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Manufacturing R&D in China

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The University of Michigan, Ann Arbor
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also
Dean, University of Michigan-Shanghai Jiao Tong University Joint Institute, China
1. Introduction and SWOT Analysis of China’s Manufacturing Industry

2. Chinese Manufacturing R&D Strategies

3. Priority Areas

4. Sample Projects

4. Conclusion

Manufacturing R&D in China
Fun Facts about China

- Population: ~ 1.3 billion (a Big multiplier)
- Rapid urbanization (800 million farmers reduced to 700 millions in 15 years and will continue to decline)
- Labor force - 795.3 million
- Unemployment rate - 4.3% (official) vs 13% (unofficial)
- More people in China are studying English than those in USA.
- Chinese lunar calendar - the oldest known calendar (This year is 4707)
- Archaeological evidence indicates Chinese grew rice as early as 5000 BC
- Greatest Ancient Inventions
  - Compass (1040-44 AD in Song dynasty)
  - Gun Powder (1040 AD in Song dynasty)
  - Paper-making (105 AD in Han dynasty)
  - Printing (220 AD in Han dynasty)
Key Statistics

- Annual production of degreed engineers over 1.6 millions
  - 0.6 million from 4-yr programs and
  - 1 million from 3-yr programs
- Manufacturing accounts for 48% of China’s GDP (2007 data)
- Manufacturing employs 11% of total workforce and 90% of industrial workforce
- China became the third largest nation in total manufacturing output following US and Japan
- China became the largest automotive market in the world
Other Ancient Inventions

- **Abacus** (first appearance: Mesopotamia, 2400 BC. First certain appearance in China: 12th century AD)
- **Armillary sphere** (invented by the Greek Eratosthenes), with the world's first water-powered armillary sphere by Zhang Heng.
- Various automata
- Bellows
- Battens in sails and cloth
- Belt drive
- Blast furnace
- Bituminous coke for the iron and steel industry
- Camera obscura
- Canal Lock
- Cannon
- Cast iron
- Chain drive
- Chain pumps
- Chinese calendar
- Chopsticks
- Collapsible Umbrella
- Crossbow
- Dry dock
- Differential gear
- Crossbow (repeating)
- Early explosive grenades
- Escapement mechanism for clocks
- Exploding cannonball
- The Flamethrower
- Flash lock
- Fire Arrow
- Firearm
- Fireworks
- Horse collar
- Hull compartments/bulkheads
- Indian ink
- Kite
- Land mines
- Lottery
Other Ancient Inventions

- Menus for Song-era restaurants
- Naval mines
- Noodle
- Odometer (also by Archimedes and Heron of Alexandria)
- Paddle wheel, for boats
- Paper money
- Parachutes
- Pendulum (Zhang Heng)
- Pontoon bridge
- Porcelain
- Postal system
- Pound lock
- Rice
- Rockets: Fire Arrow, Multistage rocket
- Rudder
- Sailing carriage
- Saw
- Scissors
- Seismometer (of Zhang Heng)
- Silk
- Sluice gates
- Segmental Arch Bridge
- Star catalogue
- Steel
- Stirrup
- Suspension bridge
- Tea
- Toothbrush
- Toilet paper
- Traditional Chinese medicine
- Trebuchet (traction)
- Trip hammer
- Vaccination
- Water clock
- Waterwheel (also of the Greco-Roman tradition)
- Wigs
- Wheelbarrow
- Windmill
- Winnowing machine
China’s Manufacturing

• “Made in China” products can be seen everywhere.

• Superficially, China is becoming a world productivity center.

