NIST approach to Promoting US Innovation and Industrial Competitiveness

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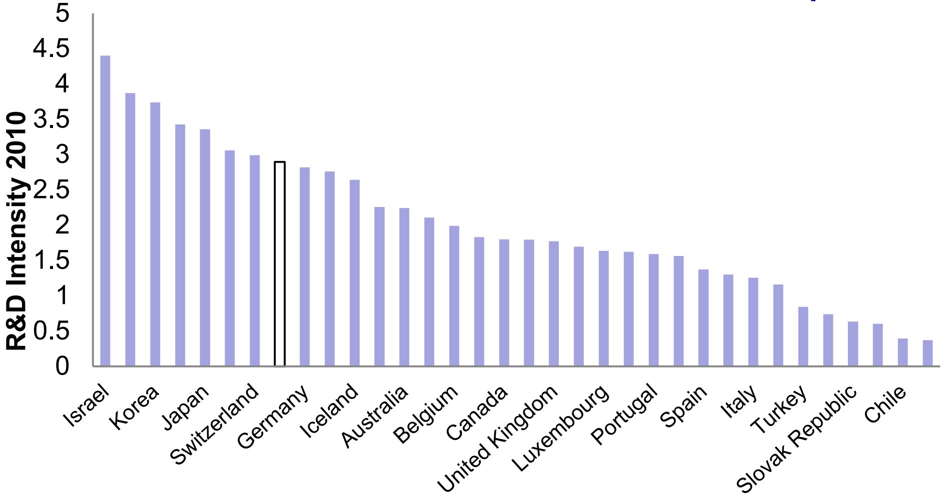
Outline

1. What is the problem?
2. Consensus building blocks
3. Status Quo (Changing?)
4. NIST and the Industrial Commons

Problem: There are disturbing trends in R&D Investment

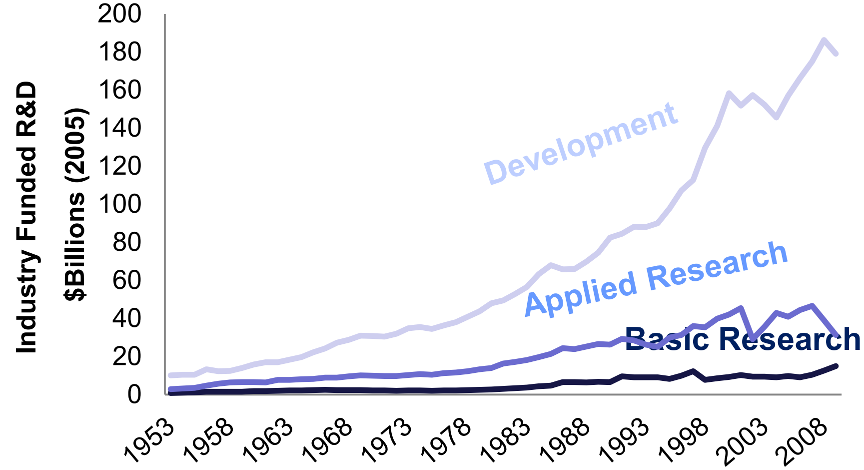
R&D intensity is lagging while R&D Composition is changing

Need: Restore international innovation leadership



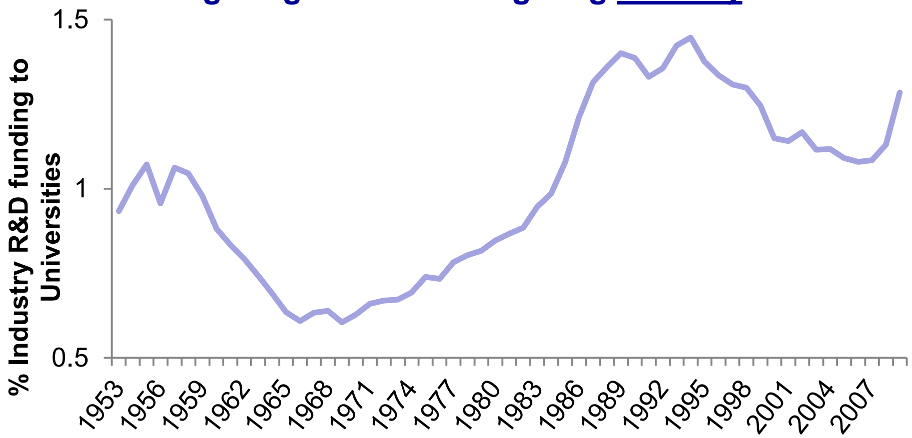
Source: OECD, Main Science and Technology Indicators

