

# **13<sup>th</sup> Foresight Conference on Advanced Nanotechnology**

## **Nanotechnology Is Not Little In Washington**

***E. Floyd Kvamme  
Co-Chair, PCAST***

***October 25, 2005***

# History of PCAST and the NNI

- **1999** - PCAST supports the establishment of an NNI
- **FY 2001** - NNI launched
- **2002** - NRC report “Small Wonders, Endless Frontiers” recommends that OSTP establish an independent standing advisory board.
- **February 2003** - President tasks PCAST with reviewing NNI
- **December 2003** - 21<sup>st</sup> Century Nanotechnology R&D Act signed, calling for the President to establish or designate a National Nanotechnology Advisory Panel
- **July 2004** - President designates PCAST as the NNAP

# **NNAP responsibilities under the 21<sup>st</sup> Century Nanotechnology R&D Act**

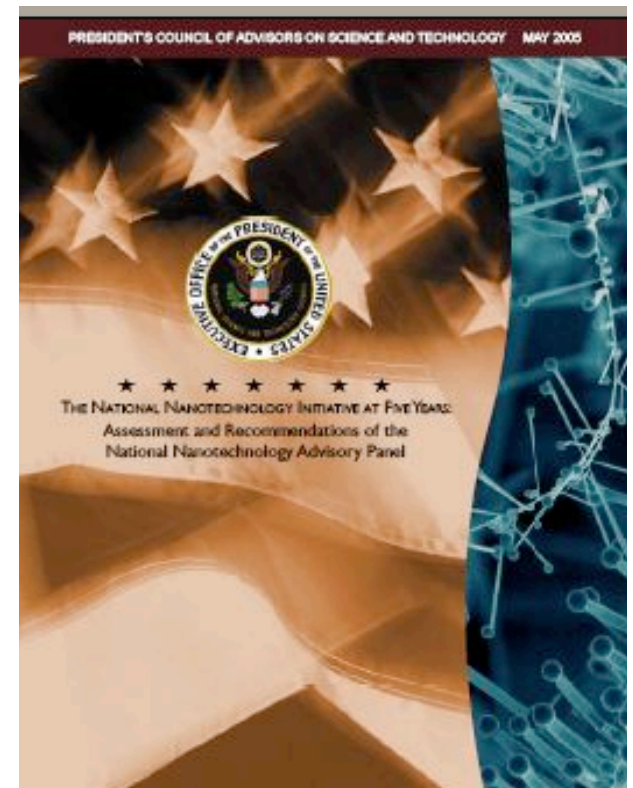
## **Assess:**

- **Trends and developments in nanotechnology.**
- **Progress in implementing the program.**
- **Need to revise the program.**
- **Balance among the component areas of the program, including funding levels.**
- **Whether program component areas, priorities, and technical goals developed by the NSET are helping to maintain US leadership.**
- **Management, coordination, implementation, and activities of the program.**
- **Whether social, ethical, legal, environmental, and workforce concerns are adequately addressed by the program.**

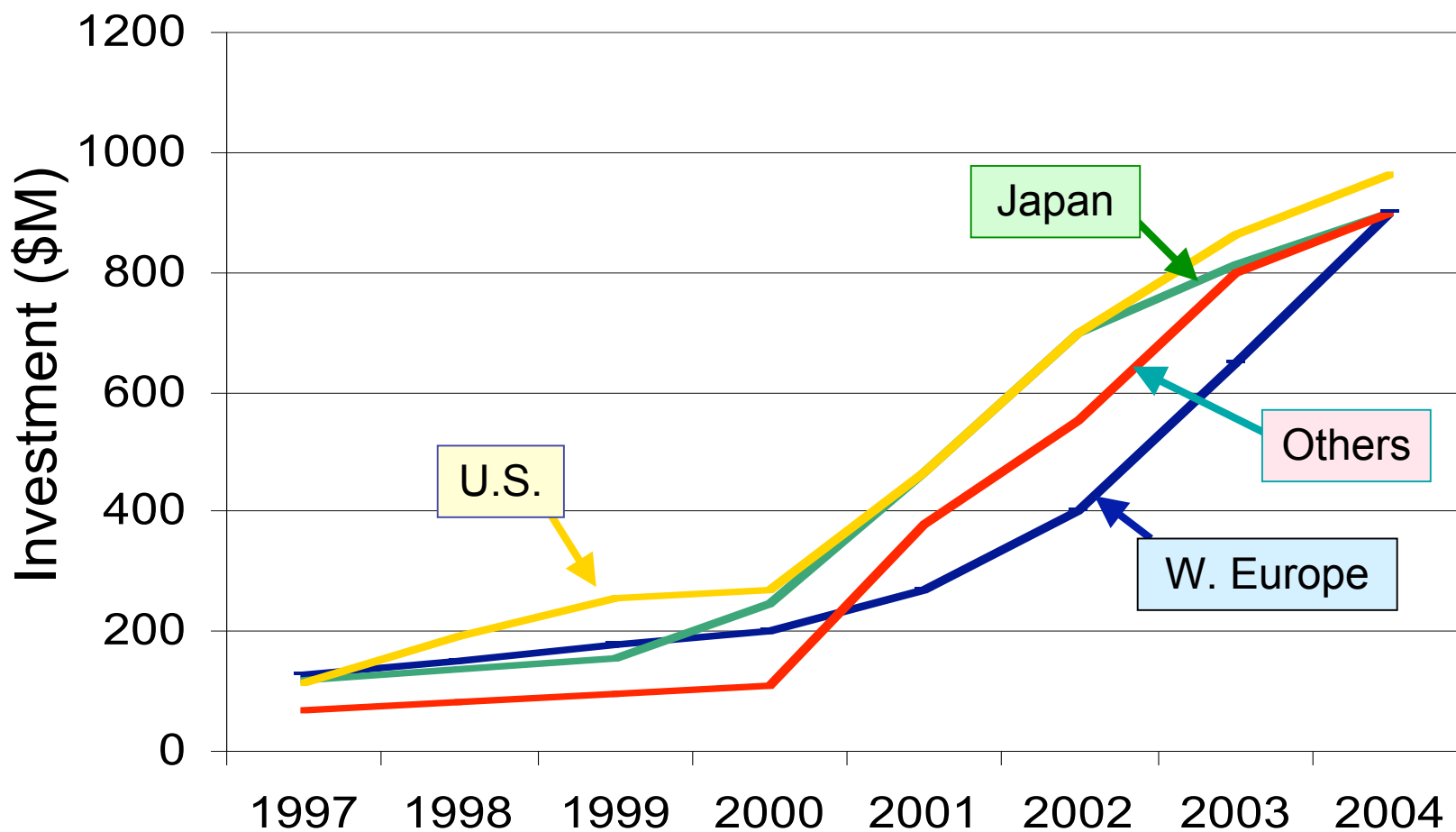
**Report and make recommendations every 2 years**

# PCAST/NNAP report (May 2005)

- How are we doing?
- Is the money well spent and the program well managed?
- Are we addressing societal concerns and potential risks?
- How can we do better?