• But, China is currently a “Manu-factory”, not a manufacturing powerhouse yet.
## Global Dominance in Industrial/Consumer Products

<table>
<thead>
<tr>
<th>Product</th>
<th>Quantity</th>
<th>Market Share</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV</td>
<td>39 million</td>
<td>29%</td>
</tr>
<tr>
<td>Washing Machines</td>
<td>14.4 million</td>
<td>24%</td>
</tr>
<tr>
<td>Refrigerators</td>
<td>12.8 million</td>
<td>16%</td>
</tr>
<tr>
<td>Air Conditioners</td>
<td>18.3 million</td>
<td>30%</td>
</tr>
<tr>
<td>Electric Fans</td>
<td>76.6 million</td>
<td>50%</td>
</tr>
<tr>
<td>Cameras</td>
<td>55.1 million</td>
<td>50%</td>
</tr>
<tr>
<td>Microwave Oven</td>
<td>12.6 million</td>
<td>30%</td>
</tr>
<tr>
<td>Electric Cooker</td>
<td>13.6 million</td>
<td></td>
</tr>
<tr>
<td>Vacuum Cleaners</td>
<td>10.1 million</td>
<td></td>
</tr>
<tr>
<td>Kitchen Exhaust Fans</td>
<td>3.7 million</td>
<td></td>
</tr>
<tr>
<td>Recorders</td>
<td>240 million</td>
<td>70%</td>
</tr>
<tr>
<td>VCD</td>
<td>20 million</td>
<td>70%</td>
</tr>
<tr>
<td>Telephones</td>
<td>96 million</td>
<td>50%</td>
</tr>
<tr>
<td>Monitors</td>
<td>45.9 million</td>
<td>42%</td>
</tr>
<tr>
<td>Watches</td>
<td>1.5 billion</td>
<td>75%</td>
</tr>
<tr>
<td>Micromotors</td>
<td>3 billion</td>
<td>60%</td>
</tr>
<tr>
<td>Batteries</td>
<td>17 billion</td>
<td>40%</td>
</tr>
<tr>
<td>Telecom Switches</td>
<td>30 million</td>
<td></td>
</tr>
<tr>
<td>Bicycles</td>
<td>42.7 million</td>
<td>40%</td>
</tr>
<tr>
<td>Motorcycles</td>
<td>11.5 million</td>
<td>44%</td>
</tr>
<tr>
<td>Syn Diamonds</td>
<td>1 billion carats</td>
<td>60%</td>
</tr>
<tr>
<td>Rare Earth Magnets</td>
<td>5360 Tons</td>
<td>43%</td>
</tr>
<tr>
<td>Sewing Machines</td>
<td>8.7 million</td>
<td>50%</td>
</tr>
<tr>
<td>Tractors</td>
<td>2.1 million</td>
<td>83%</td>
</tr>
<tr>
<td>Solar Waterheaters</td>
<td>6 million sq. meters</td>
<td></td>
</tr>
<tr>
<td>Shipping Containers</td>
<td>1.5 million</td>
<td>83%</td>
</tr>
</tbody>
</table>
Wants and Needs

• Most Chinese manufacturers want to move up in the manufacturing value chain.
• They also want to be the innovators of high-value added products.

But,
• Chinese manufacturers need first to establish their manufacturing core competence.
• They need to fully understand the know-hows, know-whys and be able to move beyond.
Manufacturing R&D in China

- Large number of highly trained workforce
- Resources
- Market
- Dividend from old planned economy
- Strong government support for R&D investment
- Large number of small-medium enterprises (SMEs)
- Entrepreneurship

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Manufacturing R&D in China
SWOT Analysis for Chinese Mfg Industry

(W-Weakness):

• Lack of key process knowledge base, technical know-how and know-why
• Lack of key equipment design and manufacturing capability
• Lack of system design and integration capability
• Most products are low value-added
• Weak in high-technical product innovation and development
SWOT Analysis for Chinese Mfg Industry

(O-Opportunity):

- Strong FDI in China
- Bonus of Globalization -> MNCs move production facilities to China
- Emergence of global R&D centers in China
- Significant market share in many products
- Competitive workforce
- Opportunity for global alliance

Manufacturing R&D in China
SWOT Analysis for Chinese Mfg Industry

(T-Threat):

