NCMS-NSF Study of Nanotechnology in the U.S. Manufacturing Industry

Achieving Sustainable Nanotechnology Products

NBCA Nanomanufacturing Summit, Philadelphia, PA

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2013 NCMS-NSF Nanotechnology Commercialization Study

Acknowledgements

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- Dr. Khershed Cooper(Program Director, NSF)

- **NanoBCA**
- Vince Caprio

The Ultimate Collaborative Network
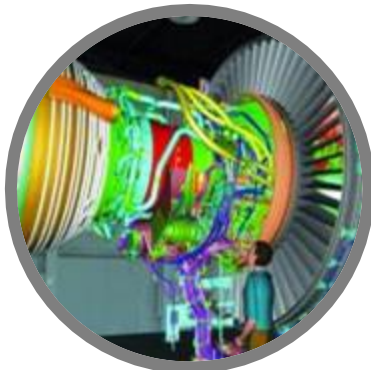
NCMS KEY INITIATIVES

CROSS-INDUSTRY COLLABORATION
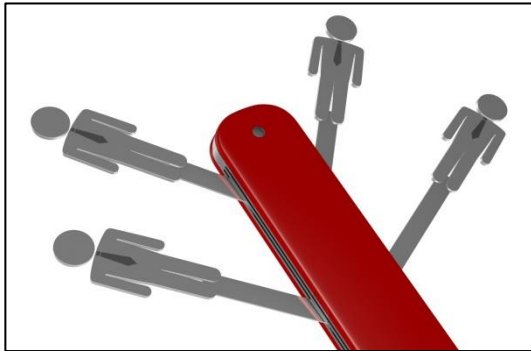
PUBLIC/PRIVATE PARTNERSHIPS

DIGITAL MANUFACTURING

AUTONOMOUS ROBOTICS

SUSTAINABLE MANUFACTURING

TALENT

Skill, knowledge, creativity, experience of people who seek successful innovation
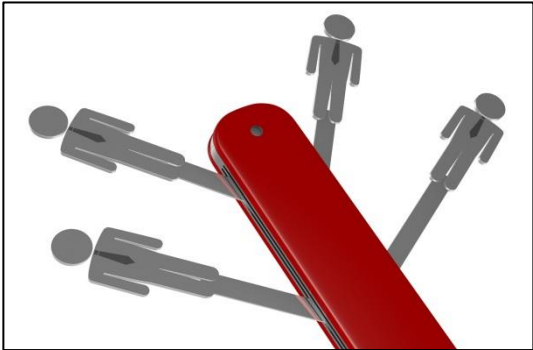
INVESTMENT

Assets, resources, and fiscal ability to support the innovation efforts to the finish line

INFRASTRUCTURE

Physical environment, logistics, and support personnel to keep the process moving

COLLABORATIVE MODEL

DEVELOPERS

Creators, scientists, thought leaders, and tinkerers who imagine and create new things
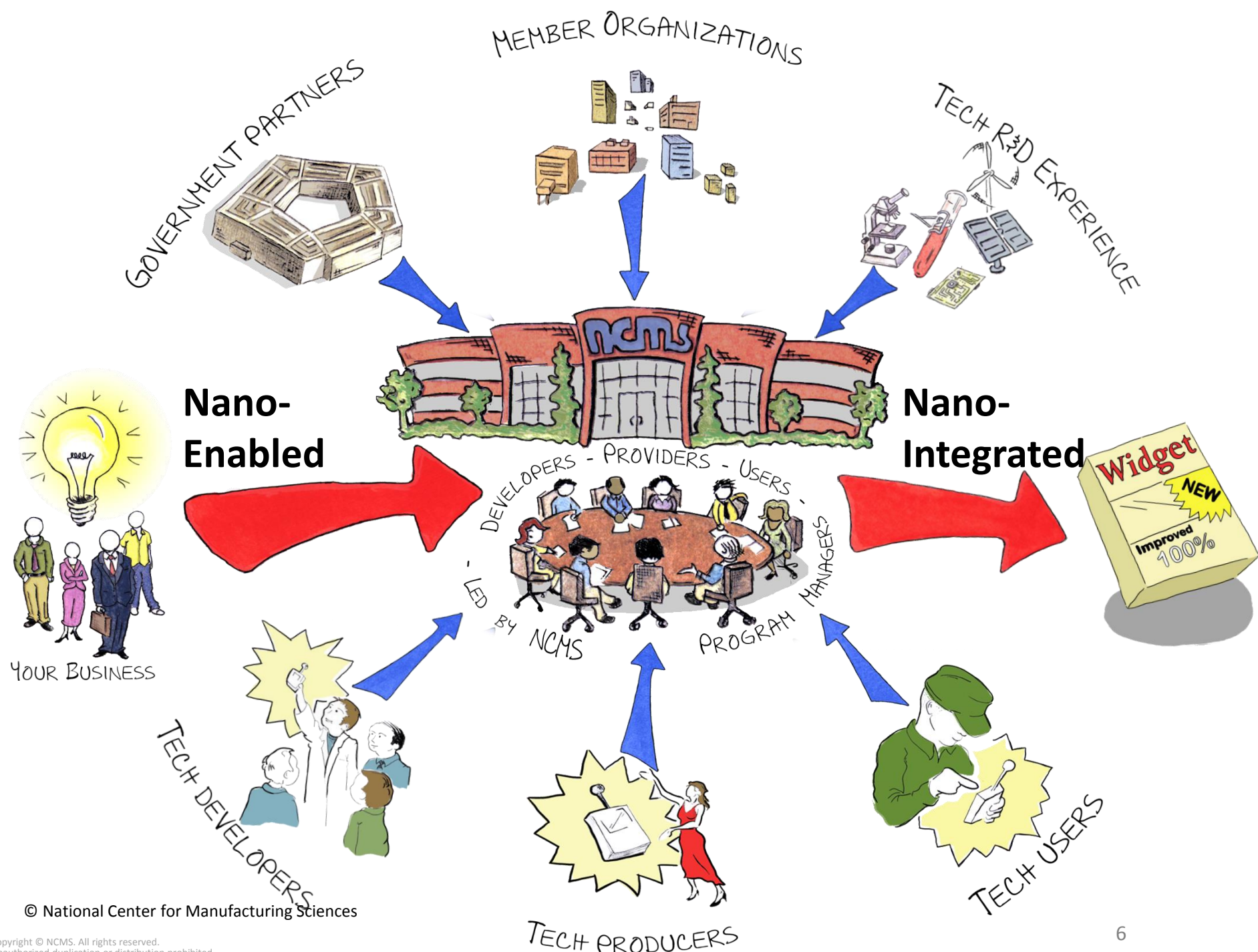
INTEGRATORS

