MANUFUTURE 2017, TALLINN

Future of Manufacturing

- China and USA Perspective

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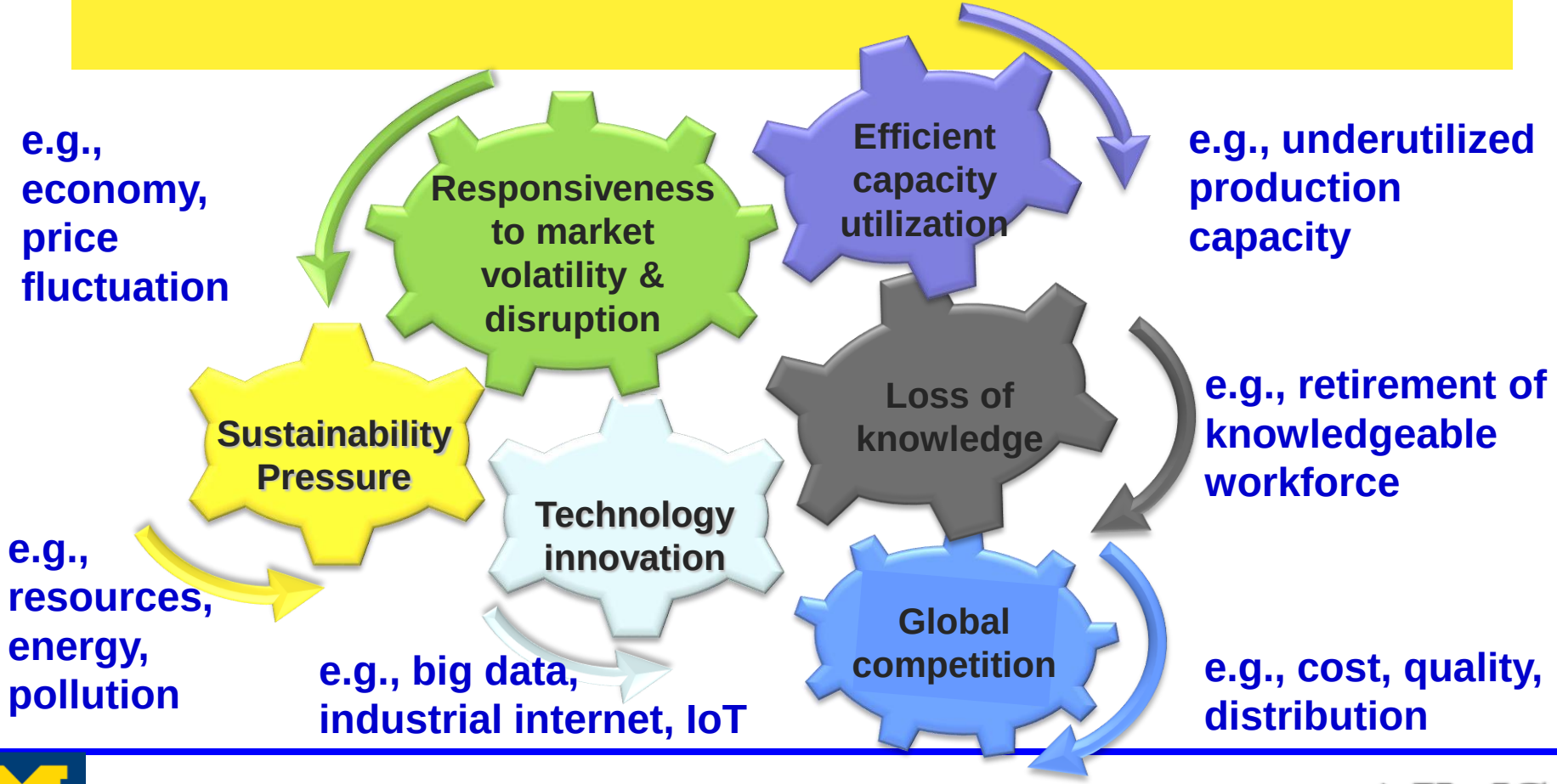
Global Challenges in Manufacturing



Key Drivers for Future Manufacturing

WORLD ECONOMIC FORUM

COMMITTED TO IMPROVING THE STATE OF THE WORLD

- Government policies
- Trade agreement
- Currency exchange
- Foreign direct investment
- Infrastructure and energy supply
- Workforce and talent development
- Wage growth
- Reliable access to material resources
- Innovation ecosystem

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China’s Manufacturing

Amazing Achievements by China

- Auto Production and Market
  - Since 2008, China has become No. 1 in both production volume and market size.
- High Speed Rail
  - In less than 10 years, China has produced over 2,400 high-speed trains and built up the largest/longest high-speed rail network in the world.
- Manufacturing Total Output
  - Since 2012, China has overpassed the United States to become the largest manufacturing output country.
- International Trade
  - In 2013 China has surpassed the United States to become the largest international trading country.