• Complacency.
• When trade barriers are taken down, business/investment environment could change like water falls.
• Without China’s own IP & key technical know-how and know-why, production facility could be moved easily to somewhere else.
• Manufacturing rise and fall can occur relatively quickly (exchange rate, FDI, new technology invention, social instability, etc.).
Challenges to Chinese Economy

• Political and social stability
• Continuing reforms in financial institutions and state owned enterprises (SOE)
• High unemployment
• Increased inequality between coastal and in-land regions
• Inflation
• Housing bubbles
• Weak world economy slows down exports
• Currency
Opportunity for U.S. Companies

• Double-digit growth in auto market
• Global manufacturing center
  – Low labor and operational costs
  – Abundant labor and skilled resources
• Global purchase center
  – Competitive price
  – Quality products
• R&D center
  – Large annual production of engineering graduates
• Emerging service sectors:
  – Financing, legal, trading, marketing, I.T., engineering, testing, after-market, education etc.
Competitive Strength/Weakness

• R&D Personnel (per 10,000 population)
  – China (83)
  – US (476)

• Total R&D Personnel
  – China (10.5 million)
  – US (13 million)

• R&D in China’s Manufacturing
  – Mfg R&D accounts for 82.8% of total industrial R&D personnel
  – 50% of industrial R&D expenditure is in mfg (45.3 billion RMB)

• Education
  – On-campus students (1 million graduate students, 16 million 4-year college students, and 15 million 2~3 year technical college students)
  – 64% of college students are in science and engineering
Green Race: U.S. Strength and Weakness

• **Strength:**
  – Profound knowledge base and technical foundation in automotive engineering and manufacturing
  – High concentration of automotive R&D talents, particularly in Michigan
  – Strong fundamental research and innovations in universities
  – Government investment in clean energy technologies

• **Weakness**
  – Lack of supply chains for critical systems, such as battery
  – Inefficiency in establishing new public policies to promote the early adoption of advanced technologies, such as clean energy and clean vehicle technologies
Green Race: China’s Strength and Weakness

• Strength
  – Significant government support for clean vehicle technologies to make up for their lagging in conventional IC automotive technologies
  – Efficiency in government to establish incentives for adopting new clean vehicle technologies
  – Mass production capability to make products cheaply
  – Strong applied research at universities
  – Abundant labor and skilled resources

• Weakness
  – Lack of vehicle engineering and system integration capability
  – Weak in system-level design and optimization
  – Lack of skills to compete in global markets
By the end of 2009, China has achieved the following stunning new energy developments:

• Hydro-electrical power generation: 197 GW (#1 in the world)
• Wind power generation: 22 GW (#3 in the world)
• Nuclear power generation: 9.17 GW from 11 power stations
  – 30 newly approved power stations: 32.7 GW
  – 23 power stations under construction (#1 in the world)
• Solar water heating capacity (#1 in the world)
• PV solar cell production: 4 GW/yr (#1 in the world, 40% worldwide production)
• Biomass electrical generation: 4.5 GW
Green Race: Opportunities for Collaboration

• Complementary strengths in clean vehicle technologies
  – U.S. innovations, system engineering and integration
  – Chinese productions, battery technologies and supply chains

• U.S. and Chinese auto markets are big enough for both countries to win.

• It might be easier for certain regions in China to be early adopter of clean vehicle technologies, which could serve as a pilot ground for wide adoption back in U.S.
Joint U.S.-China Consortium on Clean Vehicles

- U.S. and China have signed bilateral governmental agreement to promote research collaborations in clean energy (building, coal, and vehicles).
- The University of Michigan has formed a large clean vehicle research consortium consisting of several leading US universities, national labs and key automotive OEMs and suppliers, as well as key Chinese universities and companies.
- This Consortium will address technical areas of (i) biofuels and clean combustion, (ii) vehicle electrification, (iii) energy storage and harvesting, (iv) lightweight structures, and (v) system integration and demonstration.
China’s Manufacturing R&D Strategies
China’s Manufacturing R&D Strategies