Need: Increase industry focus on breakthrough research



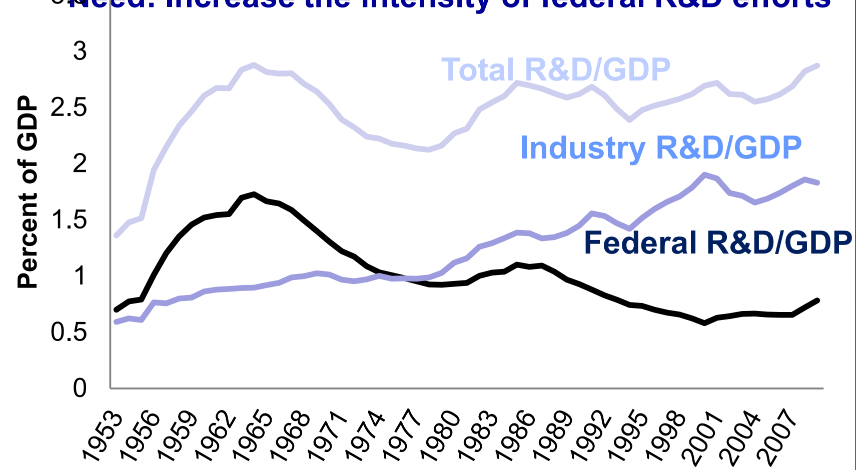
Source: National Science Foundation

Need: Long-range research targeting industry needs



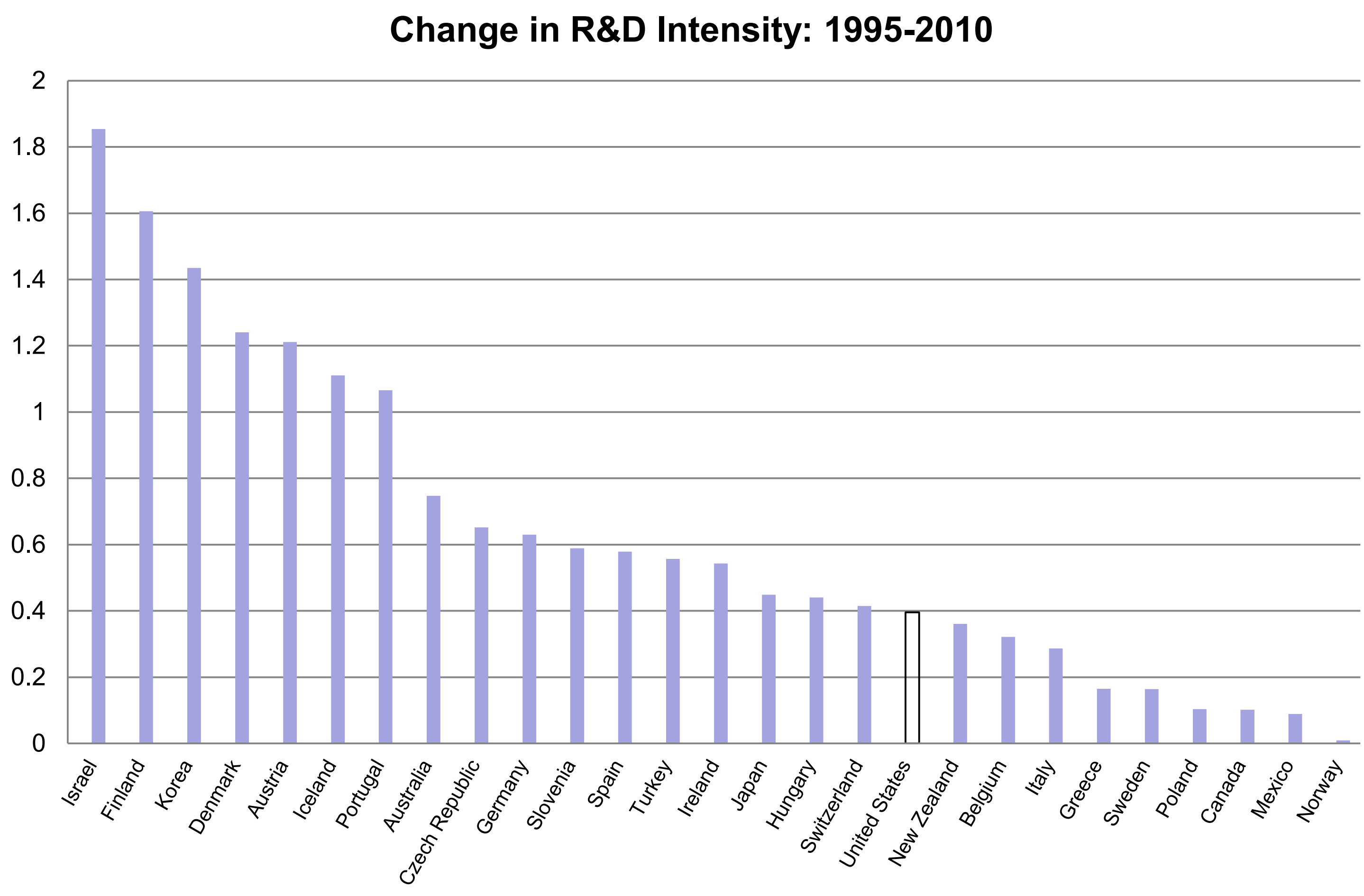
Source: National Science Foundation

Need: Increase the intensity of federal R&D efforts



Source: National Science Foundation

Problem: US position worsens when we focus on changes in R&D intensity



Source: OECD, Main Science and Technology Indicators

Consensus: R&D is a Foundation for Innovation

- Knowledge accumulation technology accounts for more than one-half of economic growth
  - Boskin and Lau (2000).
- Private and social returns to R&D are high
  - Griliches (1995), Jones and Williams (1998, 2000).
- The transition from basic research to innovation takes (a long!) time.
  - 5-8 years, Mansfield (1996), 15+ years Adams (1990), decades or more (Rosenberg (1994)).

Consensus: Location and Proximity Matter

- New manufacturing establishment increase productivity of surrounding plants
  - Greenstone et al (2010).
- Knowledge spillovers decline with distance
  - Keller (2002), Jaffe (1993), Griffith et al (2006)
- Star scientists and breakthrough research drive cluster formation.
  - Zucker et al (2002), Kerr et al (2010)

Consensus: Proximity of Research and Production

- Separating research and production increases time to market and increases innovation costs
- Hollowing out manufacturing base leads to hollowing out our innovation base
  - Tassey (2010).
- "Learning takes place as users come back with problems
  - MIT Production in the Innovation Economy
- Examples: Bell Labs (sigh); Boeing, Intel, Genentech
  - Sperling (2013)

Consensus: Goals of Federal S&T Policy

- efficiency of innovation
- increased competition in the goods market
- increased consumer surplus by introducing improved products, more types of products, and decreasing the time to introduction.

Tassey (2008) & Link and Siegel (2003)

