Innovation and US-based Manufacturing

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Innovation

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."

Going...Going...Gone

Many high-tech products can no longer be manufactured in the United States because critical knowledge, skills, and suppliers of advanced materials, tools, production equipment, and components have been lost through outsourcing. Many other products are on the verge of the same fate.

Semiconductors
ALREADY LOST
"Fabless" chips
AT RISK
DRAMs
Flash memory chips

Lighting
ALREADY LOST
Compact fluorescent lighting
AT RISK
LEDs for solid-state lighting, signs, indicators, and backlights

Electronic displays
ALREADY LOST
LCDs for monitors, TVs, and handheld devices like mobile phones
Electrophoretic displays for Amazon's Kindle e-reader and electronic signs
AT RISK
Next-generation "electronic paper" displays for portable devices like e-readers, retail signs, and advertising displays

Energy storage and green energy production
ALREADY LOST
Lithium-ion, lithium polymer, and NiMH batteries for cell phones, portable consumer electronics, laptops, and power tools
Advanced rechargeable batteries (NiMH, Li-ion) for hybrid vehicles
Crystalline and polycrystalline silicon solar cells, inverters, and power semiconductors for solar panels
AT RISK
Thin-film solar cells (the newest solar-power technology)

Computing and communications
ALREADY LOST
Desktop, notebook, and netbook PCs
Low-end servers
Hard disk drives
Consumer-networking gear such as routers, access points, and home set-top boxes
AT RISK
Blade servers, midrange servers
Mobile handsets
Optical-communication components
Core network equipment

Advanced materials
ALREADY LOST
Advanced composites used in sporting goods and other consumer gear
Advanced ceramics
Integrated circuit packaging
AT RISK
Carbon composite components for aerospace and wind energy applications

Taken from Gary Pisano and Willy Shih, "Restoring American Competitiveness", Harvard Business Review, July 2009

Industrial Commons

Industrial Commons – Engineering R&D, materials, standards, tools, equipment, scalable processes, components, and manufacturing competencies in platform technologies needed to produce cost-effective, safe and reliable products. (*Pisano & Shih, "Restoring American Competitiveness", HBR, July 2009*)

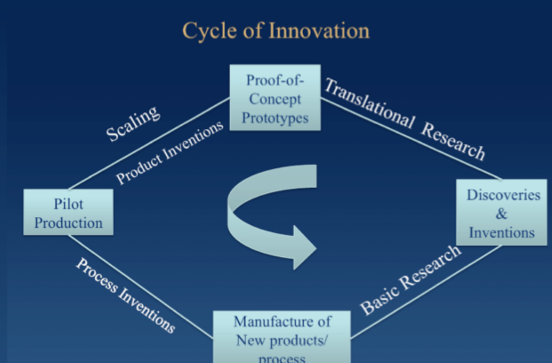
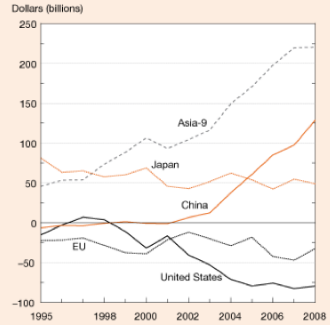


Figure O-34
Trade balance in high-technology goods for selected regions/countries: 1995–2008