- National R&D Roadmap through a national long and medium range (5 to 15 years) planning exercise
- Curiosity-driven research supported by National Natural Science Foundation of China
- State key development projects funded by Ministry of Science and Technology’s 863 programs
- Basic key research projects funded by Ministry of Science and Technology’s 973 programs
- More emphasis on original innovations
- Encouragement of industry and university collaborations
- Incentives for setting up multinational R&D centers
Growth of NSFC Funding

Manufacturing R&D in China
16 National Priority S&T Initiatives (1 Trillion RMB)

- Core Electronic Components
- High-end Chips and Fundamental Software
- Manufacturing Technologies and Equipment for VLSI
- High-end CNC Equipment and Fundamental Manufacturing Technologies
- New Generation Mobile Communication
- Development of Large Scale Oilfields and Gas Extraction in Coal Mines
- Advanced Nuclear Power Plant Core Technologies
- Water Pollution Control and Treatment
- Genetically Modified Crop Cultivation
- New Drug Discovery
- AIDS and Other Infectious Diseases Prevention and Control
- Large Aircraft
- High Resolution Earth Observation Systems
- Manned Space and Lunar Exploration
- Others
Sample Research from A Top University

• It is impossible to cover the entire Mfg R&D in China within this 30 minutes.

• It gives a good indication of the level of overall Mfg R&D in Chinese universities by looking at sample research projects from #1 ranked program.
Mfg R&D at Shanghai Jiao Tong University

- Design and manufacturing of heavy machinery
- High performance CNC machining
- Manufacturing systems research
- Automotive design and manufacturing
- Mechatronics research
- Biomedical design and manufacturing
## Design and Mfg of Heavy Machinery

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Duration</th>
<th>Fund (1000Yuan)</th>
<th>Sponsors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design and Evaluation of MDOF Heavy Payload Manipulator</td>
<td>2006-2011</td>
<td>4,160</td>
<td>National 973</td>
</tr>
<tr>
<td>Development of Ultra Heavy Forge Equipment</td>
<td>2009-2010</td>
<td>3,500</td>
<td>National 863</td>
</tr>
<tr>
<td>Heavy Duty and Large Size Modular Transport Equipment</td>
<td>2009-2010</td>
<td>500</td>
<td>National 863</td>
</tr>
<tr>
<td>Enabling Technology and Optimal Design of Large and Heavy Duty Multi-link Press</td>
<td>2008-2010</td>
<td>850</td>
<td>National 863</td>
</tr>
<tr>
<td>165MN Freeform Forging Equipment</td>
<td>2006-2008</td>
<td>1,000</td>
<td>MoST</td>
</tr>
<tr>
<td>Manufacturing Technologies for Large Scale Ship Crankshaft</td>
<td>2006-2008</td>
<td>800</td>
<td>MoST</td>
</tr>
<tr>
<td>Reliability and Compliance Design for Large Tunneling Equipment</td>
<td>2007-2012</td>
<td>5,320</td>
<td>National 973</td>
</tr>
<tr>
<td>Design and Manufacturing of Water Pumps for Nuclear Power Stations</td>
<td>2008-2013</td>
<td>3,500</td>
<td>National 973</td>
</tr>
</tbody>
</table>
## Design and Mfg of Heavy Machinery