Key Questions

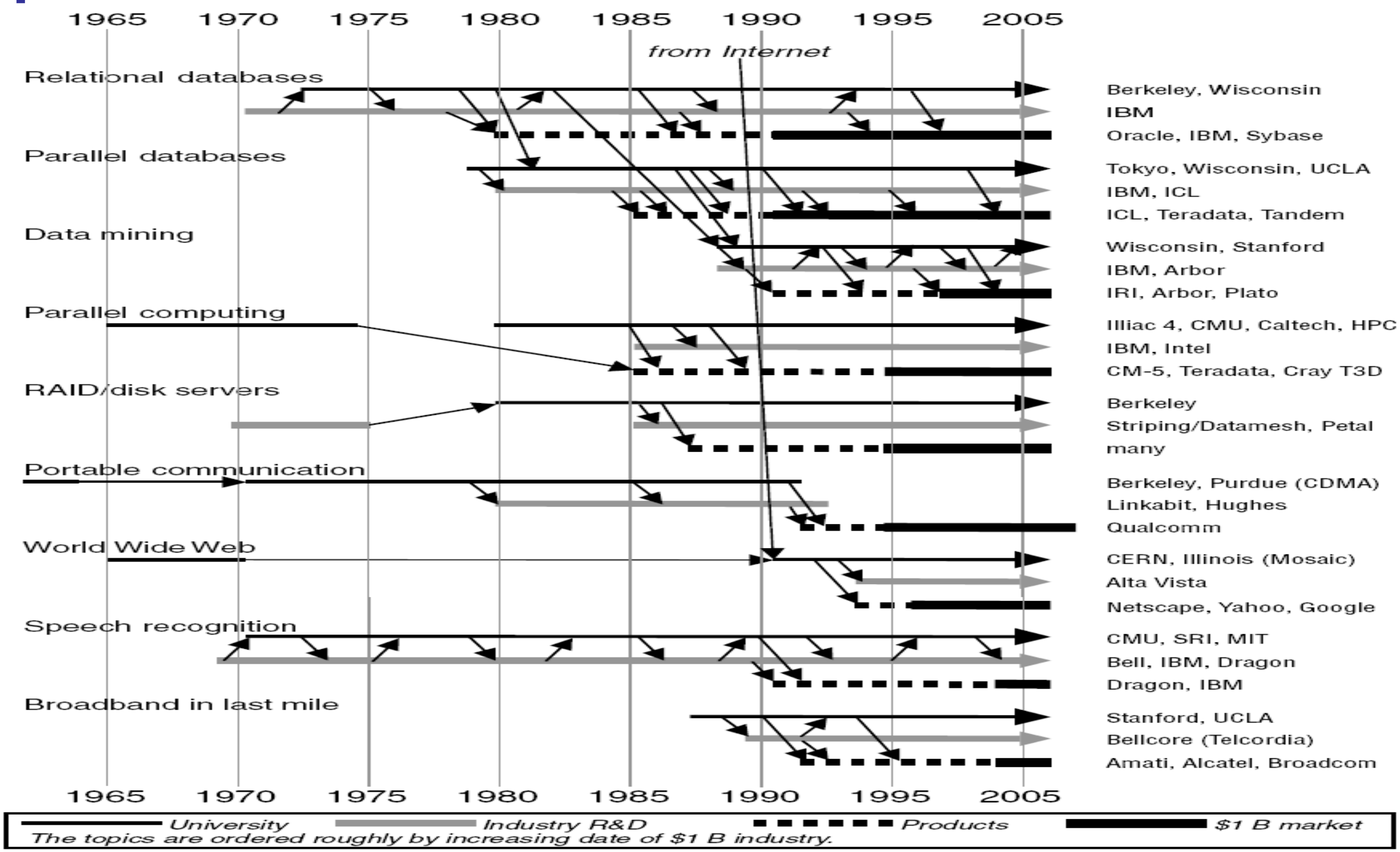
- Do we have the appropriate shared understanding of how innovation happens?
- Do we have the appropriate and institutions to support 21st century innovation?
- What steps can be taken to address the issues?

Do we have the appropriate shared understanding of how innovation works?

- Linear Model (Bush 1945)
- Black Box Model (Rosenberg (1982))
- Pasteur's Quadrant Stokes (1997) Gans and Stern
- Public private growth models (Tassey 2005, 2007).

Answer: **No**
No consensus role of government
No consensus identification of critical market failures

Do we have the "Bridging institutions" to ensure technical priorities and results move from research to production?



Source: Computer Science and Telecommunications Board, (2003)

Do we have the appropriate and institutions to support 21st century innovation?

- Federal R&D Infrastructure
  - Primarily built on strict interpretation of the Linear Model (Bush 1945)
  - Only exception to this rule is when the government is the ultimate customer and the development is seen as relevant to the agency's mission
- Private R&D Infrastructure
  - The "ability of U.S. technology corporations to sustain funding of basic research not linked to core corporate activities has been eroded (*Auerswald and Branscomb, 2005*)."

Answer: We can't go home with the institutions that got us here. We need <u>new</u> federal, state and private institutions.

What steps can be taken to address the issues?

- R&D Tax Credit
  - Weak incentives to change composition of R&D
  - Typically weak incentives to increases R&D due to incremental credit and base creep
  - Non-refundable credits offer no incentives to companies that are not yet profitable
- Federally Performed Research
  - NIST Research activities to develop new measurement capabilities to promote research efficiency, enable market adoption of innovative products, and facilitate trade in all products.
  - Mission oriented objectives may not direct research at targets appropriate to private sector innovation.
- Federally Funded Research
  - Non-Profit (university) Funding – Basic Science
  - For Profit funding
    - case studies, statistical analysis of surveys of program participants find positive impacts
    - regression analysis that includes SBIR participants and non-participants often fails to find positive impacts
- Public Private Partnerships
  - Recent progress exploring new models to engage government, university and industry researchers

What steps can be taken to address the issues?

