Innovation and
US-based Manufacturing

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According to the recent National Academies report on

*Rising Above the Gathering storm, Revisited – Rapidly
Approaching Category 5,*

“Innovation commonly consists of being *first to acquire* new
knowledge through leading edge research, being *first to apply* that
knowledge to create sought-after products and services, often
through world-class engineering; and being *first to introduce* those
products and services into the marketplace through extraordinary
entrepreneurship.”
Industrial Commons


**Cycle of Innovation**

- Proof-of-Concept Prototypes
- Translational Research
- Pilot Production
- Manufacture of New products/process
- Basic Research
- Discoveries & Inventions
- Product Introduction
- Process Innovation

Without the Commons we cannot manufacture, then we lose our ability to innovate next generation products.

**Figure Q-34**

Trade balance in high-technology goods for selected regions/countries: 1995-2006 (in billions)

- EU
- Japan
- China
- United States

NOTES: See glossary for countries included in Asia-I. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

Are Discovery, Invention, Innovation, and Commercialization enough?

"If any particular manufacture was necessary, indeed, for the defense of the society it might not always be prudent to depend upon our neighbors for the supply."

- Adam Smith
Wealth of Nations 1804

Innovation is the Missing Middle

Science → Knowledge → Engineering → Manufacturing → $, ¥, €

Federal S&T ~ $70B

DOD: SBIR, 6.2, 6.3 ~ $13B

DOD - 6.4, 6.5 ~ $30B

Private $
Innovation is the Missing Middle

Technology & Manufacturing Readiness Levels (TRLs/ MRLs)

Basic Research
Applied Research
Development
Prototype & Systems Development

Billions $

Basic Research
Applied Research
Development
Prototype & Systems Development

DoD
NIST
NSF
NASA
DOE
NIH

Manufacturing: Compensation Costs vs. GDP

Global Models for Technology Innovation

Successful Models in Other Countries

<table>
<thead>
<tr>
<th>Federal $</th>
<th>German Fraunhofer Institutes</th>
<th>Taiwan’s Industrial Tech Research Inst.</th>
<th>Private $</th>
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Technology and Manufacturing Readiness Levels

Fraunhofer-Gesellschaft: Undertakes applied research of direct utility to private industry. Clustered approach with pilot production centers to close the gap between research and products.

Korea’s Industrial Core Research Projects Program

Fraunhofer-USA Center for Manufacturing Innovation and Fraunhofer-USA Center for Molecular Biotechnology

• Fraunhofer USA has developed a fully automated, scalable “factory” that uses natural green plants to efficiently produce large quantities of vaccines and therapeutics within weeks. The factory’s robotically tended, custom engineered machines plant seeds, nurture the growing plants, introduce viral vectors that direct the plant to produce target proteins and harvest the resulting biomass.

• DARPA-funded Vaccine Manufacturing Program
• Fraunhofer developed and transitioned the technology
• DARPA had the first right of refusal on IP
• Three vaccine manufacturing facilities were established in the U.S. (Indiana, Kentucky, and Texas)

Innovation and Manufacturing

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<th>Sector</th>
<th>Percent of US GDP</th>
<th>Government Investment</th>
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<tr>
<td>Health</td>
<td>14-16%</td>
<td>NIH: ~$31 billion</td>
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<tr>
<td>Energy</td>
<td>8-10%</td>
<td>DOE: ~$11 billion</td>
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<tr>
<td>Manufacturing</td>
<td>11-13%</td>
<td>Total federal investment ~ $1 billion</td>
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Are current manufacturing investments sufficient?
Are they:
  Too generic (no practical relevance)?
  Too specific (crisis management)?
  Commercially infeasible (defense-specific)?
  Too late (large downstream costs of delayed action)?

Should we invest in establishing an Industrial Commons in order to enhance manufacturing, wealth creation, & national security in the U.S.?
Addressing the Problem: Building on our Strengths

- Smart Manufacturing
  - Fuel Efficient Vehicles
  - Composites, Batteries etc.
  - Robotics
  - Etc.

Multiagency Collaboration
(NSF, DOE, DOD, NIST etc)

- Reduce overall costs to government
- Leverage strengths and resources
- DOD procurement, Federal loan guarantees
- Scaling through industry cost sharing

Establishing a Robust Manufacturing Base

Essential Elements to Create New Industries

A. Innovation - Radical Technological Innovation
   - Discoveries, Inventions, Technology Development, Scaling, Manufacturing and Commercialization

B. Early Adoption

C. Access to Capital

Essential Elements to Grow and Sustain Existing Industries

A. Technology Innovation
   - Incremental and Radical Innovations

B. Business Innovation
   - Adjacent markets and adjacent products

C. Tools and Resources
   - Skilled workforce at all levels. Tools to improve quality, mfg flexibility, reduce costs and timing

D. Low Structural Non-production Costs
   - Taxes, Regulations
OSTP-Advanced Manufacturing

Innovation for Sustainable Growth and Quality Jobs

- Create New Industries
- Public Private Partnerships
- Flexible Electronics
- Nano-Manufacturing
- Advanced Vehicle Technologies
- Robotics
- Enhance Competitiveness of Existing Industries
  - Modeling and Simulation
  - IT-Enabled Manufacturing
- Coordinate Innovation-based Manufacturing across Federal agencies
  - Inter-agency meetings
  - PCAST-Adv. Manufacturing
  - Joint Solicitations

Revitalizing American Manufacturing

The document identified seven principles to strengthen our manufacturing base and addresses various cost drivers such as labor, access to markets, regulation, taxes, technology and business practices.