<table>
<thead>
<tr>
<th>Project</th>
<th>Duration</th>
<th>Fund (1000 Yuan)</th>
<th>Sponsor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manipulator for Large Forging Equipment</td>
<td>2009-2011</td>
<td>1,600</td>
<td>National Priority Initiative</td>
</tr>
<tr>
<td>Ultra Large CNC Milling/Boring Machine</td>
<td>2009-2011</td>
<td>1,000</td>
<td>National Priority Initiative</td>
</tr>
<tr>
<td>Digital Design of Complex Mechanical Systems</td>
<td>2009-2014</td>
<td>5,000</td>
<td>NSFC</td>
</tr>
<tr>
<td>Intelligent High Precision Position and Vibration Control for Heavy Load Manipulator</td>
<td>2006-2009</td>
<td>1,350</td>
<td>NSFC</td>
</tr>
<tr>
<td>Fundamental Research on Computational Kinematics</td>
<td>2008-2010</td>
<td>400</td>
<td>NSFC</td>
</tr>
<tr>
<td>Basic Research on High Temperature System’s Reliability</td>
<td>2009-2013</td>
<td>500</td>
<td>NSFC</td>
</tr>
<tr>
<td>Dynamic Modeling and Robust Control of Small, Autonomous Helicopters</td>
<td>2009-2011</td>
<td>500</td>
<td>NSFC</td>
</tr>
<tr>
<td>Key Enabling Technologies for Redundant Servo Control Press</td>
<td>2009-2011</td>
<td>360</td>
<td>NSFC</td>
</tr>
<tr>
<td>Key Enabling Technologies for 165MN Forging Equipment</td>
<td>2007-2009</td>
<td>10,000</td>
<td>Municipal Gov</td>
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</tbody>
</table>
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<table>
<thead>
<tr>
<th>Project</th>
<th>Duration</th>
<th>Fund (1000 Yuan)</th>
<th>Sponsor</th>
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</thead>
<tbody>
<tr>
<td>Direct Drive Manipulator in Clean and Vacuum Environment</td>
<td>2009-2011</td>
<td>18,670</td>
<td>National Priority Initiative</td>
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<tr>
<td>Precision Motion Platform</td>
<td>2009-2010</td>
<td>4,870</td>
<td>National Priority Initiative</td>
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<tr>
<td>Core Technologies for Packaging</td>
<td>2009-2010</td>
<td>4,000</td>
<td>National Priority Initiative</td>
</tr>
<tr>
<td>Critical Technologies for 7500t Floating Crane</td>
<td>2007-2009</td>
<td>4,000</td>
<td>MoST</td>
</tr>
<tr>
<td>Ultra High Acceleration Precision Motion Control Technologies</td>
<td>2009-2012</td>
<td>7,700</td>
<td>National Priority Initiative</td>
</tr>
<tr>
<td>High Precision Packaging Equipment</td>
<td>2008-2009</td>
<td>1,900</td>
<td>International Coop</td>
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<tr>
<td>MEMS Device Assembly</td>
<td>2007-2009</td>
<td>800</td>
<td>National 863</td>
</tr>
<tr>
<td>Low Temperature Packaging Materials for Microelectronics</td>
<td>2008-2010</td>
<td>400</td>
<td>Municipal Gov</td>
</tr>
</tbody>
</table>
Design and Mfg of Heavy Machinery

<table>
<thead>
<tr>
<th>Project</th>
<th>Duration</th>
<th>Fund (1000 Yuan)</th>
<th>Sponsor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Design of 400TM Manipulator for Forging Equipment</td>
<td>2008-2009</td>
<td>100</td>
<td>Industry</td>
</tr>
<tr>
<td>Design of Motorized 25 cubic-meter Shovel</td>
<td>2008-2009</td>
<td>100</td>
<td>Industry</td>
</tr>
<tr>
<td>Development of 30T Vibration Simulator</td>
<td>2009-2010</td>
<td>230</td>
<td>Industry</td>
</tr>
<tr>
<td>Development of 2500T Servo Press</td>
<td>2009-2010</td>
<td>190</td>
<td>Industry</td>
</tr>
<tr>
<td>Critical Technologies for 7500T Floating Crane</td>
<td>2007-2009</td>
<td>400</td>
<td>MoST</td>
</tr>
<tr>
<td>Evaluation of Autonomous Container Storage System</td>
<td>2009-2010</td>
<td>300</td>
<td>National 863</td>
</tr>
</tbody>
</table>
Research on Manipulator Design for Heavy Machinery