– Develop a New Model for Public Private Partnerships

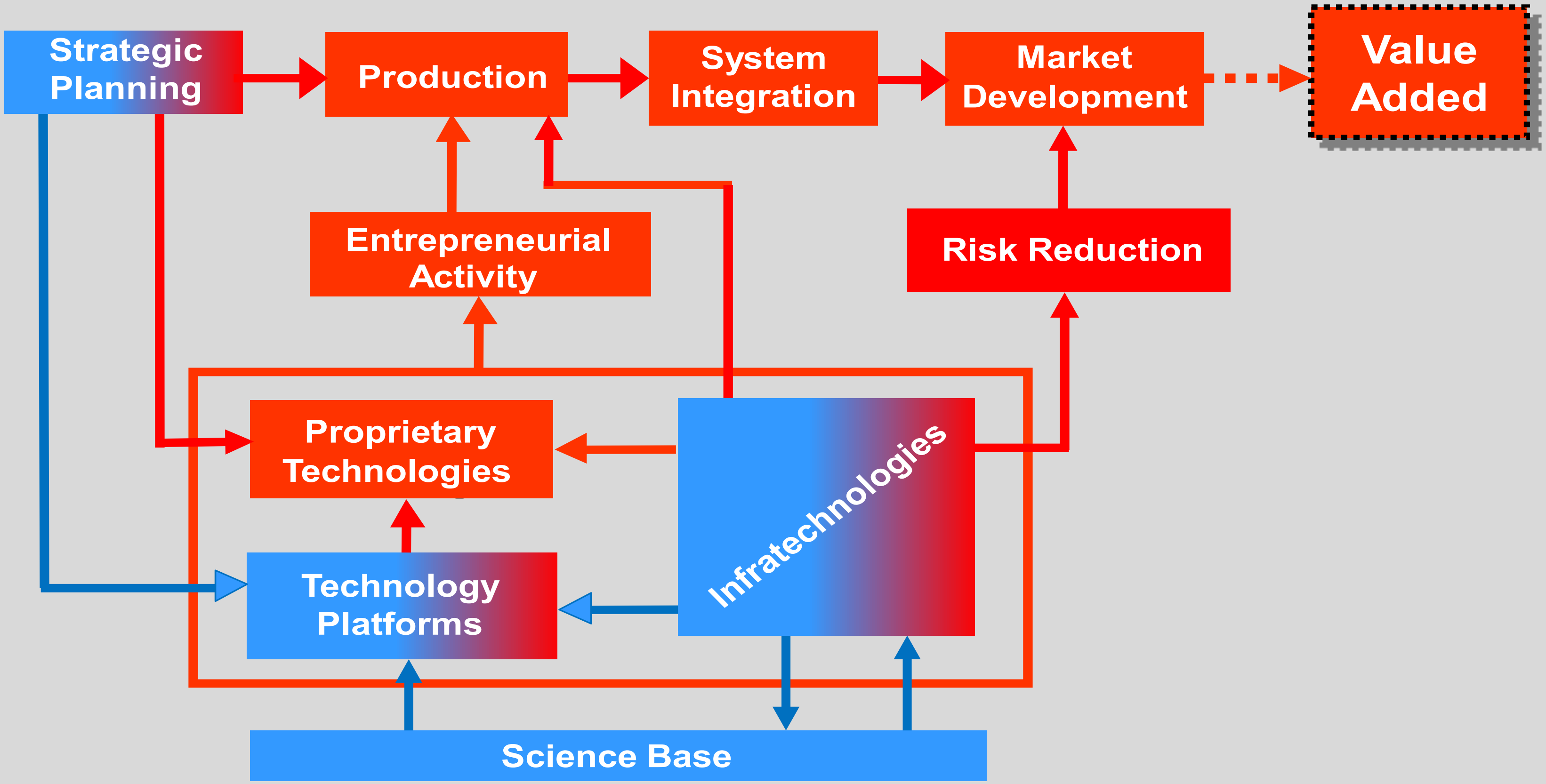
- Public private partnerships produce positive impacts
  - Federal Labs through CRADAs increase industry knowledge production and research (Adams et al (2003).
  - Industry/Government research consortia increase profitability and reduce duplicative R&D (Irwin and Klennow (1996), Link et al (1996).
  - Industry University Cooperative Research Centers increase industry patenting (Adams 2001).