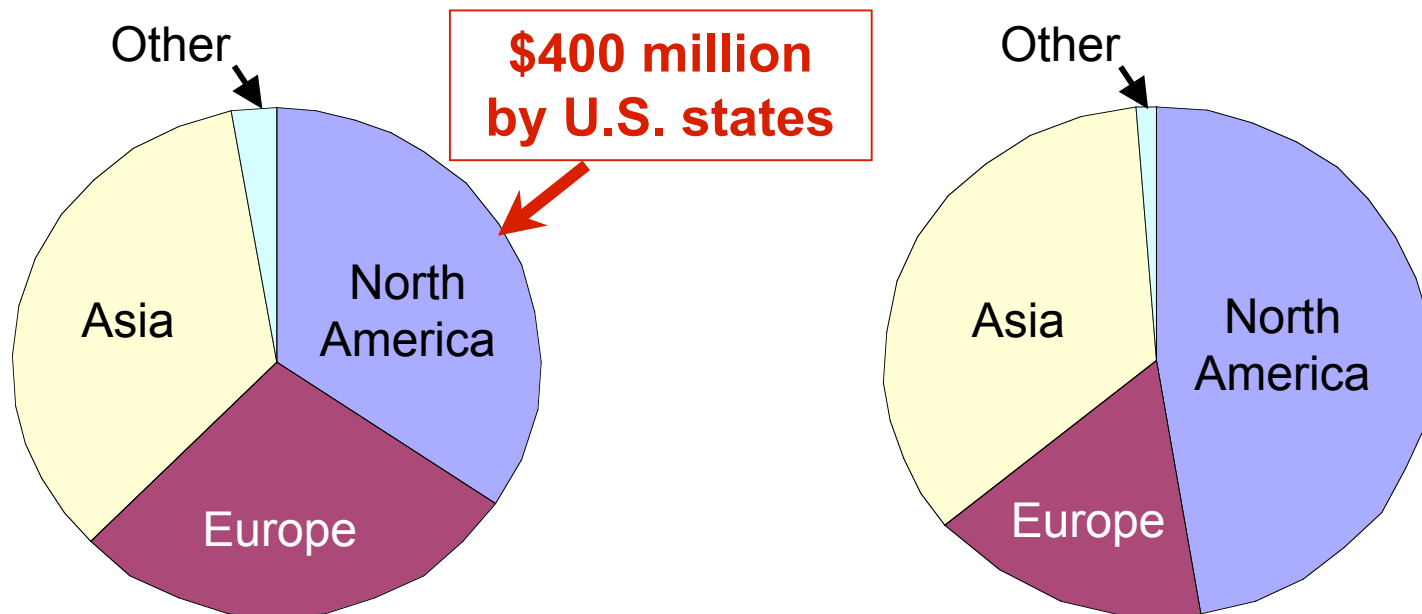


# International Nanotech R&D Investment



Source: M. Roco (NSF)

# Global investments in 2004 (Total=\$8.6 billion)



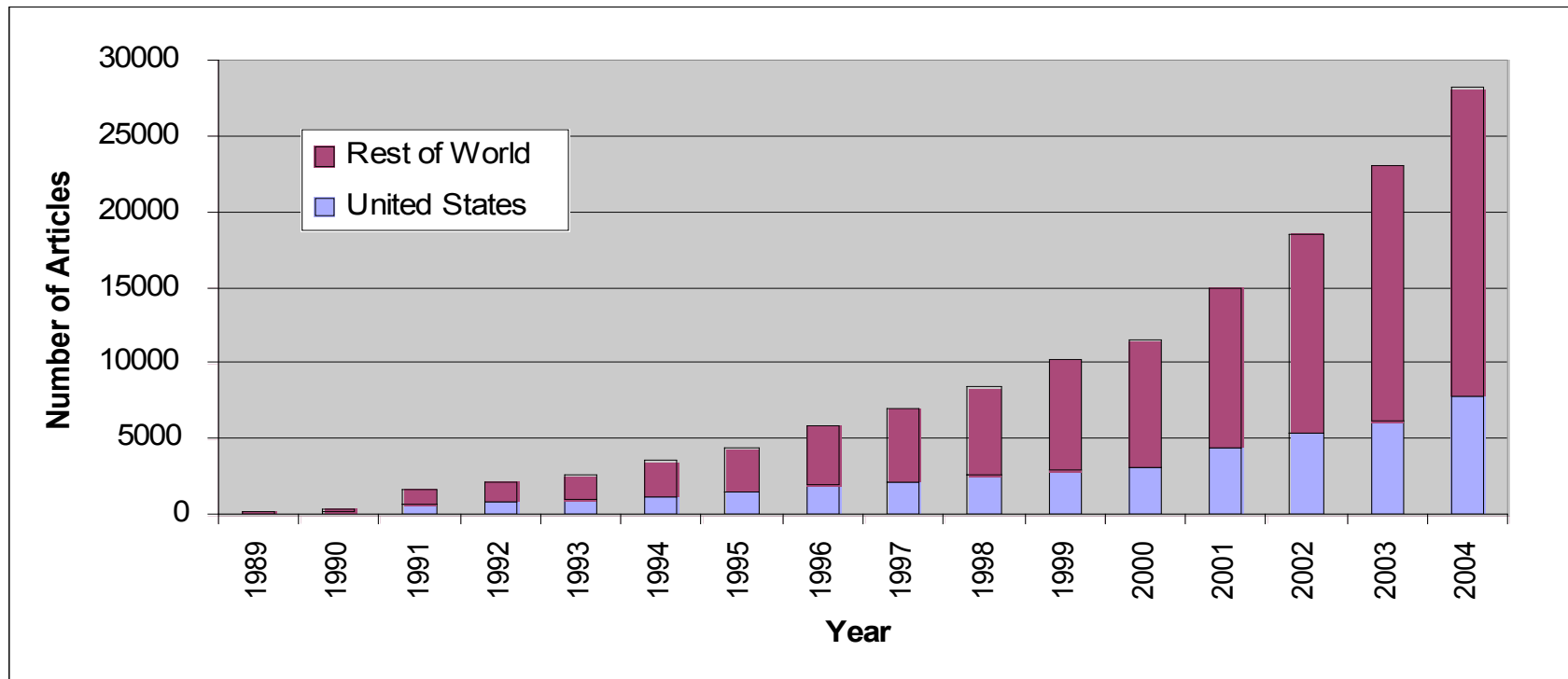
Public (National, regional, state)  
Total = \$4.6 billion