- Manipulator mechanism analysis
- Transient dynamics and damping mechanism
Prototype Development
Application to Actual Forging Manipulator Development
(4000 T-M)
Motorized Heavy Duty Shovel

25m³
Digital Design and Prototype Development
7,500-Ton Floating Crane Development
165 M-N Freeform Forging Manipulator Design
Development of 200-Ton Servo Press
5-Axis CNC Machine Tools

- 5-axis machining of turbine blades
- Large gantry CNC machine
High End CNC System Development

Manufacturing R&D in China

三轴联动
五轴联动
刀具运动
刀具上的速度分布

三轴联动
五轴联动

工具轴向
控制点

Q(u)
P(u)
Control Points

F

工具上的速度分布

角度 (rad)

角度 (rad)

三轴联动
五轴联动

nufacturing
Piston Machining Equipment

- Precision boring of non-circular holes;
- Automated CNC machining in a single setup;
- In-process precision inspection of non-circular surfaces;
- Adaptive mould temperature control for automated casting and solidification.
Precision CNC Contour Grinding Machine
CNC Spherical Grinding
Diamond Wheel Truing by EDM
Laser Surface Modification and Texturing
Large Power Generation Equipment
Micro Manufacturing
Micro/Meso-scale Material Forming
Micro Mfg and Application to Fuel Cells

Contact Resistance Modeling and Experiment
## Mfg Systems and Mfg Quality Control

<table>
<thead>
<tr>
<th>Project</th>
<th>Duration</th>
<th>Fund (1000 Yuan)</th>
<th>Sponsor</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Speed and High Precision CNC Machine Motion Control</td>
<td>2005-2010</td>
<td>1,400</td>
<td>National 973</td>
</tr>
<tr>
<td>Spring-back and Residual Stress Control in Large Structural Parts</td>
<td>2009.8-2012.7</td>
<td>4,000</td>
<td>National 973</td>
</tr>
<tr>
<td>Bipolar Plate Mfg and PEM FC Assembly Modeling and Technologies</td>
<td>2009.1-2011.12</td>
<td>900</td>
<td>NSFC</td>
</tr>
<tr>
<td>Variation Modeling and Diagnosis of Stream of Variation in Multi-Stage Mfg Process</td>
<td>2007.1-2009.12</td>
<td>280</td>
<td>NSFC</td>
</tr>
</tbody>
</table>
# Manufacturing R&D in China

## Mfg Systems and Mfg Quality Control

<table>
<thead>
<tr>
<th>Project</th>
<th>Duration</th>
<th>Fund (1000 Yuan)</th>
<th>Sponsor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mfg Quality Control in Large Structural Parts for High Speed Train</td>
<td>2008.10-2009.12</td>
<td>980</td>
<td>Industry</td>
</tr>
<tr>
<td>Mfg System Design for Aerospace Components</td>
<td>2008.10-2010.2</td>
<td>2,550</td>
<td>Industry</td>
</tr>
<tr>
<td>Key Enabling Technologies for Large Aircraft Mfg</td>
<td>2009.1-2010.12</td>
<td>11,800</td>
<td>Industry</td>
</tr>
<tr>
<td>Process Robustness &amp; Quality Control for Low Cost Manufacturing</td>
<td>2008.1-2010.12</td>
<td>630</td>
<td>Industry</td>
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<tr>
<td>Mfg Quality Improvement for Complex Products Based on Cloud Data</td>
<td>2009-2010</td>
<td>600</td>
<td>Municipal Gov</td>
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<tr>
<td>Demonstration of Collaborative Mfg Grid</td>
<td>2007-2009</td>
<td>1,600</td>
<td>NSFC</td>
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<tr>
<td>Visualization of High Performance Computing Results and Application to Mfg</td>
<td>2009-2011</td>
<td>2,000</td>
<td>Municipal Gov</td>
</tr>
<tr>
<td>Digital Testing and Evaluation of Rotating Platform</td>
<td>2007-2010</td>
<td>1,400</td>
<td>National 863</td>
</tr>
</tbody>
</table>
Mfg Systems Research Overview