What steps can be taken to address the issues?
– Develop a New Model for Public Private Partnerships

- Evaluation literature identifies factors that have limited the benefits of partnerships
  - Intellectual property
    - Hall et al. (2001), NSF (2006), every industry executive who has addressed OSTP in the past several years.
  - Research agendas and project selection
    - Feller, et al (2002), Grindley, et al (1994)
  - Transfer of Research Results
    - Grindley, et al (1994), Adams (2001)

NIST Laboratory Activities and the Industrial Commons

Technology-Element Model



Gregory Tassey, *The Technology Imperative*, 2007; and, "The Disaggregated Technology Production Function: A New Model of Corporate and University Research," *Research Policy*, 2005.

Demonstrating NIST Impact

R&D Efficiency, Manufacturing Productivity, Accelerated Innovation, Reduced Adoption Costs

Sample of Retrospective Economic Impact Studies: Outputs and Outcomes of NIST Laboratory Research			
Industry/Project	**Output**	**Outcomes**	**Measure**
Chemicals: Standards for sulfur in fossil fuels (2000)	• Measurement methods • Reference materials	• Increase R&D Efficiency • Increase productivity • Reduce transaction costs	IRR: 1,056% BCR: 113 NPV: $409M
Semiconductors: Josephson volt standard (2001)	• Measurement methods • Reference materials	• Increase R&D efficiency • Enable new markets	IRR: 877% BCR: 5 NPV: $42M
Communications: Data encryption standard (2001)	• Standard (DES) • Conformance test methods	• Accelerate new markets • Increase R&D efficiency	IRR: 270% BCR: 58–145 NPV: $345M–$1.2B
Communications: Role-based access control (2001)	• Generic technology • Reference models	• Enable new markets • Increase R&D efficiency	IRR: 29–44% BCR: 43–99 NPV: $59–138M
Energy: Gas mixture standard for regulatory compliance (2002)	• Standard (NTRM)	• Increase productivity • Reduce transaction costs	IRR: 221–228% BCR: 21–27 NPV: $49–63M
Manufacturing: Product design data standard (2002)	• Standard (STEP) • Conformance test methods/facilities	• Increase R&D efficiency • Reduce transaction costs	IRR: 32% BCR: 8 NPV: $180M
semiconductors: models and techniques for superfilling	• models and techniques for research	• Increase R&D efficiency	SRR: 79 BCR: 6 NPV: $6.4M
semiconductors: characterization data for low-k materials	• materials characterization	• Increase R&D, production, and technology adoption efficiency	SRR: -- BCR: 9 NPV: $21M
materials: combinatorial methods consortium	• combinatorial methods for polymer research	• Increase R&D efficiency and technology transfer	SRR: 161 BCR: 9 NPV: $118M

IRR=Internal (Social) Rate of Return, BCR=Benefit-Cost Ratio and NPV=Net Present Value.

Studies available at http://www.nist.gov/public_affairs/budget.htm

NIST Public/Private Partnerships as Bridging Institutions

- *National Network for Manufacturing Innovation* (*NNMI*)
  - Closing the gap between research and development (R&D) activities and the deployment of technological innovations in domestic production of goods.

- Advanced Manufacturing Technology Consortia (AMTech)
  - support new or existing industry-driven consortia to develop research plans that address high-priority challenges impeding the growth of advanced manufacturing in the United States.

NIST Office of Special Programs
NIST Energy Program

- **Vision:** *NIST is broadly recognized as an effective partner in solving the issues of measurement science and the technical bases for standards within the energy sector.*
- **Mission:** *To optimize the impact of NIST research and development in the broadly defined energy sector.*
- **Goals:**
  – *Provide information on energy research to NIST leadership*.
  – *Coordinate energy related efforts across NIST, and effectively represent NIST to external stakeholders*.