Engineers, manufacturers, product designers and builders who turn innovation into product

END USERS

The customers, people who use the product and know what they want and how they want it

GOVERNMENT PARTNERS

MEMBER ORGANIZATIONS

TECH R&D EXPERIENCE

ncms

Nano-Enabled

Nano-Integrated

DEVELOPERS - PROVIDERS - USERS -

- LED BY NCMS

PROGRAM MANAGERS

Widget NEW
Improved 100%

YOUR BUSINESS

TECH DEVELOPERS

TECH PRODUCERS

TECH USERS

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NCMS Sustainable Manufacturing

2013 Cross-Sector Nanotechnology Study

Academia
Agriculture
Chemicals
Energy
Furniture
Medical
Electronics

Aerospace
Automotive
Coatings
Food processing
Machine tool
Military
Materials

Industry Survey Launch October 1, 2013 + Selected Interviews

Study Objectives

- **Snapshot of U.S. Industry Attitudes to Nanotechnology**

- **Assess Key Trends, Strategies, Plans, Concerns**

- **Report Aggregate Industry Cross-Sector Statistics**

- **Benchmark for Best Practices in Commercialization**

- **Reports Disseminated to Policy-makers, Industry**

- **Metric of NNI, Other Public-Private Initiatives**

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Progressive *Nano*-Study Themes

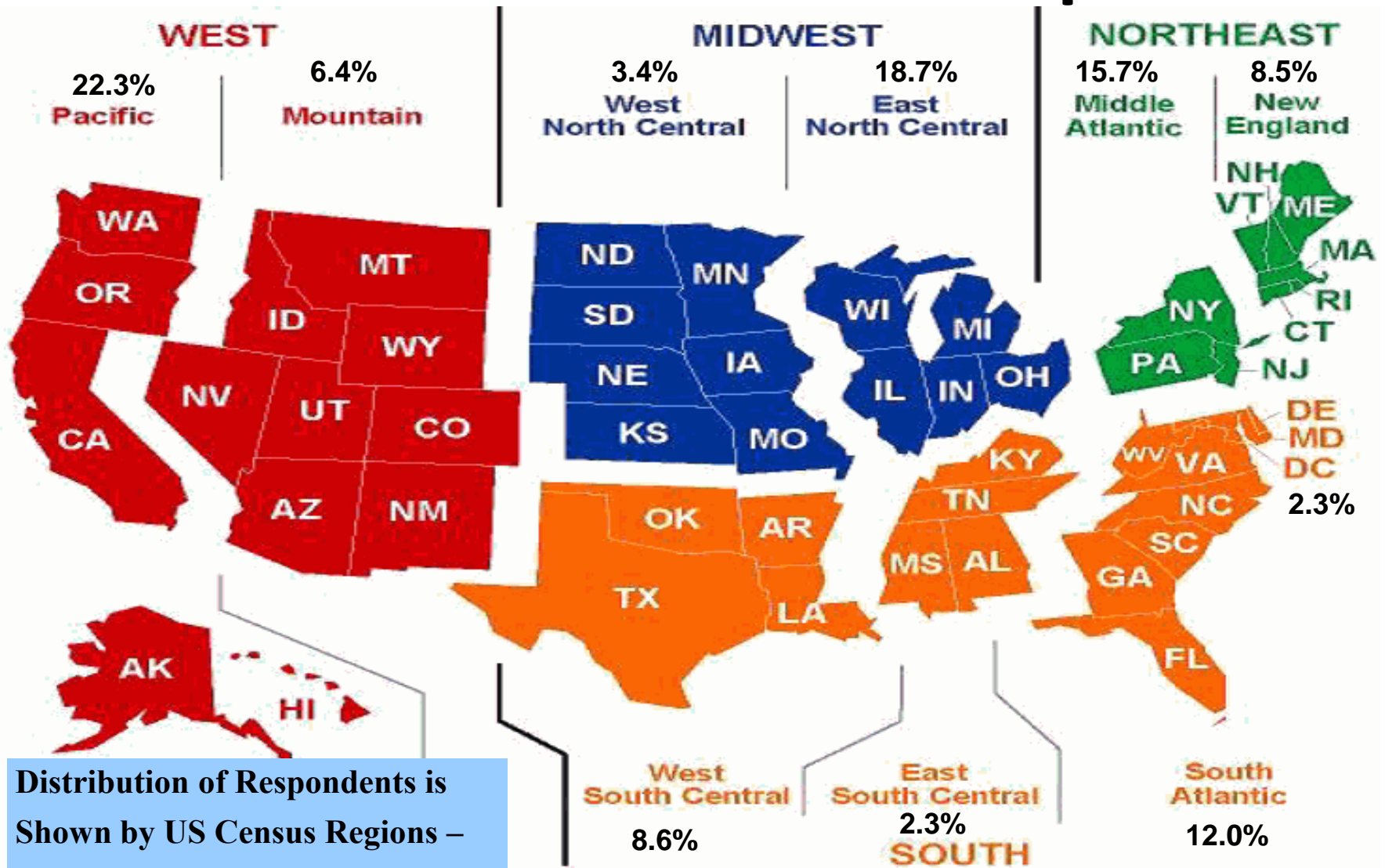Reports At: http://eprints.internano.org/565/

2003 – Do U.S. manufacturers recognize the potential of nanotechnology? (80+ datasets)