Complex Mfg System

- System Simulation And Optimization
- Sheet Metal Mfg Processes
- High Performance Machining of Complex Surfaces
- Information Management In Mfg System

- Modeling
- Precision Forming
- Lightweight Joining
- QC Software

- Mfg of CC
- GA of Large Aircraft
- High Speed Train
- Freeform CNC

- 7 NSFC Grants
- 20 SCI Papers
- 4 SW packages
- 9 Process Stds
- 5 Special Equipment

Manufacturing R&D in China
Quality Control in High Speed Train Production
Dimensional Control in Aircraft Mfg

Tolerance Control in Landing Gear Mfg

- 起落架运动机构
- 前起舱安装交点
- 分析目标确定
  作动筒剩余行程
- 建立尺寸链容差分析模型
- 挂点对作动筒收放剩余行程敏感度分析
- 作动筒剩余行程公差预测
- 剩余行程问题诊断
- 关键影响因素容差分配

Design Optimization in Fuselage Mfg

- 总装过程中装夹基准系统设计
- 总装后装配几何精度标准
- 关键特征与检测点优化设计
- 总装过程尺寸偏差传递的三维建模
  (加工误差、装配夹具、基准误差)
- 面向界面最小变形的装夹基准优化设计
- 大部件容许加工误差设计（容差分配）
- 考虑大部件加工误差的装配夹具补偿设计

Manufacturing R&D in China
Large Aircraft Design and Manufacturing

Manufacturing R&D in China
Dimensional Control in Body Design and Mfg

- Key technologies for low cost mfg of mini cars
- Dimensional control systems

- Functional build and assembly quality control
- Automated root cause identification

- Development of vehicle dimensional control system
Precision Sheet Metal Forming

Precision, Lean Stamping Design Methods

Min \( (\mu_2, \sigma_2, \mu_3, \sigma_3) \)

s.t. \( \mu_1 - 3.72\sigma_1 > 5\%

Multi-Step Roll Hemming Process and Simulation

Manufacturing R&D in China
Model-Based Design and Manufacturing
Advanced Joining of Lightweight Materials

Joining of dissimilar materials
Hybrid welding-cluing processes

Modeling and Simulation

Design Optimization

Manufacturing R&D in China
Automated Measurement and Correction of Oil Pipes
Automation in Shipping Container Port
Wind Turbine Manufacturing Technology
Precision Magnesium Casting
Enabling Technologies for Semiconductor Mfg

- Packaging Technologies for 20μm Gap POB (Particle on Bump);
- 160°C Low Temperature Bonding Methods;
- Precision Imaging and Alignment Methods under Complex Lighting Condition.
Enabling Technologies for Semiconductor Mfg

- Innovative Temperature Control and Hot Press Design;
- Large Chip Flat Hot Pressing Method;
Enabling Technologies for Semiconductor Mfg

