanotechnology Public Engagement Group (NPEG)**
 - Global Issues in Nanotechnology (GIN)**
 - Research Directions and Strategic Planning TF (each 3-5 years)**
 - Supplemental budget TF (each year, PCAs)**
 - Illustrations of collaborations in FY 2006**
- **Partnerships with industry**
 - Collaborative Boards for Advancing Nanotechnology (CBAN)**
 - Individual industry partners**
- **Partnerships with states and local organizations**
- **International exchanges and collaborations**

NNI inter-agency activities

- NSET activities:
 - Common vision, goals, R&D planning, coordination and evaluation
 - Coordinate R&D investments (ex: fund complementary fields of research that are critical for the advancement of the nanotechnology)
 - Develop a balanced infrastructure (ex: portfolio of programs, development of new specific tools, instrumentation, simulation infrastructure, standards)
 - 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
 - Address related aspects of EHS issues
 - Connections to DOE and DOL
 - Avoid unnecessary duplication of efforts
 - NSET publications
- The coordination also will address NNI management issues, interaction with nanotechnology regional alliances, and international activities.
NNCO - office of NSET for this purpose, and several NSET working groups provide support for partnerships.

NNI agency collaborations - Illustrations for FY 2006 -

- **Nanomanufacturing (main partners NSF, DOD and NIST)**

NSF's Center for Hierarchical Nanomanufacturing will become fully operational in 2006, as will the complementary DOD MURI, and the NIST N³F. NSET will also coordinate its activities in this area with the NSTC Interagency Working Group on Manufacturing Research and Development.

- **Environmental, Health, and Safety (EHS) Research**

EPA, NSF, NIOSH, and USDA plan an expanded joint extramural research program The National Toxicology Program's initiative; NIOSH's "recommended practices" for safe handling of nanomaterials; NEHI monthly meetings

- **Industry Liaison in Support of Technology Transfer and Commercialization**

The NSET Subcommittee will expand its activities to reach out to U.S. industry NSF's "Silicon Nanoelectronics and Beyond" activity DOD will place a new emphasis in 2006 on moving research innovations into applications in support of the DOD mission. NSET's informal working group on industry liaison will help to coordinate this interagency thrust.