Manufacturing plays a key role

Myth and Reality of China's Manufacturing

Myth

- "Made in China" products can be seen everywhere.
- China is becoming a world production center.

Reality

- China is currently a "Manu-factory", not a manufacturing powerhouse yet.
- Current manufacturing paradigm cannot be sustained (labor costs, resource consumption, environmental damage, etc.).
- Chinese government has realized that China needs to upgrade its manufacturing industry and move to higher value-added manufacturing.

Key Factors for China's Success

- Key factors of China's manufacturing success include:
  - Huge market
  - Low cost production (labor and natural resources)
  - Strong government support for manufacturing growth
  - Foreign direct investment (FDI)
  - Disciplined and well-educated workforce
  - Clusters of regional supply networks
  - Great physical infrastructure

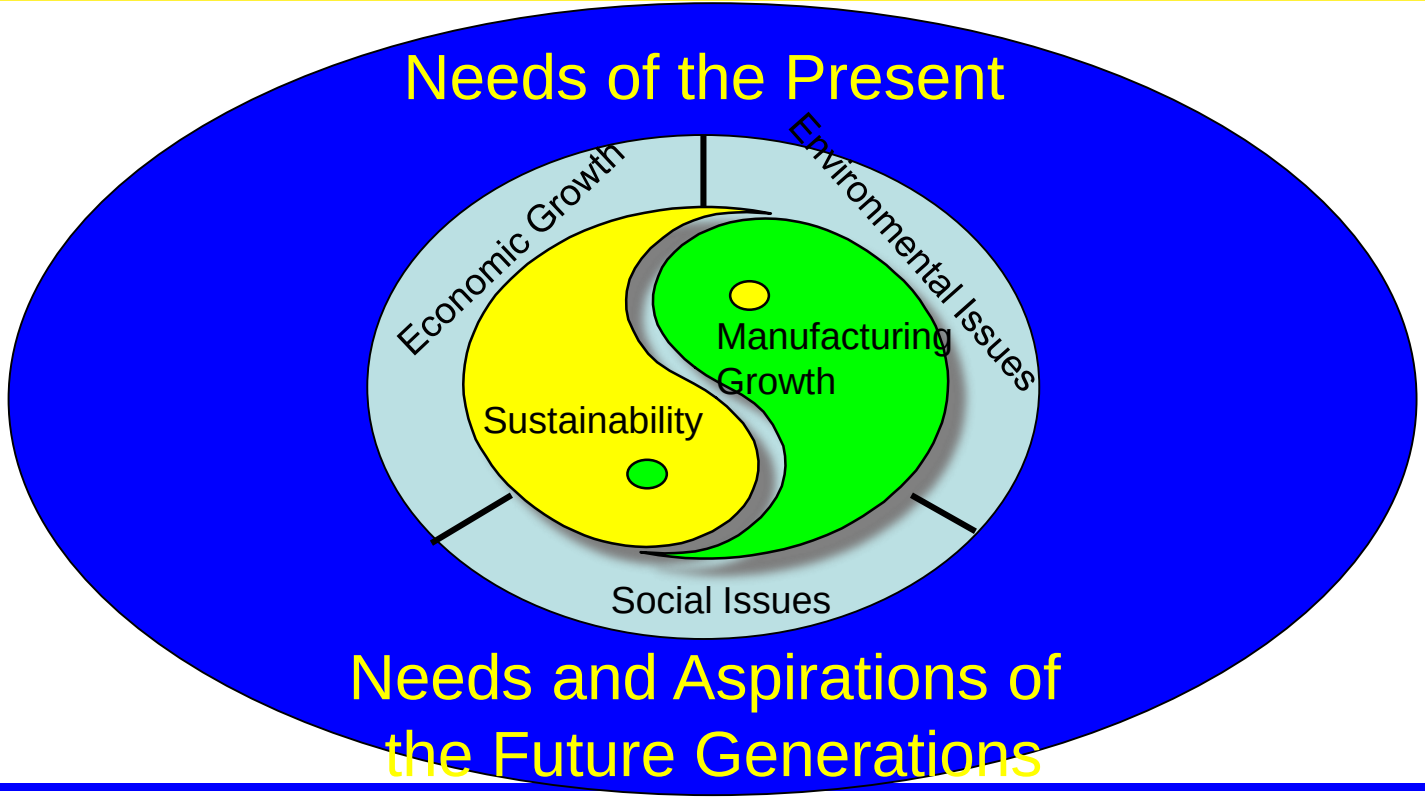
Manufacturing Companies in China

- State-owned-enterprises
  - Large, slow, and monopolized operations, not competitive in global markets
  - Plenty of financial capitals or access to financial resources
- Multi-national corporations
  - Technology leaders
  - Strong control and support from the headquarters
- Privately-owned-enterprises
  - Agile, aggressive, mostly small/medium size, some very large
  - Lack of technological sophistication

Challenges Facing Chinese Manufacturing

- Damage to environment
- Depletion of natural resources
- Rapid increase in production costs
- Shrinkage in export markets
- Slow-down of Chinese economy
- Competition from other low wage countries
- Lack of innovative products and key manufacturing know-hows and technologies

Sustainable Development of China's Manufacturing



Chinese Government's Strategies

- Strategically regulate the costs of various resources to preserve the resources and to eliminate non-competitive enterprises
- Reduce resource- and energy-intensive industries (e.g., cement, steels, glass production facilities)
- Raise the environmental protection requirement to force technology upgrading
- Increase investment for R&D and education
- Emphasize science and education (科教兴国→科教强国→科教立国)
- Promote "One-Belt and One-Road" strategies
- Establish Asia Infrastructure Investment Bank

Chinese Government's Strategies

- Create a "**China Manufacturing 2025**" three-step national strategy (to transform and upgrade manufacturing industry, particularly 10 selected key industries)
