Advanced Manufacturing and Disruptive Technologies: Implications for Strategic Competitiveness

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Presentation at DHS-DOD Meeting:
Policy Implications of Digital Fabrication: 3D Printing and Beyond
Schaefer Institute, Washington, DC
July 26, 2012
Advanced Manufacturing

Slides Available: http://casi.asu.edu/)
The Strategic Environment for Technology-Based Industries

COMPETITIVENESS

- New Business Models, Networks and Alliances
- Technology Diffusion and New Global Competitors

- Disruptive Technologies
- Technology Acceleration
- Technology Convergence
- Dual-Use Technologies

• new strategic spaces/markets
• new strategic surprises/dislocations
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<tr>
<th>Agrarian</th>
<th>Industrial</th>
<th>Digital</th>
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“It from Bits”
The Proliferation of Digital Design and Fabrication

Advanced Computing and Devices
Ubiquitous Sensing/Social Networks
Biotechnology and Synthetic Biology
Complex Autonomous Systems
Disruptive Technologies

“Cyberspace”
“Connected Space”
“Bio-Space”
“Simulation Space”
“Threat Space”
“It from Bits”
The Proliferation of Digital Design and Fabrication

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Emerging and Evolving Multi-Dimensional Matrices of Knowledge Networks

Global Challenges
Systems of Innovation
**technology convergence**
- life sciences, engineering, materials, robotics, computing

**multiscale design**
- simulation and fabrication at different scales
  - macro-, meso-, nano- and Ångstrom-level design

**dramatic expansion of “design space”**
- escalating distributed degrees of (design) freedom (DDOF)
- increasingly complex autonomous systems
- combinatorial assembly of increasingly diverse materials
- self-assembly and repair: learning from biology
- synthetic biology/directed evolution and exploring ‘biospace’
Complicated Systems (Low DDOF)

- predictable performance and failure points
Complex Adaptive Systems: Increasing DDOF

- graded levels of autonomous behavior (components, systems)
- escalating challenge of predicting system behavior and state shifts
DNA as Universal Programming Language for Self-Assembly Systems: The Rise of Synthetic Biology, Directed Evolution and Bio-CAD

Design and Regulation of Gene Expression

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<tr>
<th>code</th>
<th>translation</th>
<th>protein product</th>
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Directed Evolution

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<th>molecular breeding</th>
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Directed Molecular Assembly and Materials Science

Sensors and Molecular Machines

Biomimetic Design: Organic-Inorganic Hybrids
Synthetic Biology: Bio-inspired Systems Engineering

- designed-organisms as bio-factories
- complex, multi-step syntheses, high performance materials made in completely different ways
- manufacturing at room temperature in water versus high temperatures and toxic solvents
- mimic resource efficiency of natural ecosystems
  - self-sustaining
  - limit depletion of non-renewable resources
  - limit/eliminate waste stream cost/hazard
- highly distributed manufacturing units
“It from Bits”:
Modeling and Simulation of Complex Autonomous Systems as Foundation Competencies for R&D and Advanced Manufacturing

- large scale computer simulations of complex phenomena
- big data and open source data
- systemic application of advances in cognitive neurobiology and human: machine interactions for improved design and decision making
- simulation modeling and scenario gaming for systems performance assessment and public policy options
- Investment in national digital infrastructure and new educational curricula
Advanced Manufacturing
Distribution and Democratization of the Manufacturing Base

Product Authenticity and Provenance

- source(s)
  - QA/QC, safety, performance
- counterfeit detection
  - dynamic, evolvable tags
- IP protection
- export controls
- ‘trojan horse’ detection
- dual use monitoring
- classified methods
Social Manufacturing: Democratization of Manufacturing: The Maker Movement and Mobile Multiple Markets of One

Energy Development
Public Policy Implications of Next-Generation Manufacturing Systems

- growing gap between technology frontiers and US Institutional analytical and acquisition agilities in disruptive technologies
  - academic silos and USG funding policies
  - ‘rapid’ and ‘translation’ are countercultural to much of academia/USG agencies
  - financial short-termism and risk aversion in private sector R&D
  - lax cybersecurity: espionage-exfiltration
- outdated or lack of coherent USG policies
  - sclerotic, anachronistic FAR
  - regulation, trade policy, export controls
  - IP, counterfeits and product provenance
  - international harmonization
USG Leadership in Advanced Technologies

- DOD as pioneer of new conceptual and technology advances
- integrated DoD-industrial ecosystem
- seeding of major innovation in non-defense sectors
- risk to technical: economic strategic superiority?
USG Leadership in Advanced Technologies

Network-Centric Warfare, Intelligence and Cyber-Threats

- sophisticated purchaser versus embedded systemic innovation and seeding of new industrial domains
- classified innovation domains?
USG Leadership in Advanced Technologies

Biotechnology and Molecular Medicine

- private sector innovation versus lagging USG initiatives
  - Dx, Rx, Ix, Vax
  - novel materials, sensors, biomimetic devices
  - m(mobile)Health
  - synthetic biology and new manufacturing platforms
USG Leadership in Advanced Technologies

Biodefense, Surveillance and New Counter-Measures

- poor ROI?
- mission(s) and accountability?
- poor engagement of proven industrial expertise?
- combating agent-X, rapid response capabilities and agile stockpile management?
Understanding Complexity

Building New Systems of Innovation

Boldness Must Trump Timidity
Advanced Manufacturing: A Critical Strategic Asset for US Competitiveness and National Security

“It from Bits”: Digital Design

- impact on multiple defense and civilian sectors
- technology acceleration and convergence
- rapid diffusion and ubiquity of disruptive technologies
- escalating complexity in systems design
- modeling and simulation capabilities
- verification and validation protocols for complex autonomous systems
- new economic and defense threats
- Schumpeterian winners and losers
Advanced Manufacturing: A Critical Strategic Asset for US Competitiveness and National Security

**USG actions**

- organization and funding of transdisciplinary academic research
- agency accountability for poor ROI
- FAR reform
- build defense R&D and manufacturing capabilities in emergent domains (bio-inspired technologies)
- policy voids: regulation, trade, export rules, IP, antitrust
- cybersecurity and technology espionage/exfiltration

**improve translational science**

- reverse VC and industry retreat and the Valley of Dea(r)th
- USG agency missions/competencies/accountabilities
- pre-competitive consortia ‘Apollo Projects’ to capture critical technology platforms
Ultimate Frontiers in Advanced Manufacturing

Mike Teavee and the Television Chocolate Camera

Star-Trek Teleportation

Unicorn Meat
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