Private (Corp. + VC)  
Total = \$4 billion

Source: Lux Research

# Measures of U.S. Competitiveness: Scientific Publications

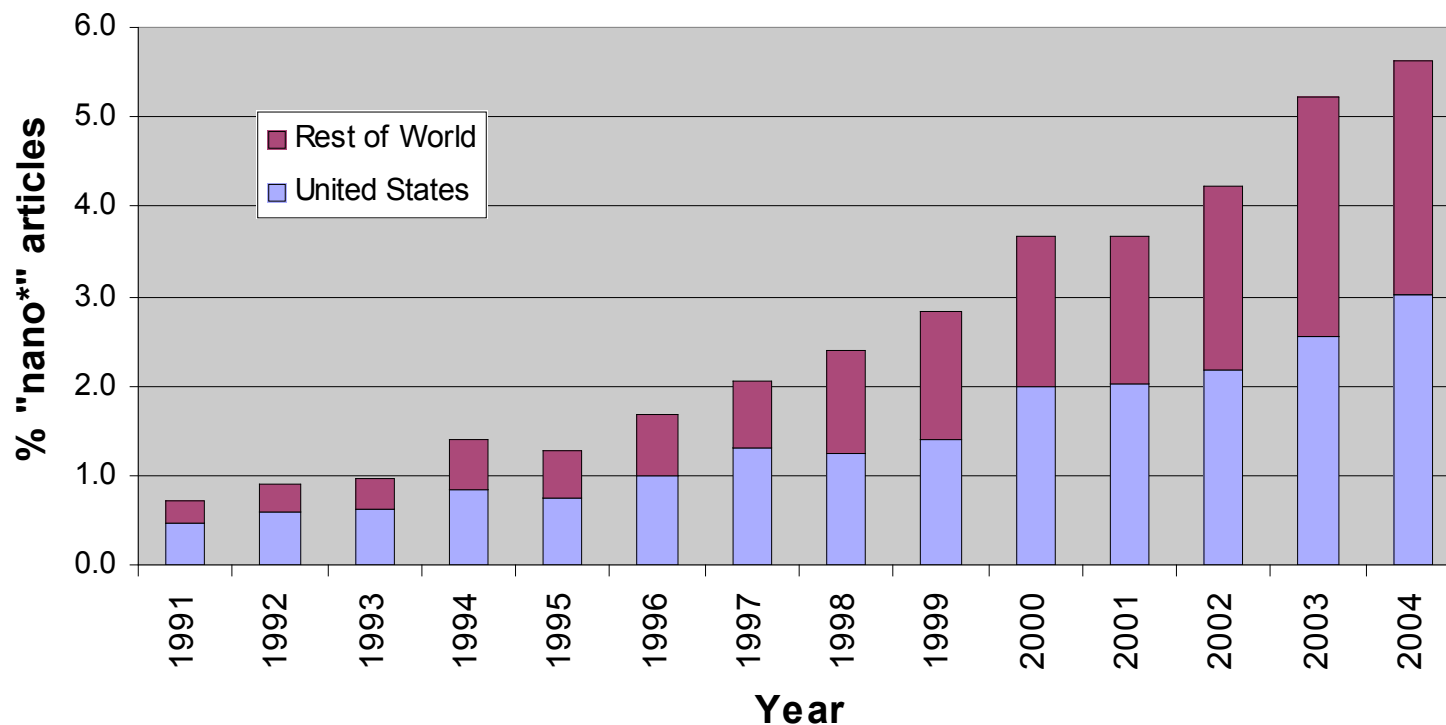
★ U.S. fraction of publications mirrors fraction of investment.



Source: J. Murday, U.S. Naval Research Laboratory; ISI search using “nano\*”

# Measures of U.S. Competitiveness: High Impact Scientific Publications

- ★ Growing % of articles in “high impact” journals\* are on nano
- ★ *U.S. share is >50%; even though U.S. investment is ~25%*