Integrated System

Wafer Handler

Chip Feeder

Integrated System in Operation
## Medical Mfg and Bio-Mechatronic Systems

<table>
<thead>
<tr>
<th>Project</th>
<th>Duration</th>
<th>Funds (1000 Yuan)</th>
<th>Sponsor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mechanics of Artificial Muscle and Clinical Research</td>
<td>2010-2012</td>
<td>300</td>
<td>NSFC</td>
</tr>
<tr>
<td>Smart Materials and Application to MIS</td>
<td>2009-2011</td>
<td>200</td>
<td>Municipal Gov</td>
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<tr>
<td>Virtual Human Mechanics Model</td>
<td>2006-2009</td>
<td>1,370</td>
<td>NSFC</td>
</tr>
<tr>
<td>Mechanics of Cochlear and Smart Device for Hearing Restoration</td>
<td>2008-2009</td>
<td>350</td>
<td>NSFC</td>
</tr>
<tr>
<td>Biological Nerve and Machine Interface and Application in Robotics</td>
<td>2005-2009</td>
<td>1,600</td>
<td>NSFC</td>
</tr>
<tr>
<td>Bio-Mechatronics Systems and Prosthetics</td>
<td>2009-2011</td>
<td>760</td>
<td>National 863 Initiative</td>
</tr>
<tr>
<td>Signal Processing and Decoding of Biological Nerve Signals and Bio-Mechatronics Interface Technology</td>
<td>2008-2010</td>
<td>450</td>
<td>Municipal Gov</td>
</tr>
<tr>
<td>Bio-mimic Control and Brain-Machine Interface Research</td>
<td>2009-2011</td>
<td>350</td>
<td>Municipal Gov</td>
</tr>
<tr>
<td>Extraction and Identification of Muscle Surface Electrical Signals</td>
<td>2008-2011</td>
<td>300</td>
<td>NSFC</td>
</tr>
</tbody>
</table>
### Medical Mfg and Bio-Mechatronic Systems

<table>
<thead>
<tr>
<th>Project</th>
<th>Duration</th>
<th>Fund (1000 Yuan)</th>
<th>Sponsor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precision Surgical Robotic Systems for Criofacial 颅颌面外科精确治疗术机器人系统</td>
<td>2009-2011</td>
<td>5,000</td>
<td>National 863 Initiative</td>
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<tr>
<td>3D Vision Based Facial Reconstruction CAD System</td>
<td>2007-2009</td>
<td>600</td>
<td>Municipal Gov</td>
</tr>
<tr>
<td>Development of Digital Facial Reconstruction System and Telemedicine</td>
<td>2009-2011</td>
<td>1,450</td>
<td>Municipal Gov</td>
</tr>
<tr>
<td>Rapid Acquisition of Facial 3D Data and Clinical Applications</td>
<td>2009-2011</td>
<td>750</td>
<td>Municipal Gov</td>
</tr>
<tr>
<td>染色体微切割微克隆装备及其关键技术研究</td>
<td>2007-2010</td>
<td>360</td>
<td>NSFC</td>
</tr>
</tbody>
</table>

*Manufacturing R&D in China*
Micro Manipulator for Chromosome Cutting
6D Hepatic Joystick
Bio-Inspired Eyes
Humanoid Robot Research
Four Leg Robot
Digital Platform for Medical Applications

Manufacturing R&D in China
Artificial Organ

- Colostomy design and implementation

- Super SMA for Sphincter Muscle
Digital System for Craniofacial Reconstruction

Facial Digitization → CAD Reconstruction → Rapid Prototype → Reconstruction Surgery

Manufacturing R&D in China
Virtual Human Mechanics Model

- Virtual System for Geometry Modeling, Motion Simulation, Dynamics and Stress Analysis.
Bio-Mechatronics and Interfaces

- Bio-signal measurement and analysis;
- Motion decoding;
- Bio-interface and bio-mechatronics
Prosthetics Research

Muscle electrical signal decoding: success rate 97 ~ 99%
Hand writing recognition success rate >90%
Brain Control Interface
Personalized Medical Device Manufacturing
Main Messages

• Manufacturing R&D has received significant government attention and funding in China. They are catching up quickly in terms of depth and breadth of Mfg R&D.

• US companies cannot no longer afford not to actively compete in one of the largest and rapidly growing markets in the world. It is a delicate balance between competition and collaboration.

• US government needs to wake up and invest in Mfg R&D if US still wants to remain a world-leader in advanced manufacturing technologies.

• Blaming China for currency manipulation is easy political rhetoric. Let’s focus on the real problem – lack of governmental support.