NIST Office of Special Programs
Energy Program: Biofuels

- **Measurements**
  - Developed characterization method for biofuel distillation curves
  - Extensive measurements on alternative fuel properties
- **Data**
  - Disseminate standard property models for major biofuel constituents
  - Develop surrogate fuel models for complex mixtures
- **Reference Materials**
  - Distributes standard reference materials for soy-based and animal-based biodiesel
  - Distributes reference materials for several biomass feedstocks
- **Cutting Edge Research**
  - Atomic force microscopy to examine lignin structure/genetics relationships for biofuel processing
  - Developing fundamental approach to biofuel modeling
- **Stakeholder Engagement**
  - International Conference on biofuel standards (11/2012)
  - Workshop on biocorrosion as related to biofuels (7/2013)

Backup Slides

Properties of Fuels

Energy

Need

- Alternative and renewable fuels are needed to extend and enhance petro derived fuels
- Knowledge of fuel property/processing relationships are vital to drive innovation in renewable and alternative fuels

Objectives

- Property information needed to optimally produce, blend, distribute, and use fuels
- Measure, as needed, chemical composition, stability, density, speed of sound, volatility, viscosity, thermal conductivity, etc.
- Develop property models (via surrogates) and disseminate via NIST REFPROP database.

Achievements and Impact

- Extensive measurements completed on aviation fuels from camelina, castor, cellular digestion, brown grease, and mixtures with petro stocks
- Extensive measurements completed on oxygenated diesel fuel and gasolines
- Comprehensive surrogate models for Jet-A, RP-1, RP-2, S-8, biodiesel fuel, developed and implemented in NIST REFPROP

Extensive Measurement and modeling on RP-1, and RP-2 for aerospace

Camelina as a jet fuel feedstock

Extensive measurement and modeling on numerous aviation fuels

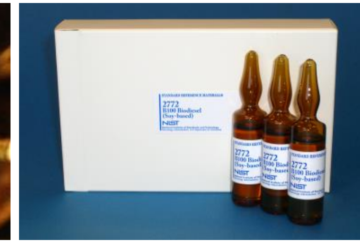
Partners and Customers include

USAF, NASA, engine and launch contractors

Development of Measurements and Standards for Biofuels

Energy

- Need
  - Measurements to assess changes in properties of biofuels associated with changing environmental conditions in combustion engines as we move toward renewable sources of energy
- Objectives
  - Development of Certified Reference Materials characterized for chemical and physical properties of importance for biofuel use and international trade
- Achievements and Impact
  - Production of two biodiesel SRMs: one soy-based and one animal-based
  - Collaboration with Brazil's National Institute of Metrology, Standardization and Industrial Quality (Inmetro) for production of two bioethanol Certified Reference Materials: one anhydrous and one hydrated
  - Collaboration with European national metrology institutes (NMIs) on development of biodiesel and bioethanol reference materials used in an interlaboratory comparison study among testing laboratories

SRM 2772 B100 Biodiesel (Soy-Based) and SRM 2773 B100 Biodiesel (Animal-Based)


Parameters Characterized in Biodiesel SRMs:
trace elements including sulfur, glycerol, glycerides, methanol, fatty acid methyl esters, water, density, kinematic viscosity, flash point, acid number, gross heating value, oxidation stability

Parameters Characterized in Bioethanol CRMs:
trace elements, acidity, density, ethanol, water, electrolytic conductivity

Customers and Partners

VSL Dutch Metrology Institute

INMETRO

irmm Institute for Reference Materials and Measurements

LGC Setting standards in analytical science

NPL National Physical Laboratory

B100 Biodiesel Standard Reference Materials

- SRM 2772 B100 Biodiesel (Soy-based) and SRM 2773 B100 Biodiesel (Animal-based)
- Certification was a collaborative effort involving NIST and the Brazilian NMI, Inmetro with each providing data for the parameters noted on the right
- In addition, SRM 2773, the animal-based biodiesel, was used in an ASTM Committee D-2 Interlaboratory Crosscheck Program for analysis of parameters of interest to the biodiesel industry. The data from the interlaboratory study is summarized in an appendix to the Certificate of Analysis for SRM 2773.
- The biodiesel industry needs reference materials to benchmark the measurements that are required on similar alternative fuels.

Parameter	NIST	Inmetro
Elements (other than sulfur)	X	X
Sulfur	X	
Glycerol and Glycerides	X	X
MeOH & EtOH	X	
Fatty acid methyl esters	X	X
Water	X	X
Density	X	X
Kinematic viscosity	X	X
Flash point		X
Acid number		X
Gross heating value		X
Oxidation stability		X
Speed of sound	X