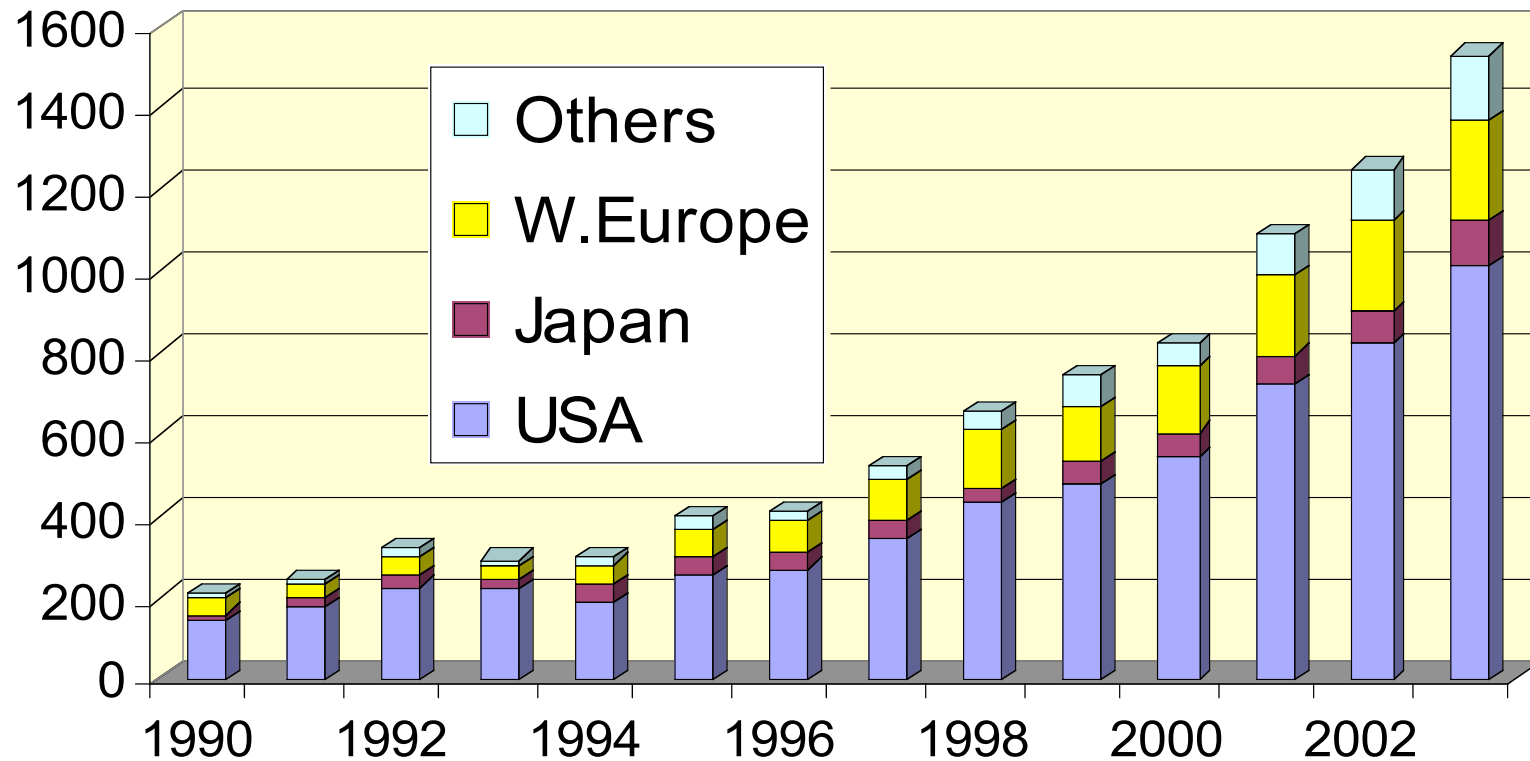


Source: J. Murday, U.S. Naval Research Laboratory

\* Search of *Science*, *Nature*, and *Phys Rev Ltr* using “nano\*”



# Measures of U.S. Competitiveness: Patents



Source: Huang et al. (2004) J. Nanoparticle Research  
Nanotechnology keyword search of titles and claims of patents in USPTO database

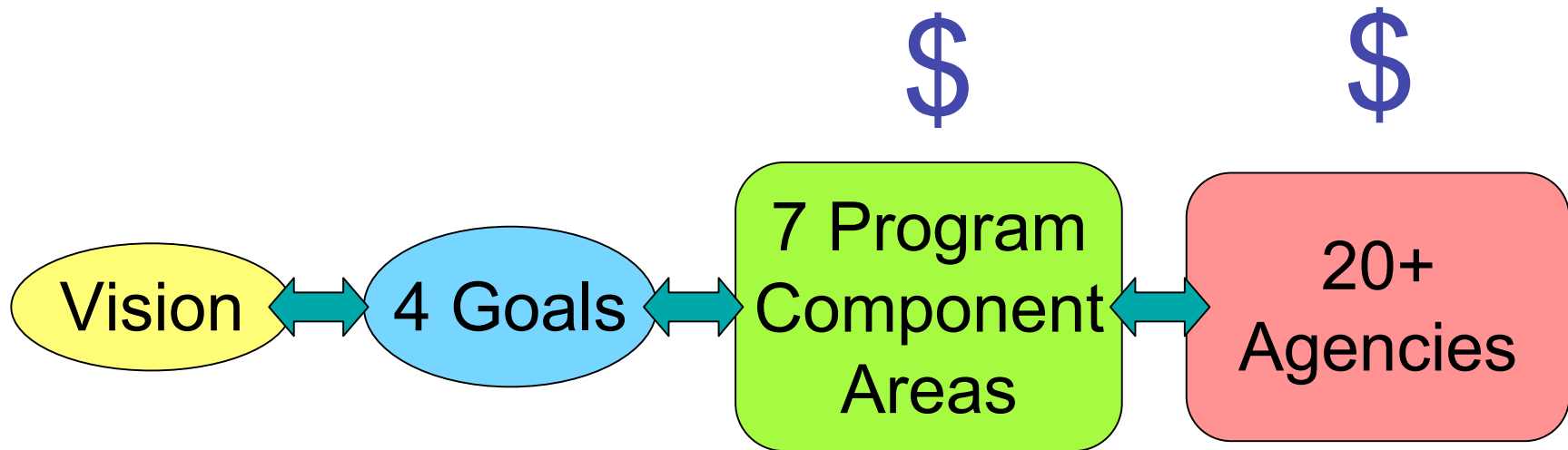
# **PCAST/NNAP Conclusions**

- **US is leading, but is being challenged**
- **NNI is on the right track**
- **Federal role in nano is to fund basic research and to educate/train scientists and engineers**

# **PCAST/NNAP Recommendations**

- **Increase Federal-State interaction**
- **Expand liaison activities with industry**
- **Use SBIR/STTR programs**
- **Coordinate with agencies responsible for protecting health and environment**
- **Build public awareness and trust**

# NNI Strategic Plan (Dec 2004)



# NNI Vision

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

**Expedite discovery, development, and deployment of nanotechnology for:**

- ❖ **Economic benefit**
- ❖ **National & homeland security**
- ❖ **Improved quality of life**

# NNI Goals

- **Sustain world class R&D**
- **Facilitate technology transfer**
- **Develop infrastructure:** education; workforce preparation; facilities & instrumentation
- **Support responsible development of nanotechnology**

# National Nanotechnology Initiative

- Over 20 Federal agencies (11 w/ R&D \$)
- Invested over \$4 billion in R&D since FY 2001
  - Over 2500 active research projects in 2004 at more than 500 research institutions in all 50 states.
- Over 30 research centers and user facilities with over 80 university partners
- Providing educational & training resources for students, teachers, and a skilled workforce
- Promoting technology transfer
- Addressing potential risks

# **NNI Participating Agencies With Nanotechnology R&D budgets**

- Department of Agriculture (USDA)
- Department of Defense (DOD)
- Department of Energy (DOE)
- Department of Homeland Security (DHS)
- Department of Justice (DOJ)
- Environmental Protection Agency (EPA)
- National Aeronautics and Space Administration (NASA)
- National Institute of Standards and Technology (NIST, Department of Commerce)
- National Institute for Occupational Safety and Health (NIOSH, Department of Health and Human Services)
- National Institutes of Health (NIH, Department of Health and Human Services)
- National Science Foundation (NSF)