2005 – Do organizations view and develop nanotechnology differently from other advanced science and technology? (600+)

2009 – Are U.S. nanotechnology businesses viable, competitive and sustainable in the current economically turbulent times? (270+)
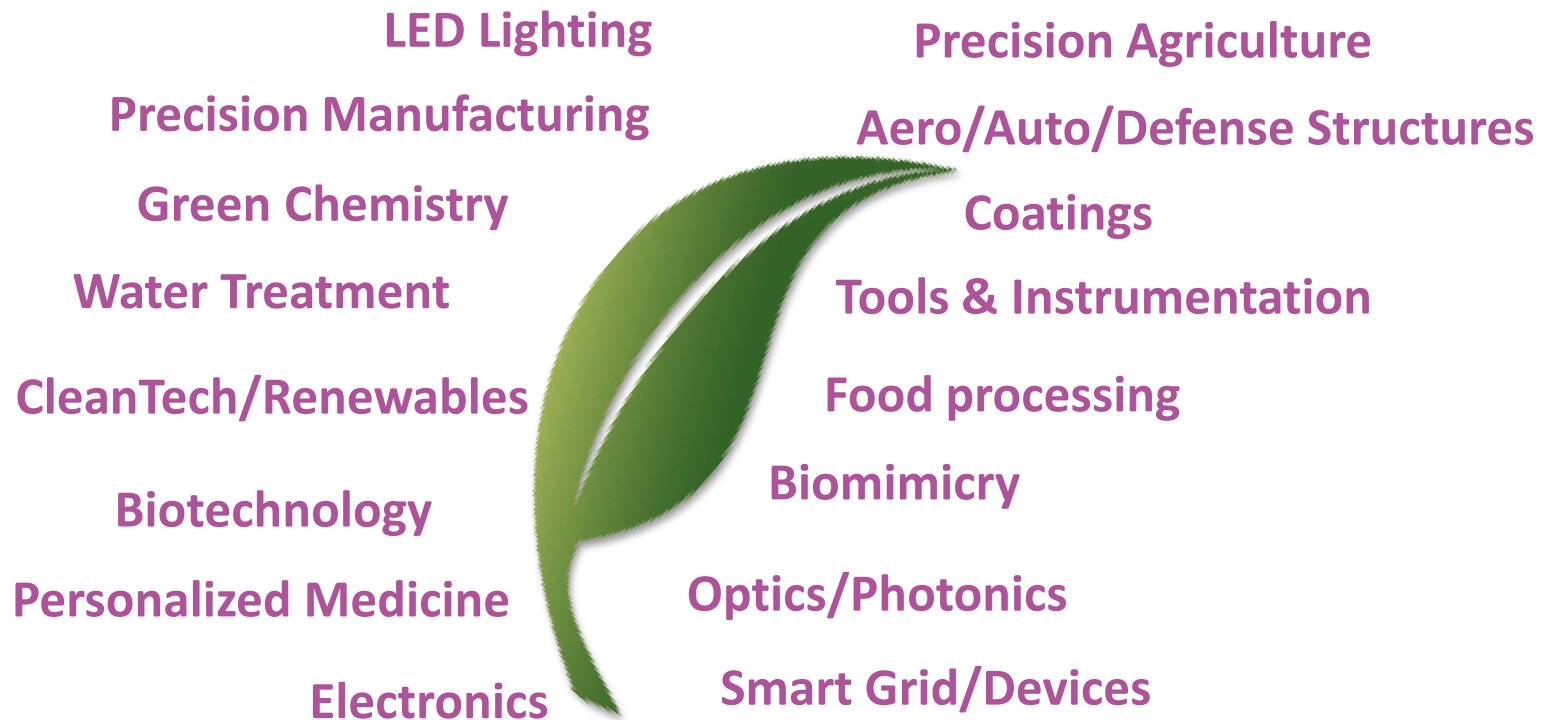
2013 – Achieving Sustainable *Nano*Products

2009 Distribution of 270 Responses

WEST

| 22.3% Pacific | 6.4% Mountain |

MIDWEST

| 3.4% West North Central | 18.7% East North Central |

NORTHEAST

| 15.7% Middle Atlantic | 8.5% New England |

2.3%

Distribution of Respondents is Shown by US Census Regions – It Mirrors the 2005 Study Dataset

West South Central — 8.6%

East South Central — 2.3%

South Atlantic — 12.0%

SOUTH

10

Nanotechnology <u>Is</u> At the Heart of Everything!