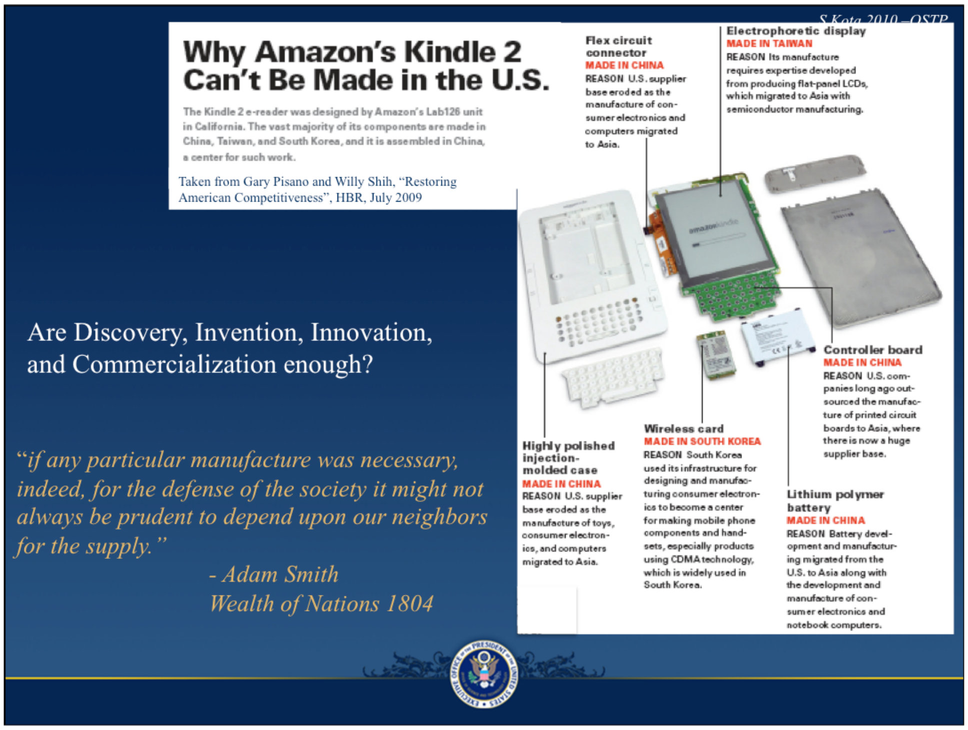
EU = European Union

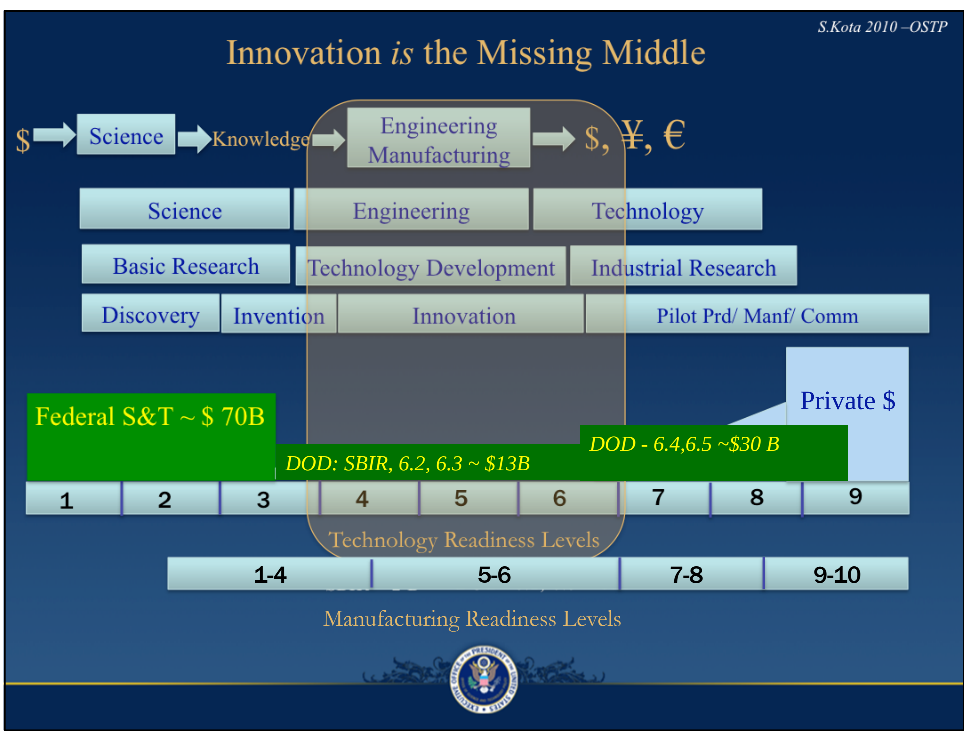
NOTES: See glossary for countries included in Asia-9. China includes Hong Kong. EU excludes Cyprus, Estonia, Latvia, Lithuania, Luxembourg, Malta, and Slovenia.

SOURCE: IHS Global Insight, World Trade Service database, special tabulations.