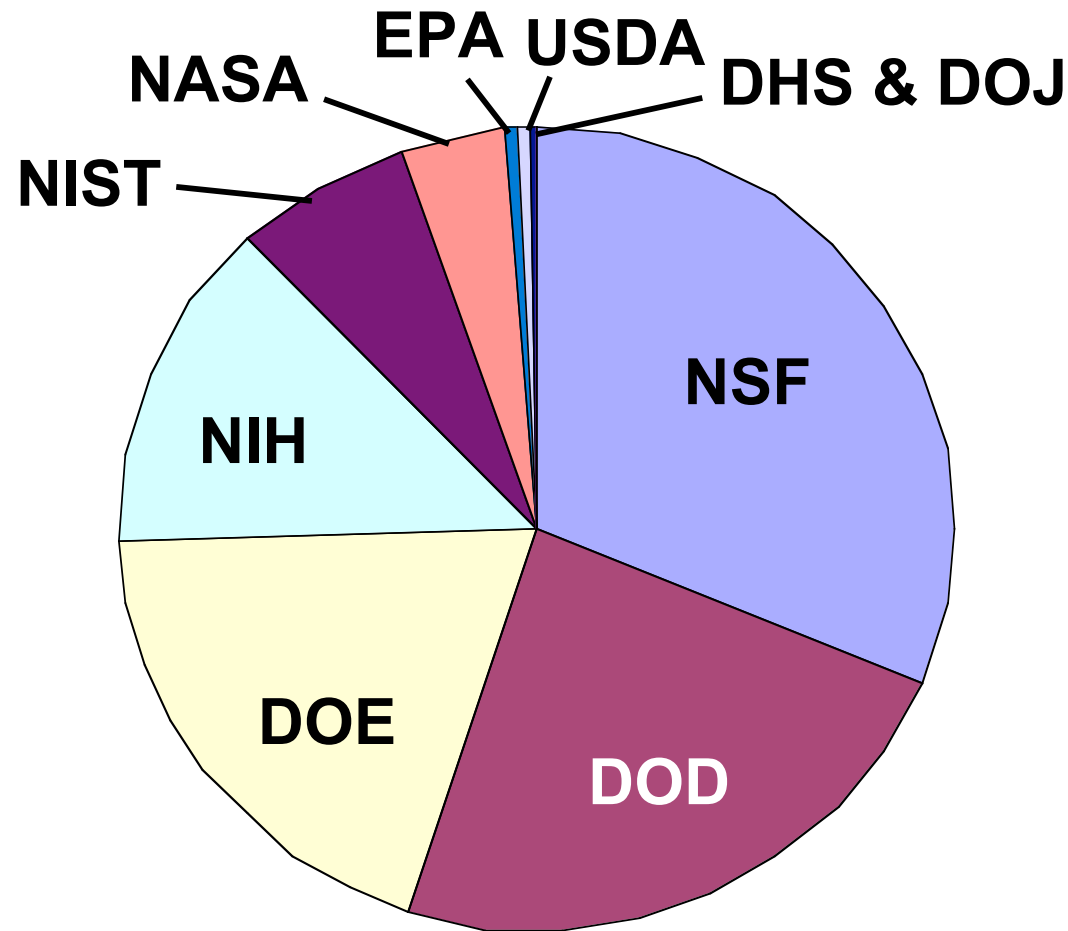
# **NNI Participating Agencies**

## **Without Nanotechnology R&D budgets**

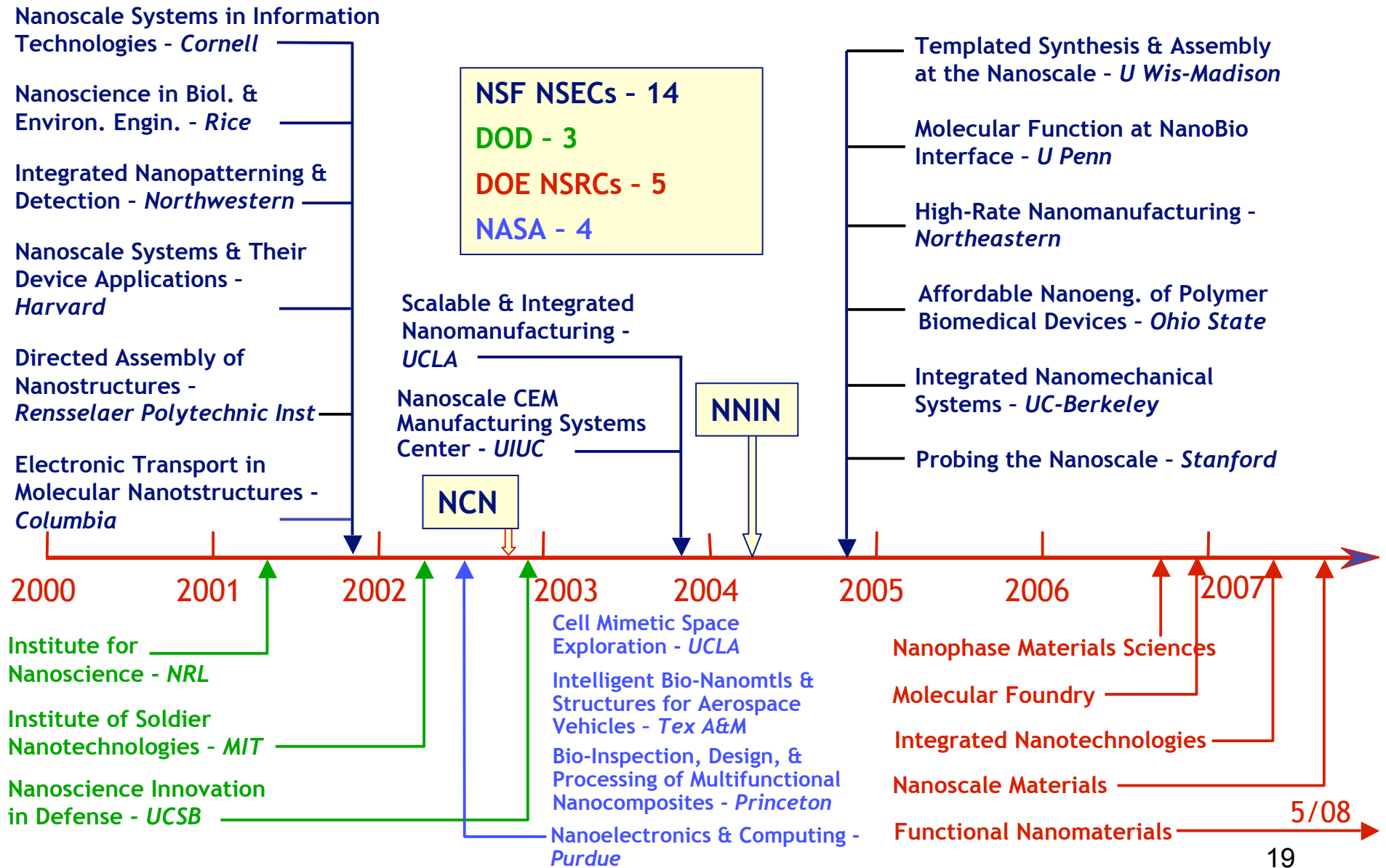
- Bureau of Industry and Security (BIS, Dept of Commerce)
- Consumer Product Safety Commission (CPSC)
- Department of State (DOS)
- Department of Transportation (DOT)
- Department of the Treasury (DOTreas)
- Food and Drug Administration (FDA, HHS)
- International Trade Commission (ITC)
- Intelligence Community (IC)
- Nuclear Regulatory Commission (NRC)
- Technology Administration (TA, Dept of Commerce)
- U.S. Patent and Trademark Office (USPTO, Dept of Commerce)