LED Lighting

Precision Manufacturing

Green Chemistry

Water Treatment

CleanTech/Renewables

Biotechnology

Personalized Medicine

Electronics

Precision Agriculture

Aero/Auto/Defense Structures

Coatings

Tools & Instrumentation

Food processing

Biomimicry

Optics/Photonics

Smart Grid/Devices

12

NCMS – NSF SUSTAINABLE *NANO*-PRODUCT STUDY

2013 Theme: "Achieving Sustainable Nanotechnology"

- **Focus on Technology 'Pull' Factors**
  - Differentiators, Strategic Enablers, Barriers
- **How Large Corporations Integrate Nanotech**
  - Key Indicators, Open Innovation, Design/ Manufacturing
- **Sustainability Factors & Best Practices**
  - EHS, Lifecycle Thinking, Supply-Chains, Standards, Clusters
- **Social Media to Promote Survey & Reporting**
  - Cross-Sector Results Reported As Aggregate Trends
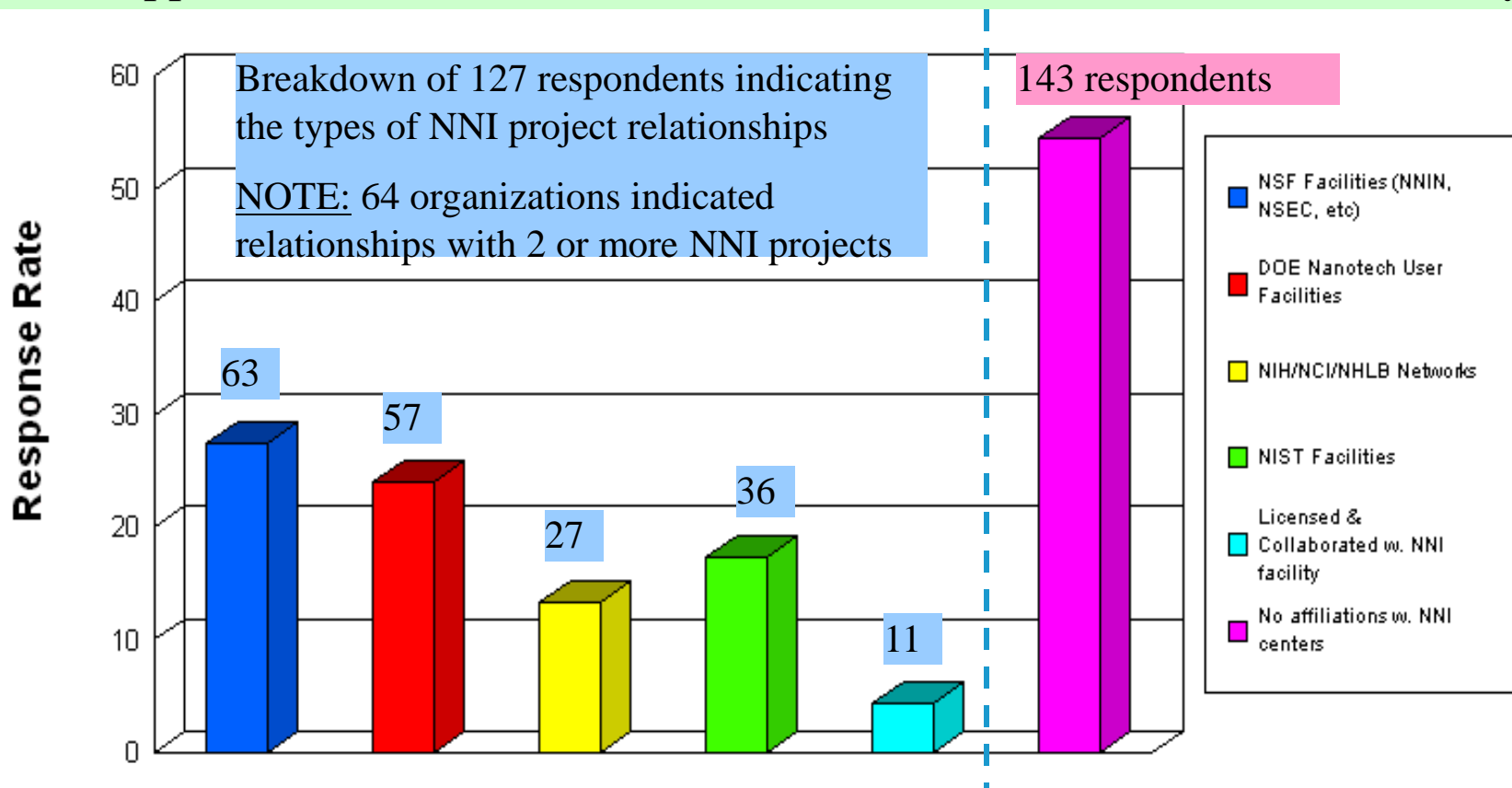- **Responsive Web – Smart Phone / Tablet Accessible**

13

20 Strategic Commercialization Issues

1. **Geographic Location/Clustering**
2. **Org Role in Nano-Value Chain**
3. **Respondent's Org Function**
4. **Nanotech Application Markets**
5. **Coping with Nano-Strategy**
6. **Corporate Priority for Nanotech**
7. **Organization Capacity**
8. **Available Infrastructure**
9. **Interactions with FFRDCs, NSERCs**
10. **Open-Innovation/Collaboration**
11. **Offshoring of Developments**
12. **Direct Staffing**
13. **Commercialization Timelines**
14. *Nano*-Product Type(s)
15. **Technology/Manufacturing Readiness Levels**
16. **Scalability**
17. **Role of Government**
18. **Key Challenges & Barriers**
19. **US Leadership/Competitiveness**
20. **Industry Outlook**
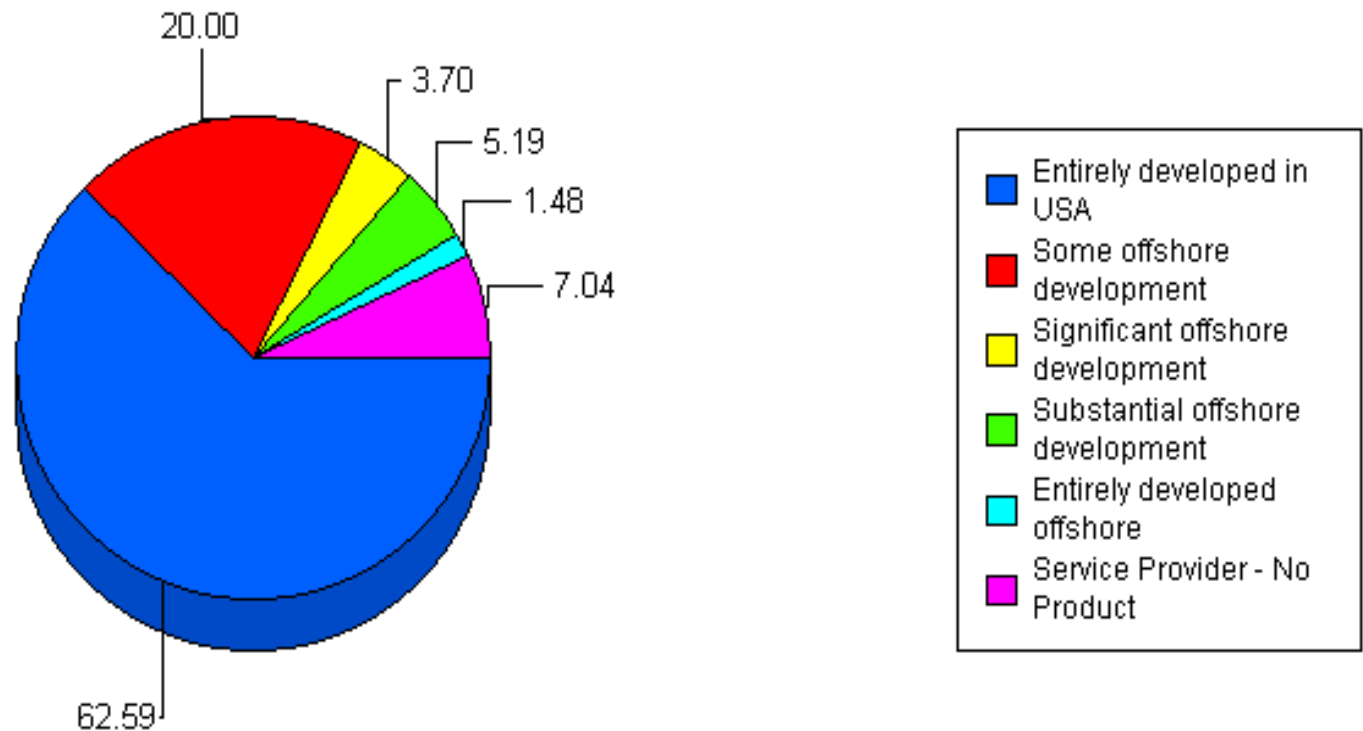
30-Question Online Survey + Interviews