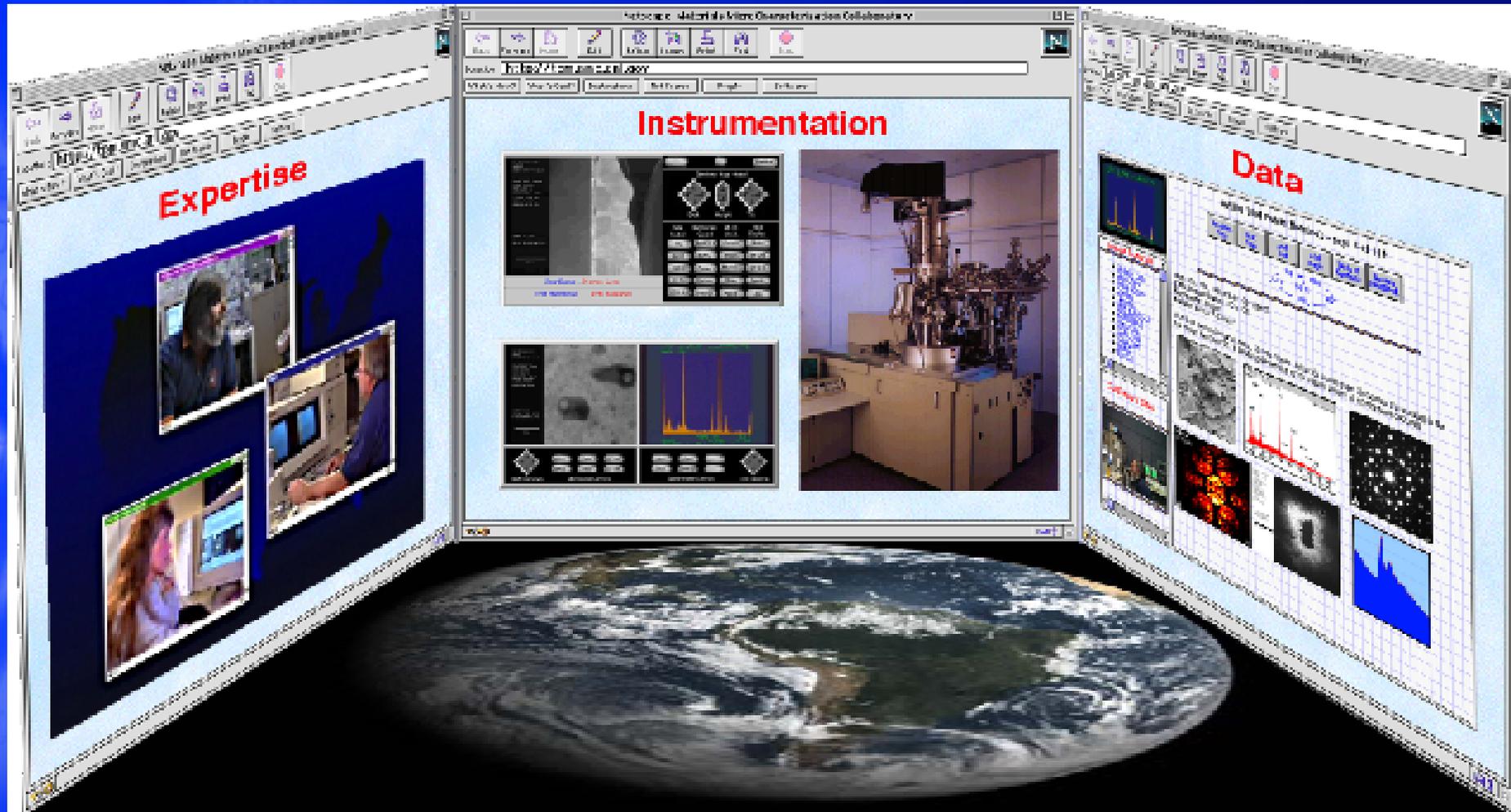
- **Standards Development**

Partner: American National Standards Institute's Nanotechnology Standards Panel (ANSI-NSP)

- **Infrastructure Development**

Among R&D centers (NSECs, NNIN and NCN, centers and network with DOD, NASA and DOE); Modeling and simulation and nanoelectronics (DOD, NASA and NSF).

NNI: Telepresence & Telecollaboratory



Ex.: Materials Characterization Laboratory Adoption of Web-based TPM Protocols between U. Illinois, ORNL, LBNL and NIST

NSET: Support partnerships with industry

- **Grand challenges (2001-2005) to create the technology base**
Ex: Nanomanufacturing – new NSF program \$22M in FY 02 - MARCO center: government – university – industry; Network: 4 NSF centers established in FY 03-05, NIST – N³Facility, DOD MURI
- **Infrastructure for instrumentation, tools, laboratories**
Ex.: 5 DOE labs; NSF's NNIN and NCN; 40 centers and networks; NCI; NIST metrology and standards; NSF instrumentation program
- **Prepare the workforce at all levels**
Ex: Technological, Community Colleges and UE in PA (PFI award)
- **Various mechanisms for interaction with industry**
Ex.: Fund collaborations with industrial partners (GOALI, centers); Provide the NNI results to industry (ex: with SIA, CCR); Provide user facilities; Assistance for instrumentation, standards, manufacturing; Direct technology transfer and funding industrial projects: about 600 SBIR/STTR awardees by all agencies (\$70 million/year)

Programs and activities related to industry: Examples NSF

	Program/ activity	Effective dates	Annual funding	Brief description
1	Industry partners at centers and user facilities	2001-2005	-	Over 1300 industry partners and users in FY 2004 (571 at NNIN, 300 at NCN, 100 at NSECs, 324 at MRSECs, and 42 at other NSF user facilities such as Cornell High-Energy Synchrotron Source and National Magnetic Field Laboratory)