Science and Engineering Indicators 2010

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


S.Kota 2010 –OSTP
Why Amazon's Kindle 2 Can't Be Made in the U.S.
The Kindle 2 e-reader was designed by Amazon's Lab126 unit in California. The vast majority of its components are made in China, Taiwan, and South Korea, and it is assembled in China, a center for such work.
Taken from Gary Pisano and Willy Shih, "Restoring American Competitiveness", HBR, July 2009
Flex circuit connector
MADE IN CHINA
REASON U.S. supplier base eroded as the manufacture of consumer electronics and computers migrated to Asia.
Electrophoretic display
MADE IN TAIWAN
REASON Its manufacture requires expertise developed from producing flat-panel LCDs, which migrated to Asia with semiconductor manufacturing.
Controller board
MADE IN CHINA
REASON U.S. companies long ago outsourced the manufacture of printed circuit boards to Asia, where there is now a huge supplier base.
Highly polished injection-molded case
MADE IN CHINA
REASON U.S. supplier base eroded as the manufacture of toys, consumer electronics, and computers migrated to Asia.
Wireless card
MADE IN SOUTH KOREA
REASON South Korea used its infrastructure for designing and manufacturing consumer electronics to become a center for making mobile phone components and handsets, especially products using CDMA technology, which is widely used in South Korea.
Lithium polymer battery
MADE IN CHINA
REASON Battery development and manufacturing migrated from the U.S. to Asia along with the development and manufacture of consumer electronics and notebook computers.