2009: Interactions with NNI Projects

- 127 (46%) Respondents indicated collaborations with NNI centers/projects
- 143 (54%) Respondents indicated no formal NNI project relationships exist
  - < 5% respondents indicated licensing IP from NNI centers/projects
 - Opportunities abound for interactions between NNI centers and industry

Breakdown of 127 respondents indicating the types of NNI project relationships

NOTE: 64 organizations indicated relationships with 2 or more NNI projects

143 respondents

Legend:
- NSF Facilities (NNIN, NSEC, etc)
- DOE Nanotech User Facilities
- NIH/NCI/NHLB Networks
- NIST Facilities
- Licensed & Collaborated w. NNI facility
- No affiliations w. NNI centers

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16

2009: Offshoring Trends in Nanotechnology

■ ~30% Respondent Organizations Involved in Offshore Developments
E.g., Electronics/Semiconductor, Pharma/Medicine/Biotech, Energy

20.00
3.70
5.19
1.48
7.04
62.59

Legend:
- Entirely developed in USA
- Some offshore development
- Significant offshore development
- Substantial offshore development
- Entirely developed offshore
- Service Provider - No Product

17

2009: *Nano*-Technology Readiness Levels

NOTE: TRL = Technology Readiness Level (a risk assessment index used in the DoD)