2	GOALI	2001-2005	\$5M (average)	Grant Opportunities for Academic Liaison with Industry
3	PFI	2003-2005	\$10M including nano	Partnership for Innovation
4a	NSF-SRC MOU to Enhance Research Emphasis in Silicon Nanoelectronics and Beyond	2004-2005	Over \$15M/year	NSF (ENG, MPS, and CISE Directorates) and the Semiconductor Research Corporation (SRC) signed a formal agreement seeking to increase university research emphasis on Silicon Nanoelectronics and Beyond (SNB). The partnership is considered vital to development of the fundamental research base and creation of new knowledge needed to sustain the U.S. leadership and competitiveness in the global semiconductor industry.
5	NSF-SIA Graduate Student and Postdoctoral Fellow Supplements to NSF Centers	2005	Approx. \$2M/year	NSF has initiated a joint activity with the Semiconductor Industry Association (SIA) to support mechanisms that advance long-term research in nanoelectronics. They are jointly offering the opportunity for NSF Centers with research focii in nanoelectronics. Fellows who will work in collaboration with SIA member industry mentors or assignees on exploratory beyond CMOS research topics.
6	SBIR, STTR	2001-2005	\$15 M in average	Key areas supported at NSF: - Synthesis and Processing, Materials, Devices, Systems, and Architectures, Nanomanufacturing, Nano-bio-info convergence
7	A review criterion includes industry relevance	2001 - 2005	All awards in NSF	Broader relevance is a criterion for evaluation. It includes industry interactions, spin-offs, transfer of technology. It applies especially to centers.
8	Educating nanotech workers	2001-2005	About 10% of NNI NSF budget	About 10,000 students and teachers in the NNSF educational and training programs (in 2005)