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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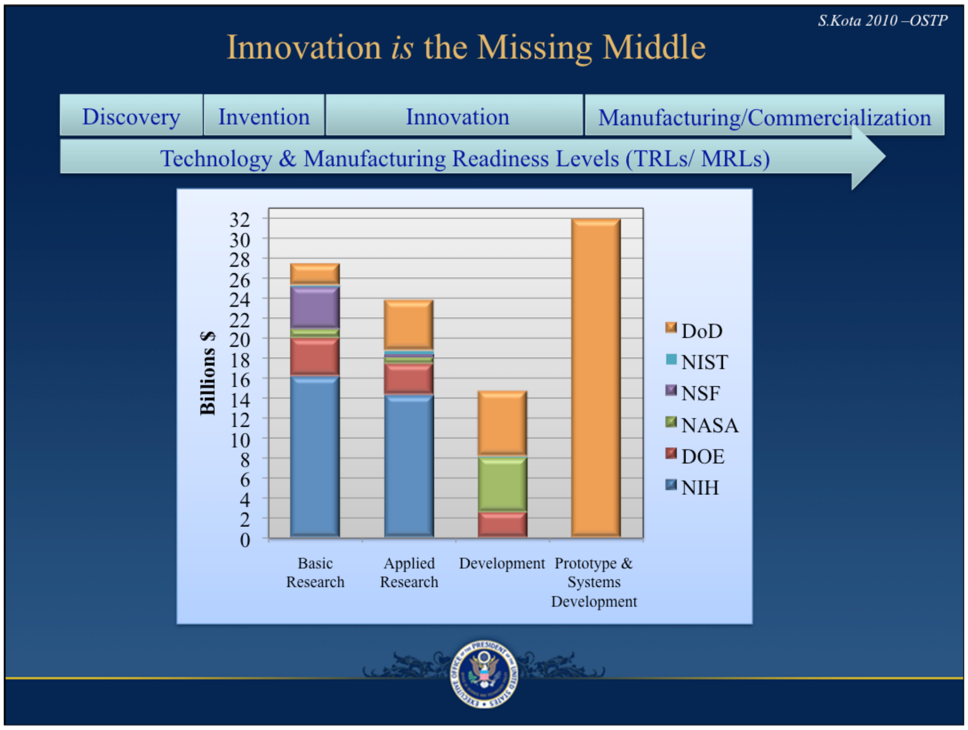
Innovation *is* the Missing Middle
$
Science
Knowledge
Engineering
Manufacturing
$, ¥, €
Science
Engineering
Technology
Basic Research
Technology Development
Industrial Research
Discovery
Invention
Innovation
Pilot Prd/ Manf/ Comm
Private $
Federal S&T ~ $ 70B
DOD: SBIR, 6.2, 6.3 ~ $13B
DOD - 6.4,6.5 ~$30 B
1
2
3
4
5
6
7
8
9
Technology Readiness Levels
1-4
5-6
7-8
9-10
Manufacturing Readiness Levels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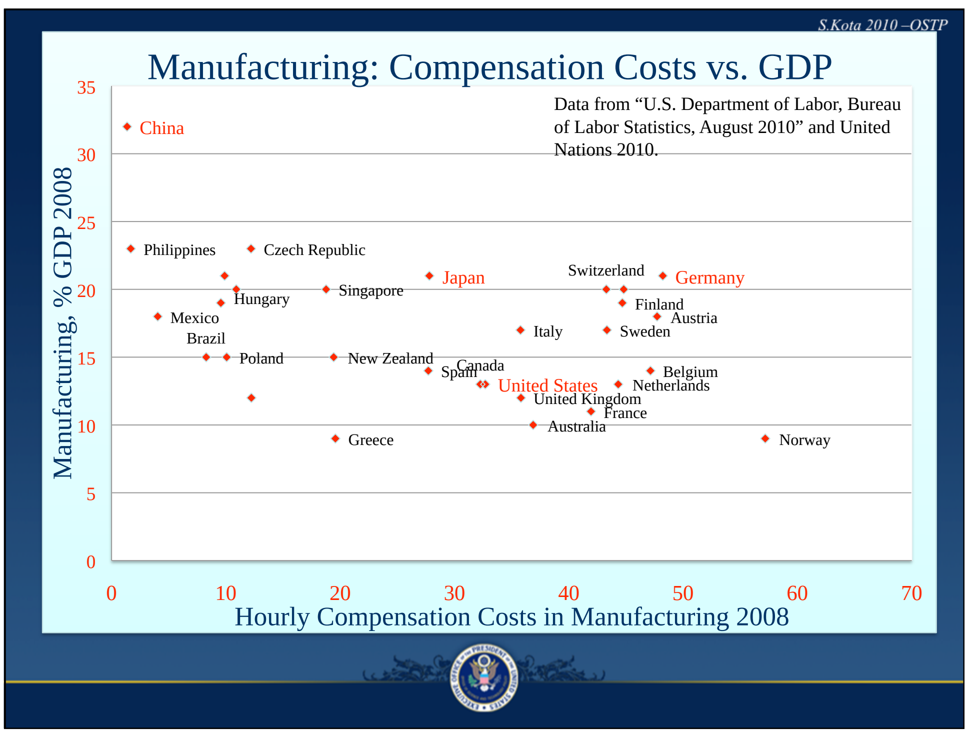
Innovation *is* the Missing Middle
Discovery
Invention
Innovation
Manufacturing/Commercialization
Technology & Manufacturing Readiness Levels (TRLs/ MRLs)
Billions $
32
30
28
26
24
22
20
18
16
14
12
10
8
6
4
2
0
Basic Research
Applied Research
Development
Prototype & Systems Development
DoD
NIST
NSF
NASA
DOE
NIH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Manufacturing: Compensation Costs vs. GDP
Data from "U.S. Department of Labor, Bureau of Labor Statistics, August 2010" and United Nations 2010.
Manufacturing, % GDP 2008
Hourly Compensation Costs in Manufacturing 2008
0
5
10
15
20
25
30
35
0
10
20
30
40
50
60
70
China
Philippines
Czech Republic
Japan
Switzerland
Germany
Hungary
Singapore
Finland
Mexico
Austria
Brazil
Italy
Sweden
Poland
New Zealand
Canada
Spain
Belgium
United States
Netherlands
United Kingdom
France
Australia
Greece
Norway