18
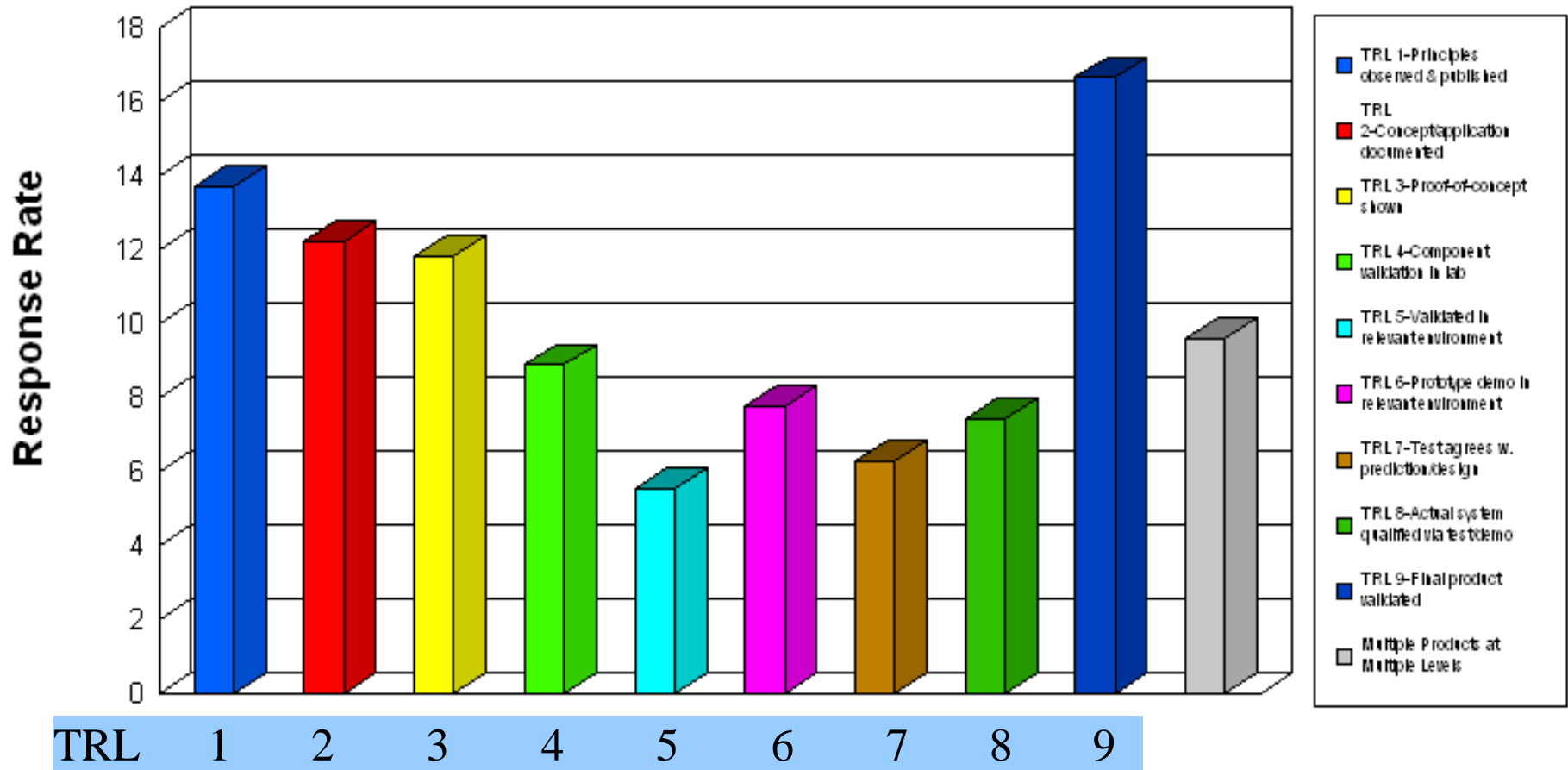
2009: Aggregate Barriers to Nanomanufacturing
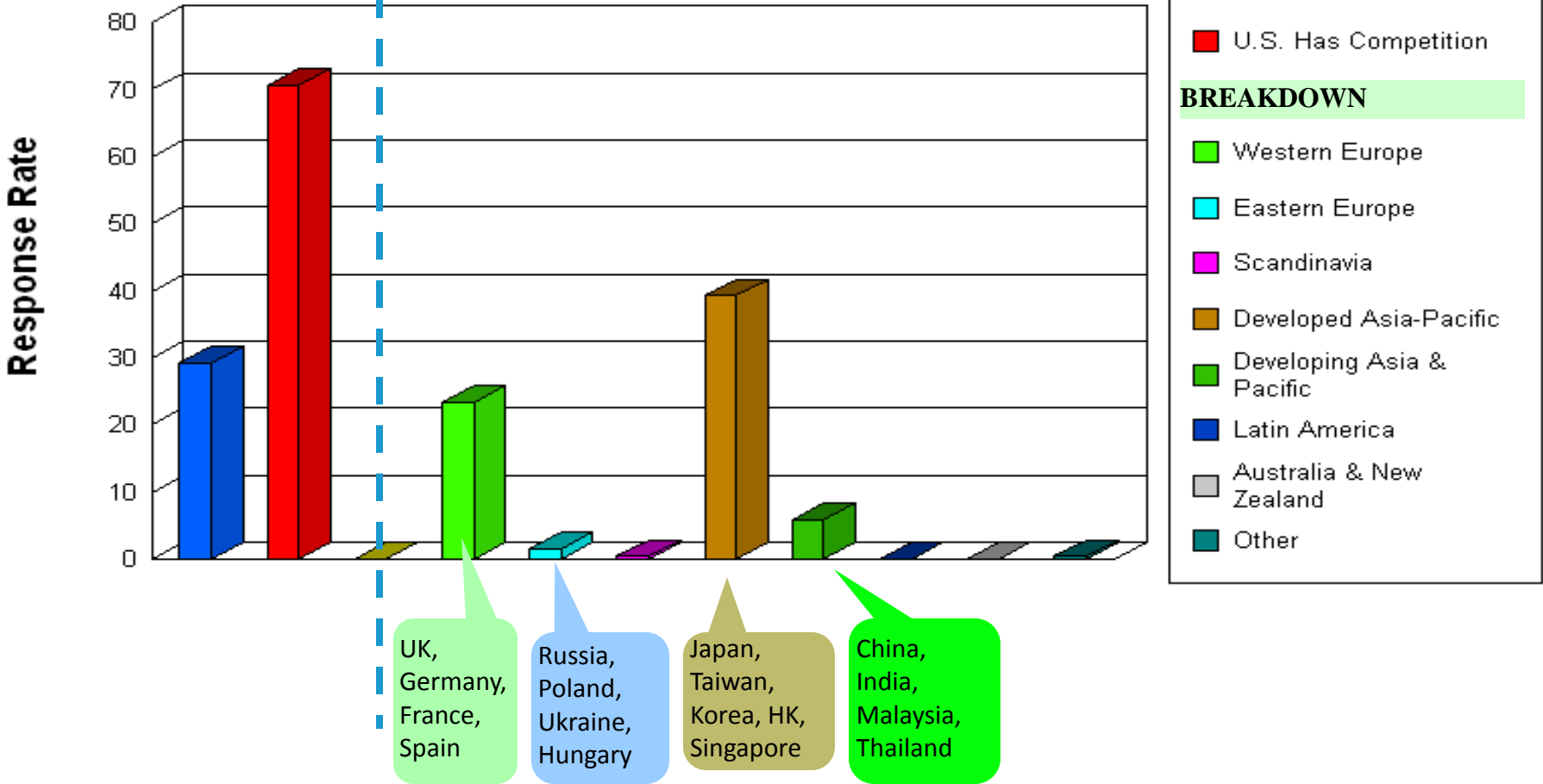
List & Ranks Largely Unchanged From 2005 NCMS Study
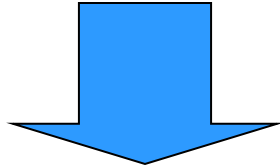
19
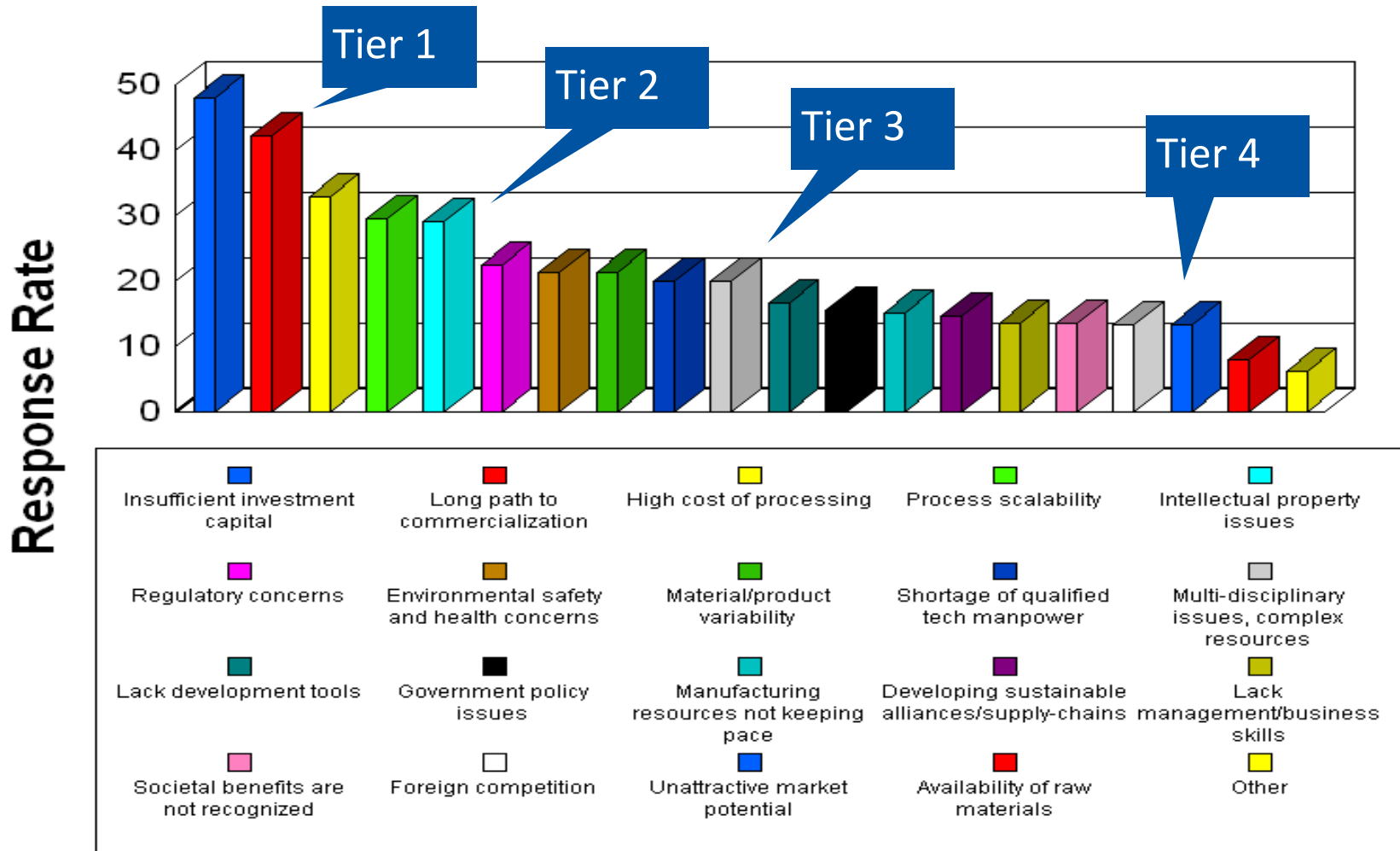
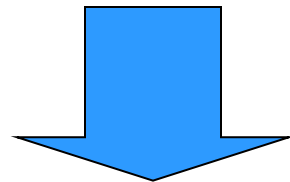# 2009: US Competitiveness in Nanotechnology

