Implementing A New Manufacturing Vision

Challenges, Mechanisms, Partnerships and Lessons Learned

Ben Wang | Georgia Tech
Manufacturing is a national imperative
GT thought leadership at all levels
Snapshots of grand challenges & emerging manufacturing innovations
A model for the factory of the future
Outline

- Manufacturing is a national imperative
- GT thought leadership at all levels
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- A model for the factory of the future
Why Manufacturing?

- Major wealth creator
- Effective return on investment
- Dominant innovation driver
Exports Create Wealth for the U.S.

U.S. Exports

Mfg Goods 70%

Non-Mfg 30%
Excellent Return on Investment

$1 investment in manufacturing

$2.48 economic activity
Manufacturing Drives Innovation

U.S. Patents

- Mfg Industry 90%
- Non-Mfg 10%
Since the 1980s, GDP growth has steadily slowed in many large economies.
## Innovation-driven GDP growth will be KEY - The productivity imperative -

### The global growth challenge of the next 50 years

In the past 50 years, GDP growth has been achieved equally by increasing productivity and labor, but this is changing.

<table>
<thead>
<tr>
<th>Past 50 years</th>
<th>Productivity growth 1.8% annually</th>
<th>Labor growth 1.7% annually</th>
<th>Next 50 years</th>
<th>1.8%</th>
<th>0.3%</th>
<th>Growth would be 40% slower</th>
</tr>
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</table>

Even if productivity growth continues, labor expansion will slow sharply, cutting GDP growth.

Global Growth, McKinsey January 2015
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Advanced Manufacturing Partnership

Carnegie Mellon, Georgia Tech, Michigan, MIT, Stanford, UC Berkeley

Allegheny Technologies, Caterpillar, Corning, Dow, Ford, Honeywell, Johnson & Johnson, Intel, Northrop Grumman, P&G, Stryker, UTC
There is Hope – The Inforum Model

Boosting Real Manufacturing Demand: Exports and Imports

(billions of 2005$)


The Manufacturing Resurgence, The Aspen Institute, 2013
AMP identifies 11 top cross-cutting technologies

- Advanced forming and joining technologies
- Additive manufacturing
- Advanced materials design, synthesis and processing
- Advanced manufacturing and testing equipment
- Advanced sensing, measurement and process control
- Biomanufacturing and bioinformatics
- Flexible electronics manufacturing
- Industrial robotics
- Nanomanufacturing
- Sustainable manufacturing
- Visualization, informatics, and digital manufacturing technologies
# MANUFACTURING USA INSTITUTES