NNI-Industry Consultative Boards for Advancing Nanotech (1)

Key for development of nanotechnology, Reciprocal gains

❑ **NNI-Electronic Industry (SRC lead), 10/2003 -**

Collaborative activities in key R&D areas
5 working groups, Periodical joint actions and reports
NSF-SRC agreement for joint funding; other joint funding



❑ **NNI-Chemical Industry (CCR lead)**

Joint road map for nanomaterials R&D; Report in 2004
2 working groups, including on EHS
Use of NNI R&D results, and identify R&D opportunities



❑ **NNI – Organizations and business (IRI lead)**

Joint activities in R&D technology management
2 working groups (nanotech in industry, EHS)
Exchange information, use NNI results, support new topics



❑ **NNI-Biotechnology (BIO lead), 10/2004-**

Collaborative activities in key R&D areas
2 working groups, R&D collaboration and EHS; joint funding



NNI-Industry Consultative Boards for Advancing Nanotech (2)

Key for development of nanotechnology, Reciprocal gains

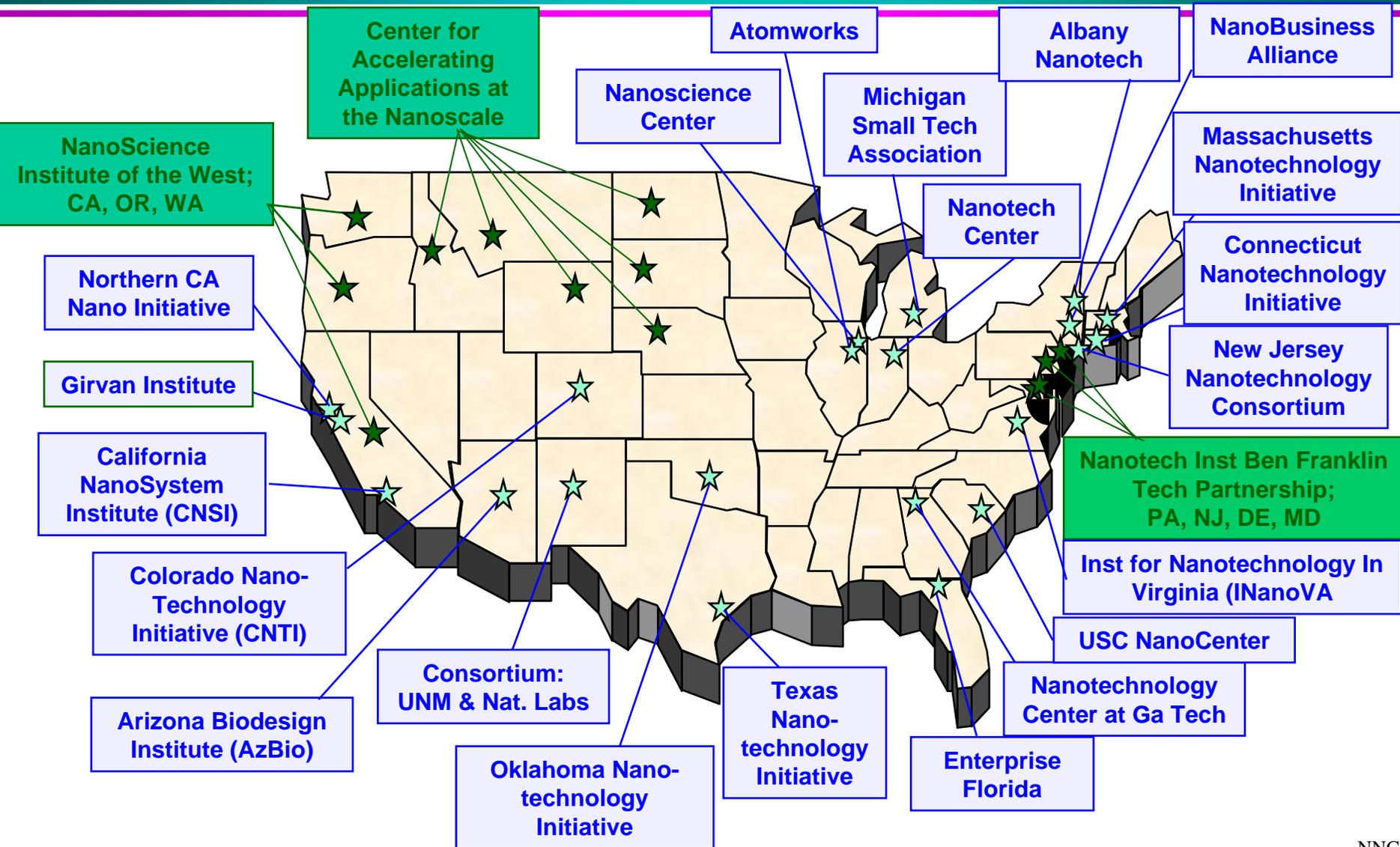
In preparation

- ❑ **NNI – Forestry and paper products (FS lead), 10/2004-**
Workshop / roadmap for R&D
2 working groups (nanotech in industry, EHS)
Exchange information, use NNI results, support new topics
- ❑ **NNI - Pharmaceuticals (Phrma lead), 4/2004-**
Joint road map for nanomaterials R&D
2 working groups, including on EHS
Use of NNI R&D results, and identify R&D opportunities
- ❑ **NNI - Automotive Industry, 3/2005-**
- ❑ **Other contacts: industry sectors such as aeronautics, plastics , food products, energy-related**

NNI meetings and reports on interactions with states and regional alliances

- **Regional workshops of NNI**
 - "Nanotechnology: Opportunities and Challenges"
South-west region; host UCLS, September 2001,
wtec.org/nanoreports/FinalUCLAnanoRpt0302.pdf
 - "From the Laboratory to New Commercial Frontiers"
South-east regional; host Rice University, May 2002,
wtec.org/nanoreports/ACF64.pdf
- **NNI Workshop on Regional, State, and Local Initiatives in Nanotechnology, 2003.** Washington, D.C.
- **Buildings for Advanced Technology Workshop**, at NIST, Jan 14-16, 2003; www.nanobuildings.com/bat/overview/default.htm
- **New workshop in planning**
(Updates information on : www.nano.gov)