Economic Output Figures and Structural Costs

Sources: 1. Bureau of Economic Analysis; *2.* Daniel S. Hamilton and Joseph P. Quinlan, *Germany and Globalization*, 2008; *3.* NSF Science and Engineering Indicators 2010; *4.* World Development Indicators database, World Bank, 2005; *5.* Organization for Economic Cooperation and Development, Main Science and Technology Indicators, 2008; *6.* Bureau of Labor Statistics, 2010; *7.* Jeremy A. Leonard, "The Tide is Turning – An Update on Structural Cost Pressures Facing U.S. Manufacturers," Manufacturers Alliance/ MAPI and the Manufacturing Institute, November 2008.

	U.S	Germany	Japan	China	Source
Trade balance ($ B) (2007)					1, 2
• **goods**	-823	+199			
• **services**	+121	-16			
• **net**	-702	+183			
Manufacturing as % GDP -	**13**	**20.5**	21	33.4	4
Hourly Compensation of Manufacturing Workers	$32.26	$48.22	$27.80	$1.36	6
Govt. Research budget in millions of dollars: Industrial Production & Technology / Total expenditure	427/116663 (0.4%)	2267/18542 (12%)	1861/2532 (74%)		3
Share (%) of Business R&D expenditures on Manufacturing	69.6	90.0	89.9	84.6	3
R&D as % GDP	2.68	2.53	3.39		5
Raw Cost Index of Manufacturers	**$0.47**	**$0.52**	$0.30	$0.13	7
Statutory Corporate Tax Rates	**40.0**	**38.3**	40.7	25.0	7
Social Insurance Expenditures & Other Labor Taxes (% of compensation)	22.9	22.8	17.0	8.0	7
Industrial Pollution Abatement and Control Expenditures (% of value added)	6.2	6.0	5.5	2.8	7
End-User Industry Energy Costs (Index U.S. = 100)	**100.0**	**124.7**	122.8		7

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Global Models for Technology Innovation

Successful Models in Other Countries

Federal $			German Fraunhofer Institutes Taiwan's Industrial Tech Research Inst.					Private $
1	2	3	4	5	6	7	8	9

Technology and Manufacturing Readiness Levels

Fraunhofer

- 59 Institutes, 17 000 employees
- Non-profit organisation
  - ≈ 33 % basic funding by goverment
  - ≈ 33 % public funded projects
  - ≈ 33 % direct contracts by industry

- Information and Communication Technology
- Life Sciences
- Microelectronics
- Light & Surfaces
- Production
- Materials and Components - MATERIALS
- Defense and Security

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

ITRI
Industrial Technology Research Institute

- Information and Communications
- Material, Chemical and Nanotechnologies
- Biomedical Technologies
- Advanced Manufacturing and Systems
- Energy and Environment

- Total Patents: 10,132
- Start-Ups: 158

Taiwan's ITRI

ITRI is the Winner – Wall Street Journal Technology Award Sept. 2010.

Department of Defense Labs?
University Research Centers?
DOE Contractor Labs?
Non-profit institutes?
"Bell Labs"?

Korea's Industrial Core Research Projects Program

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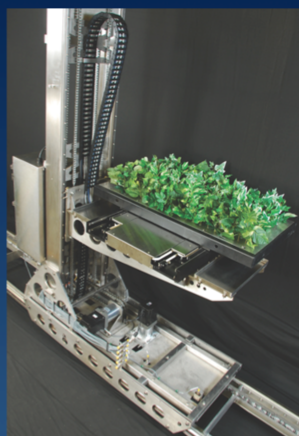
A Recent Example

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)

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Innovation and Manufacturing

Sector	Percent of US GDP	Government Investment
Health	14-16%	NIH: ~$31 billion
Energy	8-10%	DOE: ~$11 billion
Manufacturing	11-13%	Total federal investment ~ $1 billion

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. ?

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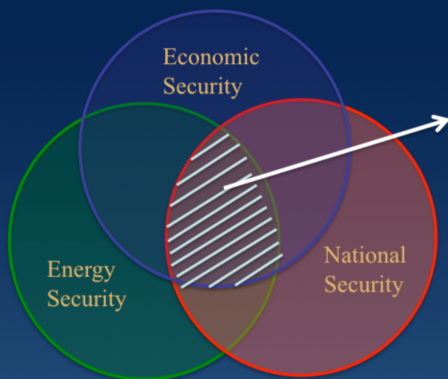
Addressing the Problem : Building on our Strengths



- 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

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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

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OSTP-Advanced Manufacturing

Innovation for Sustainable Growth and Quality Jobs

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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

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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.

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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
  - RFIDs, displays, medical imaging, flexble solar cells, flexible batteries, solid state lighting
- Open architecture design of automobiles

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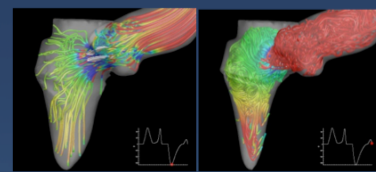
Enabling Innovation in Manufacturing

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 Sci &Engineering curricula*

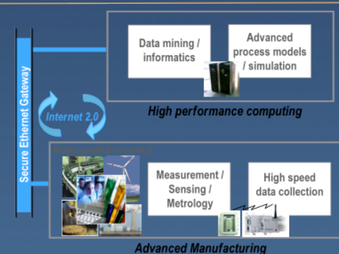


Multi-physics model of blood flow through a human heart enables optimum design of an artificial heart valve