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<tbody>
<tr>
<td>DoD USAF/AFRL</td>
<td>$50M ($30M)</td>
<td>America Makes (NCDMM*)</td>
<td>Industry 50 Univ. 28 Other 16</td>
<td>Additive Mfg.</td>
<td>50 yr. Funding</td>
<td>$70M</td>
<td>$70</td>
<td>$70M</td>
<td>$70m</td>
<td>$100M</td>
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<tr>
<td>DoD ARMY/NAVY/AMRDEC</td>
<td>$39M 1.3 : 1</td>
<td>Digital Manufacturing and Design Institute (UI Labs*)</td>
<td>Industry 41 Univ. 23 Other 9</td>
<td>Digital “Thread”</td>
<td>Industry 41 Univ. 23 Other 9</td>
<td>$106M 1.51 : 1</td>
<td>$78m 1.11 : 1</td>
<td>$180M 2.57 : 1</td>
<td>$70m 1:1</td>
<td>$350M 3.5 : 1</td>
<td>$75M 1.28 : 1</td>
<td>2.5:1</td>
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<tr>
<td>DoD/NAVY/ONR</td>
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<td>Light Weight Innovations for Tomorrow (EWI*)</td>
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<td>Lt. Wt. Metallics</td>
<td>Industry 35 Univ. 17 Other 25</td>
<td>$70M</td>
<td>$70</td>
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<td>$70m</td>
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<tr>
<td>DOD Adv. Mfg. Office</td>
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<td>Institute for Advanced Composites Manuf Institute (UTK*)</td>
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<td>Low Cost FRP Composites</td>
<td>Industry 41 Univ. 23 Other 9</td>
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<td>DOE Adv. Mfg. Office</td>
<td>$70M</td>
<td>Power America (NCState*)</td>
<td>Industry 18 Univ. 7 Other</td>
<td>WBG Power Elec</td>
<td>Industry 18 Univ. 7 Other</td>
<td>$106M 1.51 : 1</td>
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<tr>
<td>DoD AFRL</td>
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<td>AIM Photonics (Research Foundation SUNY*)</td>
<td>Industry 27 Univ. 16 Other 22</td>
<td>Integrated Photonics</td>
<td>Industry 27 Univ. 16 Other 22</td>
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<td>2.5:1</td>
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<tr>
<td>DoD/USAF/AFRL</td>
<td>$100M</td>
<td>NextFlex (FlexTech Alliance*)</td>
<td>Industry 14 Univ. 12 Other 6</td>
<td>Flexible Electronics</td>
<td>Industry 14 Univ. 12 Other 6</td>
<td>$106M 1.51 : 1</td>
<td>$78m 1.11 : 1</td>
<td>$180M 2.57 : 1</td>
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<td>$75M 1.28 : 1</td>
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<tr>
<td>DoD/Army NSRDC</td>
<td>$75M</td>
<td>Advanced Functional Fabrics of America (MIT*)</td>
<td>Industry 16 Univ. 31 Other 72</td>
<td>Technical Fabrics /Garments</td>
<td>Industry 16 Univ. 31 Other 72</td>
<td>$106M 1.51 : 1</td>
<td>$78m 1.11 : 1</td>
<td>$180M 2.57 : 1</td>
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<th></th>
<th>Advanced Tissue Bio-Fabrication</th>
<th>Smart Manufacturing</th>
<th>Collaborative Robotics</th>
<th>NIST Open Call</th>
<th>Process Intensification</th>
<th>Sustainability / Reuse</th>
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</thead>
<tbody>
<tr>
<td><strong>Federal 5 Year Funding</strong></td>
<td>$80m</td>
<td>$70m</td>
<td>$80m</td>
<td>$70M</td>
<td>$70m</td>
<td>$70M</td>
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<tr>
<td><strong>Industry Match</strong></td>
<td>$214M 2.7:1</td>
<td>$140M 2:1</td>
<td>$173M 2.2:1</td>
<td>$129M 1.8:1</td>
<td>$2m in-kind</td>
<td>$70M 1:1</td>
</tr>
<tr>
<td><strong>Institute Lead: NFP</strong>*</td>
<td>Advanced Regenerative Manuf. Inst (ARMI*)</td>
<td>Smart Manufacturing Leadership Coalition (SMILC*)</td>
<td>Advanced Robotics Manufacturing (Carnegie Mellon*)</td>
<td>National Institute for Innovations in Manufacturing of Biopharma (U Del*)</td>
<td>Rapid Adv. in Process Intensification Deployment (AICHE*)</td>
<td>Sustainable Manufacturing Innovation Alliance (SAII*)</td>
</tr>
<tr>
<td><strong>Collaborators</strong></td>
<td>Industry: 47, University: 26, Other: 14</td>
<td>Industry: TBD, University: TBD, Other: TBD</td>
<td>Industry: 123, University: 40, Other: 64</td>
<td>Industry: 85, University: 35, Other: 20</td>
<td>Industry: University: Other: 130 partners</td>
<td>Industry: University: Other: 100 partners</td>
</tr>
<tr>
<td><strong>Technology Focus Area</strong></td>
<td>Regenerative Medicine; Tissue Fab</td>
<td>Integrated Sensor, Control, and Platform Modeling</td>
<td>Collaborative Robotics, Robot Control, Sensing</td>
<td>Precision Medicine, accelerated biopharma manuf, standards dev</td>
<td>Modular chemical process intensification</td>
<td>Recycling and Remanufacture Separation of mixed mat, disposal meth.</td>
</tr>
<tr>
<td><strong>Lead Gov. Agency</strong></td>
<td>DoD</td>
<td>DoE</td>
<td>DoD</td>
<td>NIST</td>
<td>DoE</td>
<td>NIST</td>
</tr>
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</table>
GT Major Decision Affecting Manufacturing