# NNI FY 2006 Budget Request

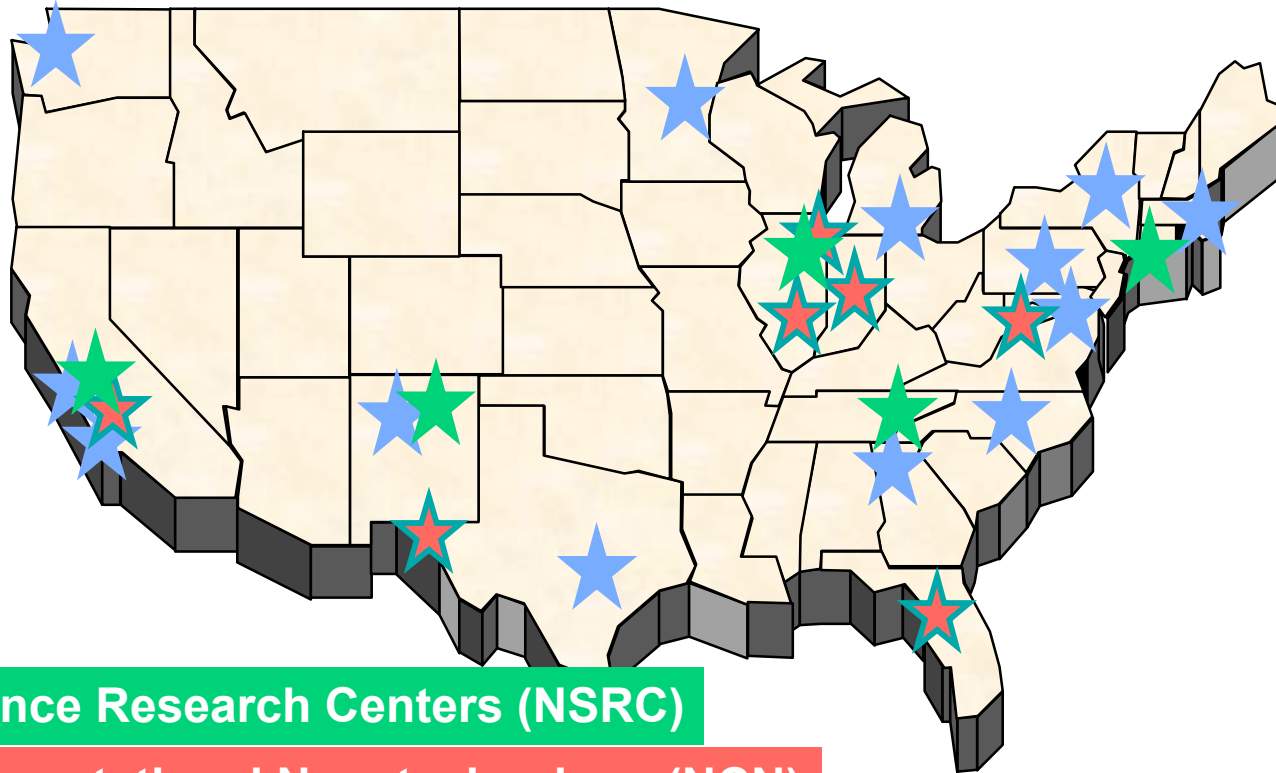
Total = \$1,054 million



# NNI Centers and User Facilities



# NNI User Facilities



Nanoscale Science Research Centers (NSRC)

Network for Computational Nanotechnology (NCN)

National Nanotechnology Infrastructure Network (NNIN)

# Areas of investment (aka Program Component Areas)

 **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 (EHS, ELSI, Educ.)**

# 1. Fundamental Nanoscale Phenomena and Processes

***Discovery and development of fundamental knowledge pertaining to new phenomena in the physical, biological, and engineering sciences that occur at the nanoscale. Elucidation of scientific and engineering principles related to nanoscale structures, processes, and mechanisms.***

## 2. Nanomaterials

***Research aimed at discovery of novel nanoscale and nanostructured materials and at a comprehensive understanding of the properties of nanomaterials (ranging across length scales, and including interface interactions). R&D leading to the ability to design and synthesize, in a controlled manner, nanostructured materials with targeted properties.***

# 3. Nanoscale Devices and Systems

***R&D that applies the principles of nanoscale science and engineering to create novel, or to improve existing, devices and systems. Includes the incorporation of nanoscale or nanostructured materials to achieve improved performance or new functionality. To meet this definition, the enabling science and technology must be at the nanoscale, but the systems and devices themselves are not restricted to that size.***



## 4. Instrumentation Research, Metrology, and Standards for Nanotechnology

***R&D pertaining to the tools needed to advance nanotechnology research and commercialization, including next-generation instrumentation for characterization, measurement, synthesis, and design of materials, structures, devices, and systems. Also includes R&D and other activities related to development of standards, including standards for nomenclature, materials, characterization and testing, and manufacture.***

## 5. Nanomanufacturing

*R&D aimed at enabling scaled-up, reliable, cost-effective manufacturing of nanoscale materials, structures, devices, and systems. Includes R&D and integration of ultra-miniaturized top-down processes and increasingly complex bottom-up or self-assembly processes.*

## 6. Major Research Facilities and Instrumentation Acquisition

***Establishment of user facilities, acquisition of major instrumentation, and other activities that develop, support, or enhance the Nation's scientific infrastructure for the conduct of nanoscale science, engineering, and technology research and development. Includes ongoing operation of user facilities and networks.***

## 7. Societal Dimensions

***Various research and other activities that address the broad implications of nanotechnology to society, including benefits and risks, such as:***

- Research directed at environmental, health, and safety implications of nanotechnology development and risk assessment of such impacts***
- Education***
- Research on the ethical, legal, and societal implications of nanotechnology.***

## FY 2006 Budget Request (\$ millions) by Agency and Program Component Area

	Fundamental Nanoscale Phenomena and Processes	Nano-materials	Nanoscale Devices and Systems	Instrumentation Research, Metrology, and Standards for Nanotechnology	Nano- manufacturing	Major Research Facilities and Instrumentation Acquisition	Societal Dimensions	NNI Total
NSF	95	75	54	12	24	24	60	<b>344</b>
DOD	35	83	99	3	2	6	2	<b>230</b>
DOE	48	33	5	11	0	109	1	<b>207</b>
NIH	46	17	67	6	0	1	8	<b>144</b>
NIST	5	1	2	39	19	8	1	<b>75</b>
NASA	5	17	9	0	1	0	0	<b>32</b>
USDA	1	2	6	0	1	0	1	<b>11</b>
EPA	<0.5	0	<0.5	0	0	0	4	<b>5</b>
NIOSH	0	0	0	0	0	0	3	<b>3</b>
DOJ	0	0	0	0	0	0	2	<b>2</b>
DHS	0	0	1	0	0	0	0	<b>1</b>
<b>TOTAL</b>	<b>234</b>	<b>228</b>	<b>244</b>	<b>71</b>	<b>47</b>	<b>148</b>	<b>82</b>	<b>1,054</b>