NCMS Study Approach

1. **Identification of Key Performance Indicators**

2. **Develop 20-Screen Interactive Electronic Questionnaire**

3. **Target Manufacturing & Nanotechnology Industry**
   - **Senior Executives Solicited, Selective Interviews**
   - **Sampling Period: September – December 2013**

4. **Responses Analyzed, Report to NSF & Dissemination**
   - **November 2013 – March 2014**

Why It Matters…

http://www.usnanosurvey.org/survey/

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Respondent's Name, Organization & Geographical Location

Q1 – To Get Started Please Provide Your Name, Organization's Name, E-Mail And Location. As In Our Past Three NSF-Sponsored Surveys, Your Information Is Kept Confidential, And Will Only Be Used For Authentication And Priority Notification When The Aggregate Survey Results Are Available.

Your Name (First, Last)

Organization :

E-mail

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Respondent's Function/Role

Q2 – Which Category Best Describes Your Role In The Organization?

○ Senior Business Executive (President, CEO, General Manager, Executive Director, Sales, CIO, CFO)

○ Senior Technical Executive (VP, CTO, R&D Director)

○ Specialized Scientific/Engineering Staff (R&D Scientist, Product Engineer)

○ Non-technical Management (Sales, Marketing, Operations, Facilities)

○ Academic Entrepreneur (Founder of startup company with academic roots)

Other

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Stage Of Commercial Maturity

Q4 – Which Term Best Describes The Current Stage Of Your Commercial Entity?

○ Early Stage Startup (R&D or discovery phase with seed/angel funds, SBIR grant)

● Late Stage Startup (multiple rounds of funding raised, products in development pipeline)

○ Growth Phase (generating profit from early production and sales, mature product/technology)

○ Established Corporation (commercial operation, economies of scale, diverse locations and/or specialized units)

○ Intermediate Integrator/Assembler (of nano-enabled components or systems)

○ Not a commercial manufacturer (e.g., academic, non-profit, government, service provider)

Other

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Open Innovation Practices

Q12 – Is Your Organization Experienced In "Open Innovation* (OI) Strategies To Develop Nanotechnology–Enabled Products Or Processes?"

*Open Innovation is defined as "the opportunistic leverage and co-development programs that firms pursue to accelerate technological innovation by combining internally developed ideas with externally sourced ideas and intellectual property." **Please select the one term that best describes your situation.**

○ My organization is not involved with OI in nanotechnology

○ My organization occasionally participates in OI (on a case-by-case basis)

○ My organization routinely participates/invests in OI to stage-gate new developments

◉ Our proven OI approaches have consistently accelerated readiness and/or realized ROI on our line of nanotechnology product(s)

○ Don't know

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Open Innovation Practices

Q13 – The Open Innovation (OI) Practices Most Often Used For Development Of Nano-Enabled Products Include:

◯ Technology-scouting and investment in external sources of competitive advantage

◯ Seeking outside resources such as laboratories, prototype/pilot facilities and test capabilities

⦿ Leveraged multi-disciplinary or subject matter expertise (via large/small companies, universities, non-profit consortia)

◯ Funding or pursuing technology challenge awards (e.g., X-prize)

◯ Co-development partners with complementary technical skills, scale-up capabilities or knowledge of adjacent markets

◯ Don't know/Do not use OI

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Interactions With NNI Agencies & Centers

Q14 – Which Of The Following NNI–Funded Agencies And Groups Has Your Organization Interacted/Collaborated With For Nanotechnology Development? (This Engagement May Range From Participating On Joint Or Sponsored Research, To Serving On An Advisory Board, Or Licensing Nanotechnology, Etc). Check All That Apply.