1991: State of Georgia created Manufacturing Research Center (MaRC) at Georgia Tech

- Through a successful private-public partnership
- 20+ years of proven leadership and contribution in industrial, manufacturing and materials engineering
The Strategic Framework for GTMI

**Engage – Leverage – Accelerate**

- **GT schools & colleges**
- **GTRI**
- **GTMI’s excellence in mfg research**

**Missing middle Valley of death**

- **Sector Products Requirements Validation Market pull**

**Competencies**

1. **Intellectual leadership**
   - basic research
2. **Translational leadership**
   - accelerated campus-wide synergy & interdisciplinary readiness
3. **Deployment leadership**
   - commercialize innovative products & services with industry partners

**Business case initiated**

**Business case validated**
(Tipping point for industry partners)

**Ei2**
**GaMEP**
**GDEcD/COI-M**
**TCSG**
Prestigious Boeing Supplier of the Year Award

Academia

Georgia Institute of Technology
Recent Visitors

*Impact on national policy decisions!*
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3D printing applies to many sectors

Aerospace
Automotive
Repair & Maintenance
Medical
3D printing medical solution workflow

Engagement of medical doctors and staff at every step
Uneven shoulders
Curve in spine
Uneven hips
Spine Curvature Disorders
Designing Patient Matched Surgical Guides and Pre-op Simulations
Successful Clinical Cases
What we do now is primitive compared to what it can be and should be
Cancer Immunology and Immunotherapy

Inside the brutally selective, hugely expensive, lifesaving trials of immunotherapy.

By Alice Park
Currently incurable diseases: neurological, cardiovascular, inflammatory,…

New tools and platforms for diagnostics, drug discovery, tissue repairs,…

Aging population

Cost of healthcare & economic impact
Production Scale-up

10,000 – 50,000 cells

1,000,000,000+ cells
3.4 defects in 1,000,000 cells → 34,000 bad cells in each treatment NOT ACCEPTABLE
Product Cost

- Way too expensive ~ $100,000 per dose
- High production cost due to low yield
- Some cells take months to grow
- S&H sometimes costs more than production

Target cost per dose: $1,000-$5,000
Cell Manufacturing Consortium

NIST
National Institute of Standards and Technology

AMTECH
Advanced Manufacturing Technology Consortium

Competitive Planning Grants to:
establish and strengthen industry-focused research consortia,
develop shared vision technology roadmaps of industry's needs.

... aims to position the United States as the leading developer of cell-manufacturing technologies and the chief authority on cell manufacturing standards, worldwide.

Georgia Research Alliance

Aruna Biomedical, Celgene Cellular Therapeutics, Cellular Dynamics International, Georgia Inst of Technology, North Carolina State Univ, RoosterBio, Univ of California Berkeley, Univ of Georgia, Univ of Wisconsin
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The image depicts a scene from a cartoon featuring Homer Simpson and other characters. In the background, there are robotic droids labeled with numbers such as M16, N28, S12, and K11. The droids are followed by black dogs with menacing expressions. The setting appears to be an indoor environment with arched doors and a high ceiling. The characters are looking surprised or concerned, indicating a sense of foreboding or danger.
Hybrid Manufacturing System
Challenges of implementing new manufacturing technologies

- Re-defining “manufacturing”
- Interfaces
- Standards
- Cybersecurity
- Supply chain innovation (small & medium sized enterprises, SMEs)
- Monetizing investment in new manufacturing technologies
- Workforce training & education
Concluding Remarks

Manufacturing of the future is innovation-rich, value-driven focusing on high value-added sectors.

Convergence of advanced manufacturing and high-value service requires new business models and global partnerships.

Green (sustainable) manufacturing is the only way to harmonize economic growth with the environment and society.

Georgia Tech is a global leader in advanced manufacturing and innovative materials.

Georgia Tech has a robust pipeline of manufacturing and materials technologies for the global market.
Georgia Tech Manufacturing Institute catalyzes and accelerates transition of advanced technology from research lab to market