- Integrating manufactured goods and information technology to create "cyber-physical systems" that have greater adaptability, autonomy, efficiency, functionality, reliability, safety and usability.

Technology Investments-2011 budget examples
- Increase in NSF, 6.1 and 6.2 budgets
- NIST-TIP to $150 million by 2015
- $12M for University-Innovation centers (NSF)
- $10M additional for nano-manufacturing
- $20M additional for NIST-TIP
- $300 million for ARPA-E

Business Investments
- Provide access to capital: DOE 1703 and 1705 loan guarantees
- Ensure access to capital for exporters
- 1603 cash grants in lieu of tax credits
- Section 48C manufacturing tax credit
- Adv. Vehicle Mfg Loan Program
FY - 2012 Budget Guidance

Excerpts from OMB/OSTP directors’ memo (July 21, 2010) to Federal agencies on Administration’s S&T priorities for the FY 2012 budget

- The memo provides program guidance for S&T activities in Executive Departments and Agencies
- The memo highlighted six challenges and areas to be strengthened in the 2012 budget – economy, health care, clean energy, climate change, ecosystem management, national defense

- Promoting sustainable economic growth and job creation
  - Support R&D in advanced manufacturing to strengthen U.S leadership in areas of robotics, cyber-physical systems, and flexible manufacturing.

- Clean Energy
  - Prioritize R&D on advanced vehicle technologies, particularly modeling and simulation of lightweight materials and their manufacturing processes, batteries, and hybrid power trains; and systems integration and demonstration of advanced vehicle platforms

Cyber Physical Systems

- IT-Enabled Manufacturing
  - Modeling and Simulation with real-time manufacturing data - Quality
  - Part Genealogy (tracking capabilities) – product safety
  - Energy efficiency of industrial processes
  - Reduction in unit cost of goods and services – flexible manufacturing
  - Broaden and accelerate use of simulation tools by Small and Medium Sized Manufacturing Enterprises (SMEs) – cloud computing platforms
  - Simulation-based Medical Device Innovation

- Robots as co-workers, co-inhabitants, co-protectors, co-explorers and co-drivers
  - Connected Vehicles
  - Health Monitoring
    - Elderly care (sensor networks)
    - Civil Infrastructure (embedded sensors, UAVs)

- Flexible Electronics
  - RFID’s, displays, medical imaging, flexible solar cells, flexible batteries, solid state lighting

- Open architecture design of automobiles
Enabling Innovation in Manufacturing
Foundational Role of Cyber Infrastructure

Reinvigorating Manufacturing through Modeling and Simulation

New computational methodologies and tools including:
- parallel algorithms, languages, and software for multi-core and cloud computing platforms.
- verification, validation, and uncertainty quantification
- Integrated Computational Science & Engineering curricula

Smart Process Manufacturing

Enables part genealogy; captures errors before they propagate, etc.
1. Data interoperability
2. Networked sensors
3. Material properties and models
4. Multi-scale dynamic modeling & simulation and large scale optimization – for real-time process control
5. Scalable, requirements-based multi-level security

Multi-physics model of blood flow through a human heart enables optimum design of an artificial heart valve

Smart Manufacturing

Dramatically intensified application of manufacturing intelligence using advanced data analytics, modeling and simulation throughout the manufacturing and supply chain enterprise.

Demand-driven use of resources and highly optimized plants and supply networks
- 80% reduction in cost
- 25% reduction in safety incidents
- 25% improvement in energy efficiency
- 10% improvement in overall operating efficiency
- 40% reduction in cycle times
- 40% reduction in water usage

Product Safety
- 10X improvement in time to market in target industries
- 25% reduction on consumer packaging

80% reduction in cost
25% reduction in safety incidents
25% improvement in energy efficiency
10% improvement in overall operating efficiency
40% reduction in cycle times
40% reduction in water usage

Taken from SM-Workshop Outcomes – Sept. 2010
Robots as Co-workers, Co-Inhabitants, Co-Protectors, Co-Explorers and Co-Divers
Innovation and Manufacturing

Bridging the Innovation Gap

• Being the world leader in scientific research is vital to our success, but is no longer sufficient to compete in the global economy.

• We must capitalize on our scientific discoveries by bridging the innovation gap between research and manufacturing to ensure economic and national security.

Revitalizing American Manufacturing

“When new technologies are developed and new industries are formed, I want them made right here in America. That’s what we’re fighting for.” - President Obama, August 16, 2010