# Relationship of PCAs to Goals

<b>Program Component Areas:</b>	Goal 1: Maintain a world-class research and development program aimed at realizing the full potential of nanotechnology	Goal 2: Facilitate transfer of new technologies into products for economic growth, jobs, and other public benefit	Goal 3: Develop educational resources, a skilled workforce, and the supporting infrastructure and tools to advance nanotechnology	Goal 4: Support responsible development of nanotechnology
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				

	critical to goal
	primary relevance
	secondary relevance

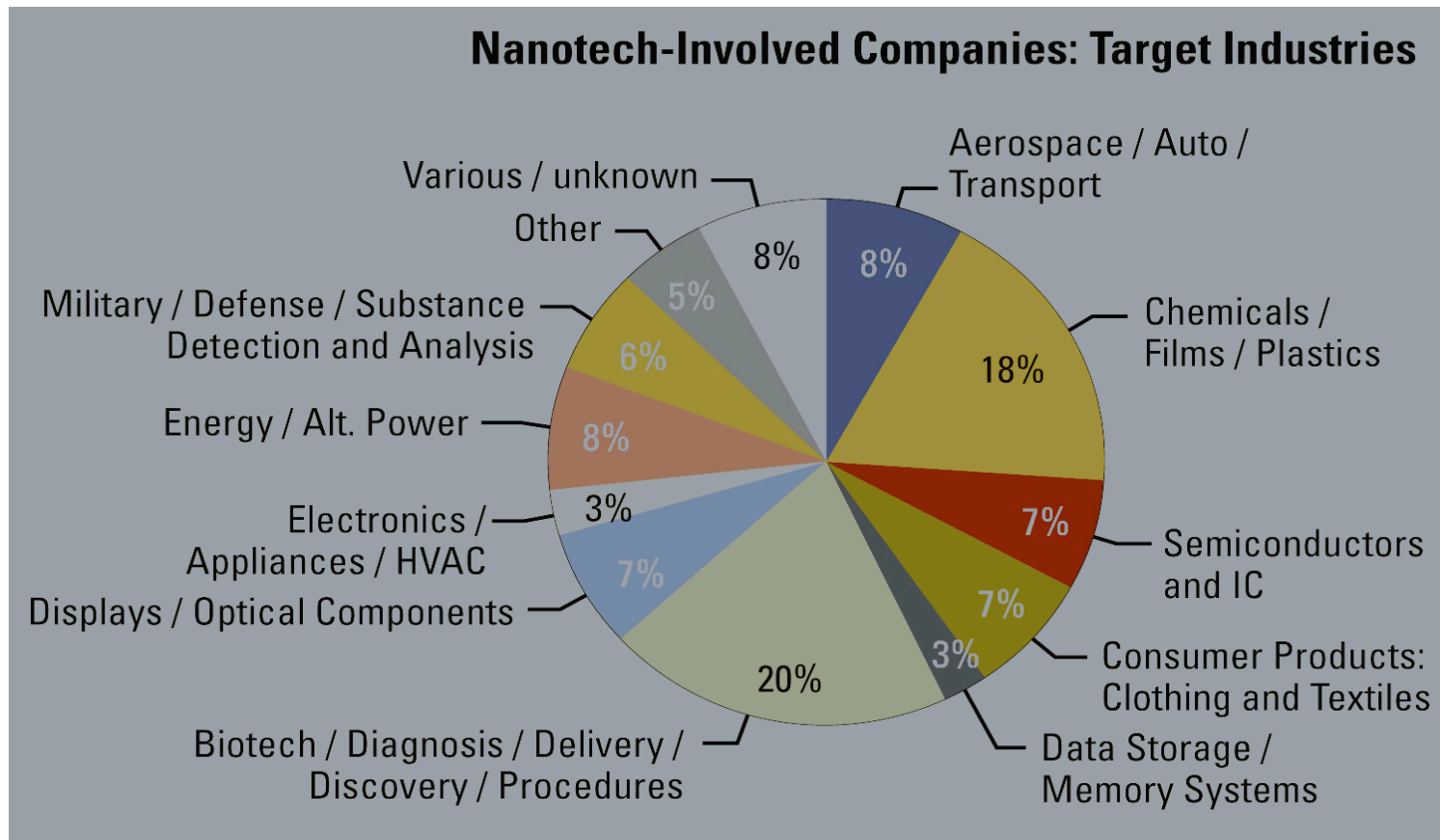
# Relationship between PCAs and NNI Agency Missions

● 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	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>			<input checked="" type="checkbox"/>
DHS	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input type="checkbox"/>	<input checked="" type="checkbox"/>
DOC (BIS)	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>		
DOC (NIST)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
DOC (TA)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
DOC (USPTO)		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		
DOD	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
DOE	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
DOJ			<input checked="" type="checkbox"/>				
DOS							<input checked="" type="checkbox"/>
DOT	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		
DOTreas		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>				
EPA	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
HHS (FDA)		<input type="checkbox"/>	<input checked="" type="checkbox"/>				<input checked="" type="checkbox"/>
HHS (NIH)	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>		<input type="checkbox"/>
HHS (NIOSH)		<input type="checkbox"/>			<input type="checkbox"/>		<input checked="" type="checkbox"/>
IC	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input type="checkbox"/>		<input type="checkbox"/>
ITC		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>		<input checked="" type="checkbox"/>
NASA	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input type="checkbox"/>	<input type="checkbox"/>	
NRC			<input checked="" type="checkbox"/>				
NSF	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
USDA	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>		<input type="checkbox"/>		<input checked="" type="checkbox"/>