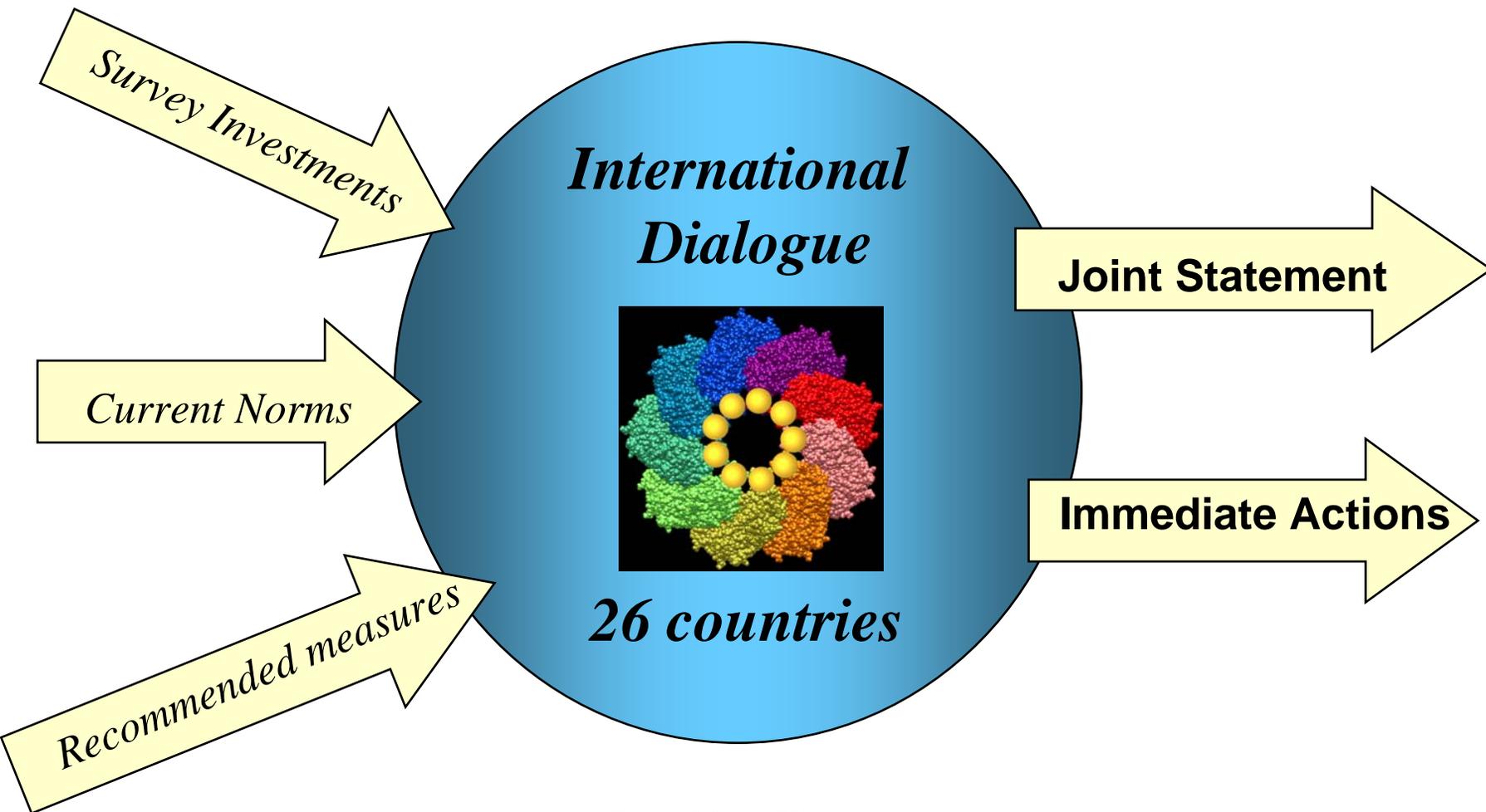
Sampling of Current Regional, State, & Local Initiatives in Nanotechnology



International partnerships for Nanotechnology

- Nanotechnology included in bilateral S&T agreements, OECD, ATIP, UN
- Typical activities
 - Bottom-up by individual partnerships in research; joint programs
 - Periodical NanoForums with Japan, EC, Korea, Switzerland, France, others; topical workshops
 - Using networks: NNIN/NCN and partner networks/facilities
 - Young scientists exchange programs
- Areas and modes of increased collaboration:
 - fundamental knowledge (precompetitive) - *by twinning and networking*
 - education - *by visits, int. courses, books, int. accreditation*
 - broad societal implications: health, environment, energy, water filtration, ethics - exchanges, leveraging
 - contribute to international S&T challenges (see "International Strategy for Nanotechnology R&D", J. Nanoparticle Research, 2001)

International Dialogue on Responsible Nanotechnology R&D



June 2004, Virginia

<http://www.nsf.gov/home/crssprgm/nano/dialog.htm>

International Dialogue on Responsible Nanotechnology R&D

Activities after the June 2004 International Dialogue on Responsible Nanotechnology (Virginia, U.S.)

- **October 2004/October 2005 - Occupational Safety Group**
- **November 2004 – OECD group on nanotechnology**
- **December 2004 – Meridian study for developing countries begins (next meeting in March 2005)**
- **December 2004 - International collaboration for nomenclature and standards has been initiated (ISO, ANSI)**
- **February 2005 – N-S Dialogue on Nanotechnology (UNIDO)**
- **March 2005 – Education exchange group**
- **May 2005 – Global Nano Net, MRS (Materials, Education)**
- **July 2005 – International Dialogue II (host: EC)**

NNI governance approach

- **NNI has combined**
 - **bottom-up agency programming, horizontal-multidisciplinary, broad and transparent interaction with various communities, and centralized coordination**
 - **into an inclusive, responsible and visionary governance approach**
- **COV, NSF, 2004:**
 - **“Two significant and enduring results have emerged from this investment: .. the creation of a nanoscale science and engineering community, and the fostering of a strong culture of interdisciplinary research”**
- **Chuck Vest, at PCAST meeting March 2005 (NNI review):**
 - **“NNI is a new way to run a national initiative”**