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*



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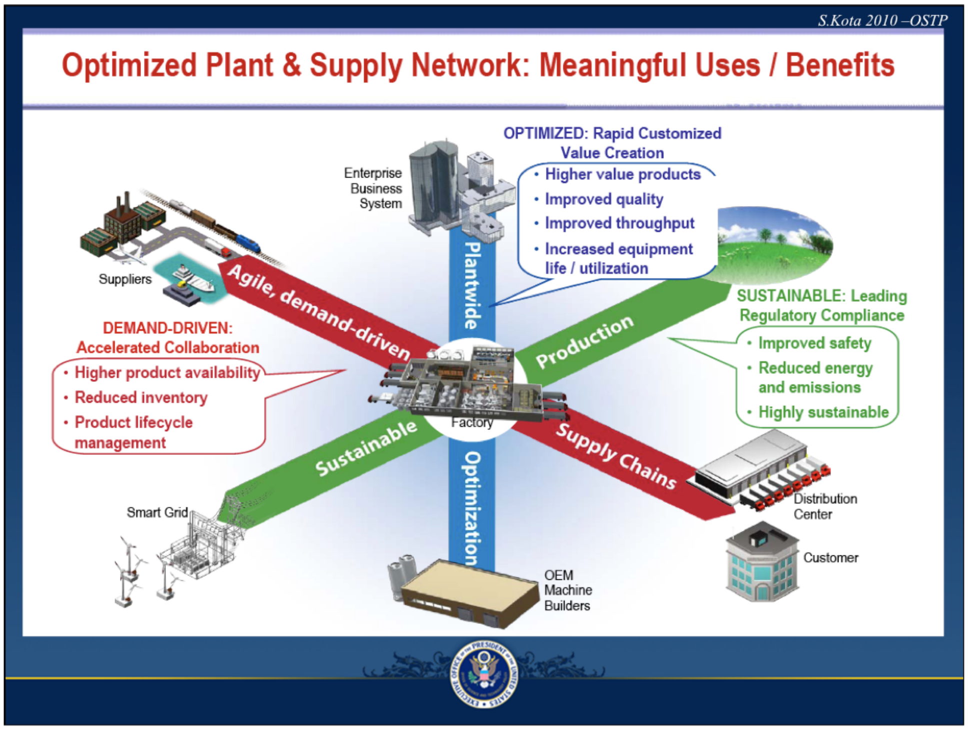
Smart Manufacturing

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

Taken from SM-Workshop Outcomes – Sept. 2010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Optimized Plant & Supply Network: Meaningful Uses / Benefits
OPTIMIZED: Rapid Customized Value Creation
• Higher value products
• Improved quality
• Improved throughput
• Increased equipment life / utilization
Enterprise Business System
Plantwide
Optimization
Suppliers
Agile, demand-driven
DEMAND-DRIVEN: Accelerated Collaboration
• Higher product availability
• Reduced inventory
• Product lifecycle management
Production
SUSTAINABLE: Leading Regulatory Compliance
• Improved safety
• Reduced energy and emissions
• Highly sustainable
Factory
Sustainable
Supply Chains
Smart Grid
Distribution Center
Customer
OEM Machine Builders


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Robots as Co-workers, Co-Inhabitants, Co-Protectors, Co-Explorers and Co-Drivers
NASA
NATIONAL INSTITUTES OF HEALTH
NIST
NSF
USDA
United States Department of Agriculture

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.

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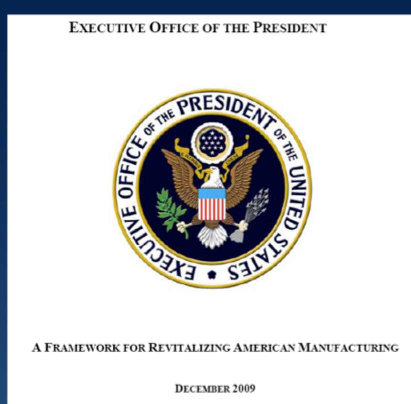
Revitalizing American Manufacturing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"When new technologies are developed and new industries are formed, I want them made right here in America. That's what we're fighting for." - President Obama, August 16, 2010