# Where do we stand?

## Areas of private sector activity in U.S.

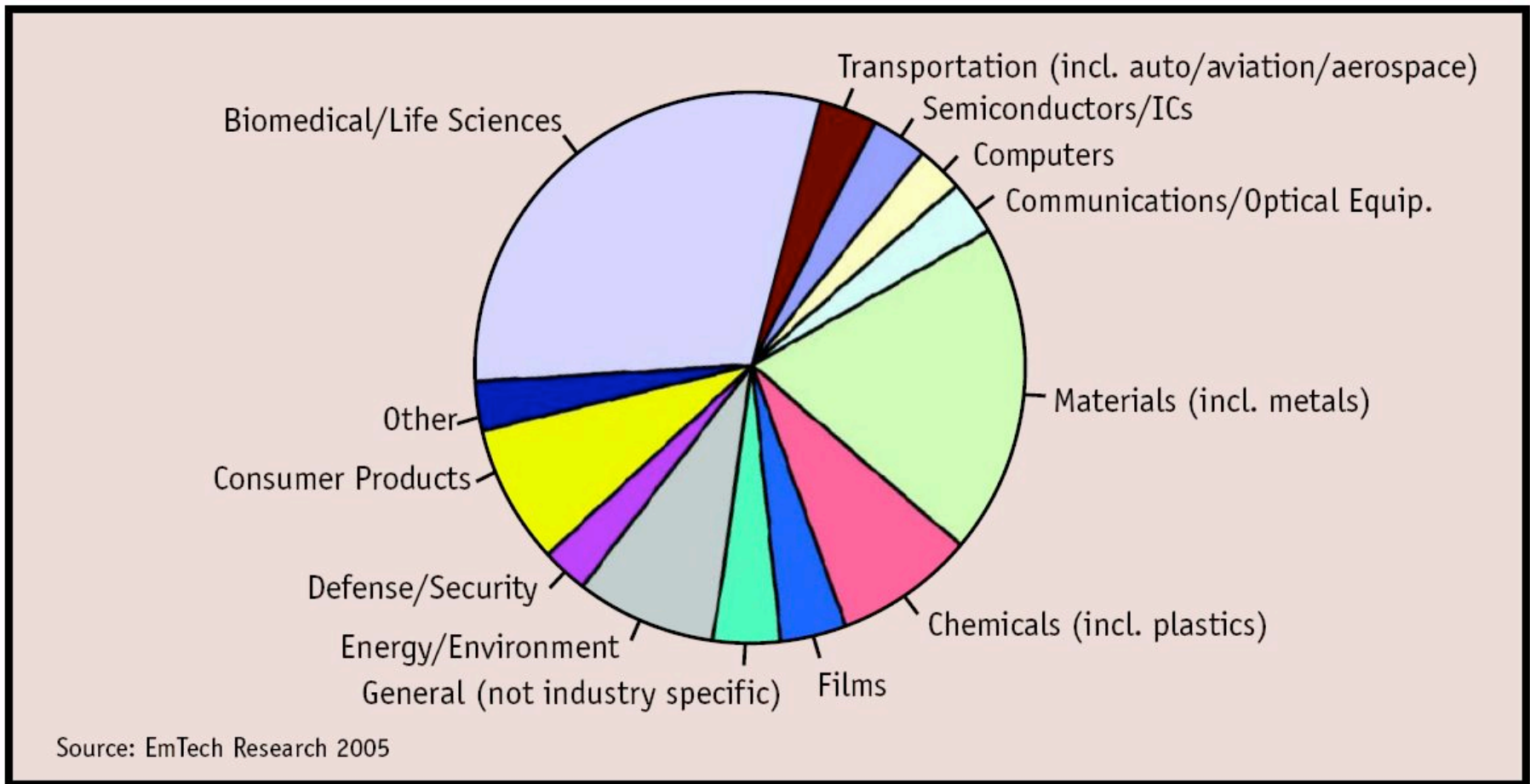


Source: *Small Times Media* (2004)



Figure 5.

**Target Industries for Companies Involved in R&D, Manufacture, Sale, and Use of Nanotechnology in 2004 (Total Number of Companies = 599)**



# Where do we stand?

## TAG identified areas of opportunity

### Near-term (1-5 years):

- Nanocomposites with greatly improved strength-to-weight ratio, toughness, etc.
- Nanomembranes and filters (including for water purification and desalination)
- Improved catalysts with one or more orders of magnitude less precious metal
- Sensitive, selective, reliable solid-state chemical and biological sensors
- Point-of-care medical diagnostic devices
- Long-lasting, rechargeable batteries

# Where do we stand?

## TAG identified areas of opportunity

### Mid-term (5-10 years):

- Targeted drug therapies
- Enhanced medical imaging
- High efficiency, cost effective solar cells
- Improved fuel cells
- Efficient technology for water to hydrogen conversion
- Carbon sequestration

# Where do we stand?

## TAG identified areas of opportunity

### Long-term (20+ years):

- Drug delivery through cell walls
- Molecular electronics
- All-optical information processing
- Neural prosthetics for treating paralysis, blindness, etc.
- Conversion of energy from the environment (thermal or chemical)

# NNI Accomplishments

- ***Advanced the foundational knowledge for control of matter at the nanoscale with:***
  - **Over 2500 active research projects in 2004**
  - **Research projects at over 500 universities, Government labs, and other research institutions in all 50 states.**
- ***“Created an interdisciplinary nanotechnology community,”*** according to the NSF Committee of Visitors, an outside review panel, in 2004.
- ***Built up an infrastructure of over 35 nanotechnology research centers, networks, and user facilities.***

# NNI Accomplishments

- ***Promoted understanding of societal implications and applications*** through investment of ~10% of NNI budget for research related to the environment, health, safety, and other societal concerns.
- ***Established nanotechnology education programs*** to reach students in graduate, undergraduate, high school, and middle school. NNI has impact on 10,000 graduate students and teachers in 2004 alone.
- ***Supported public outreach*** via a regularly updated website ([www.nano.gov](http://www.nano.gov)), a major resource for researchers, educators, the press, and the public. [Website gets ~14,000 *new* visitors each month.]



## How to Start an NNIN Project

NNIN sites are set up with streamlined methods for user access. We have provided a number of resources on this site to assist in your project planning. While there are many paths to a successful project, overall the process is described below.

1. Review NNIN web site for process and capability information
  - o Please use the [Technical Resources](#) for a technology and equipment based description of NNIN capabilities and to other sections of the web site to learn about our capabilities.
  - o Also refer to the [Technical FAQ](#) for answers to common questions.
  - o You may also find the [Education link](#) useful for various training resources
2. Contact one or more NNIN sites to discuss your application. The Site contact will be particularly interested in assessing the technical feasibility of the project and the scope of your desired work and interaction.
3. After these discussions, the site technical contact will be able to either 1) commit to doing the project at that site, 2) refer you to a site more appropriate, or 3) explain why the project is not feasible with the available resources.
4. If you are unsuccessful in your initial site discussions, please [contact NNIN management](#) for guidance.
5. Prepare a brief written project description and submit to chosen NNIN site. This will not be externally reviewed but is primarily for documentation of agreed scope.
6. You will need to prepare a purchase order to cover charges and sign a brief user agreement. Interaction is done, however, without a formal contract between you and the selected university.



Upon approval, your project will be scheduled at a mutually agreeable time, generally within 1 month. The selected site will arrange for appropriate training and project supervision.

[HOME](#) · [BACK TO THE TOP](#)