☐ NASA

☐ NSF academic research centers (e.g., NSECs, NNINs, etc)

☐ NIH research centers (e.g., NCI, NHLBI, BRAIN, etc)

☐ Dept of Commerce (e.g., NIST user facilities)

☐ Dept of Energy (DOE) research centers (e.g., National Laboratories, user facilities)

☐ Dept of Defense (e.g., DARPA, DoD research centers or depots of the Army, Air Force, Navy, Marines, Coast Guard)

☐ U.S. EPA

☐ U.S. State Department

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Nano–Product Commercialization Timeline

Q18 – When Does Your Company/Organization Expect To Introduce Nanotechnology Products Or Processes On A Commercial Scale?

- ● Already deployed nanotechnology-based materials/products/processes

- ○ Within 1 year

- ○ Between 1 - 3 years

- ○ Between 3 - 5 years

- ○ More than 5 years to market

- ○ Multiple nanotechnology products in various stages of market introduction

- ○ My organization does not produce a nanotechnology product

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Technology Readiness Levels for Nanotechnology Products

Select one	Readiness Level	Durable Nano-Product / Process	Medical / Pharma Product Analog
○	Technology Deployed TRL 9	Actual system has operated over the full range of expected conditions	Post-marketing studies for optimization of new drug
○	TRL 8	Actual system completed and qualified through test and demonstration	FDA Approval complete
○	TRL 7	Full-scale validation in relevant environment	Phase III: Expanded clinical trials, documentation and pilot scale-up
○	TRL 6	Engineering / pilot-scale validation in relevant environment	Phase II: Experimental drug in larger clinical trials
◉	TRL 5	Laboratory scale, similar system validation in relevant environment	Phase I: Experimental drug in small clinical trials
○	TRL 4	Component and system validation in laboratory environment	Pre-Clinical Evaluation
○	TRL 3	Analytical and experimental critical function and / or proof of concept	Drug discovery and Investigational New Drug filing
○	TRL 2	Technology concept and / or application formulated	Late exploratory, molecules are formulated as drugs for preliminary testing
○	TRL 1 Basic Research	Basic principles observed and reported	Early exploratory, new molecules are discovered
○	Multiple nanotechnology products are in development at different readiness levels		
○	Don't know / Not Applicable / We do not have nanotech products under development		

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Near-Term Business Outlook

Q25 – In The Next One Year, My Organization...(Select The Top 3 Most Likely Outcomes From The Following Statements):

☐ Plans to increase employment in nanotechnology

☐ Plans to make capital outlays in nanotechnology

☐ Plans to increase workforce training in nanotechnology

☐ Plans to introduce / manufacture a nanotechnology product in a foreign market

☐ Expects *real* sales of product incorporating nanotechnology

☐ Expects to acquire, sell-out or merge

☐ Expects to go to initial public offering (IPO)

☐ May contract in size, market-share or profit

☐ May fold or shut down its nanotechnology-related activities

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EH&S Practices

Q26 – Does Your Organization Have A Documented New Product Development Process Specific To Products Incorporating Nanotechnology?

○ Yes, we have a documented process for handling nanotechnology products

○ No, we do not have a documented process for nanotechnology

○ We do not differentiate handling of nanotechnology products from conventional technologies or materials

○ Don't know / Not Applicable

Other

(state in 20 words or less)

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Q27 – For Environmental Health And Safety (EHS) And Risk Guidance On Nanotechnology Or Nanomaterials, We Primarily Access Published Resources At (Select One Or More Options):

☐ Don't Know

☐ Internal guidelines

☐ Industry guidelines/Material Safety Data Sheets

☐ Online tools / wikis / guidance

☑ U.S. EPA (e.g., Labs or Compliance Assistance Centers)

☐ NSF

☐ NIOSH, OSHA

☐ FDA, CDC, NIH

☐ European Union or OECD Guidelines

Other

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Risk Management

Q28 – What Is Your Opinion Regarding Public Disclosure / Eco–Labeling Of Nanomaterials / Nanotechnology Included In Consumer And Industrial Products (I.e., Durable Goods)? Select One Opinion.

○ Disclosure should be voluntary, OK if reporting requirements vary across states

○ Disclosure should be mandatory for consumer products but voluntary for industrial products

◉ Disclosure should be mandatory for both consumer and industrial products

○ Don't know

Other

(less than 20 words)

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Sustainability Of Nanotechnology Products

Q30 – What Are The Key Sustainability Attributes Of Your Organization's Nanotechnology-Enabled Product Or Process. Select All That Apply.

☐ Differentiated product whose net benefit far exceeds the negative impacts

☑ Developed with life-cycle (i.e., holistic) approaches to assess impacts

☐ Contains green (i.e., environmentally preferable) materials by design

☐ Contains low-cost materials

☐ Manufactured using environmentally and socially responsible practices

☐ Manufactured using clean or renewable energy sources (e.g., non-fossil-based)

☐ Recyclable, reusable or recoverable at End-of-life

☐ Reduced use of toxic components or ingredients

☐ Minimal human health risks

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Q31 – Do You Agree With The Following View? "Nanomanufacturing Is A Top-Tier Wage Provider With High Quality Jobs That Require Considerable Skill."

◉ Agree

○ Disagree

○ Don't Know / Not Sure

Previous   Next