- Establish national innovation strategies (协同创新, coordinated innovation among industry, academia and government)
- Leverage capital market to accelerate technology innovation and transformation (including oversea M&A)
- Provide significant incentive funds to high-tech startups
- Open up new stock markets for innovative companies

Key Elements of “China Manufacturing 2025”

- Innovation driven
  - Establishing national innovation mechanism, legal framework and ecosystem
- Quality first
  - Promoting regulatory system, standardization, and culture
- Sustainable development
  - Improving the effectiveness of resource utilization, energy consumption and environmental protection
- Structural optimization
  - Upgrading industrial sectors and eliminating backward industries
- Talent development
  - Attracting top talents internationally and encouraging STEM education

China's Smart Manufacturing Goals

	Year 2025	Year 2035	Year 2045
Manufacturing Capability	Less than 30% of technologies depending upon import	Less than 20%	Less than 5%
Key Equipment Technology	Change the situation of heavily depending on import	Mostly meeting the needs	Leading design and manufacturing innovation
Intelligent Manufacturing	Smart automation to improve efficiency by 10%	Collaborative human/machine control and management systems	Intelligent and autonomous automation systems

Ten Key Strategic Areas

- New Generation IT Industry
- High-end CNC Machines and Robotics
- Aerospace Industry
- Marine Engineering Equipment and High-tech Ships
- Advanced Rail Road Equipment
- New Energy Vehicles
- Electric Power Generation Equipment
- Agricultural Equipment
- New Materials
- Biomedicine and High-performance Medical Equipment

Main Messages

- China's manufacturing industry has entered a critical and challenging period, and we will see major transformations in the next decade and beyond.
- 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.
- Chinese government has made manufacturing a key national priority and established comprehensive national strategies to transform and upgrade manufacturing industry.

United States’ Strategy

United States' Strategy

- President Obama launched Advanced Manufacturing Partnership (AMP) initiatives in 2012
- Formed an interagency Advanced Manufacturing National Program Office in Washington, DC
- Established national network of manufacturing innovation institutes
- Trying to fill the gap between fundamental research and implementation/commercialization
- Provided incentives for re-shoring manufacturing operations (e.g., GE, Apple)

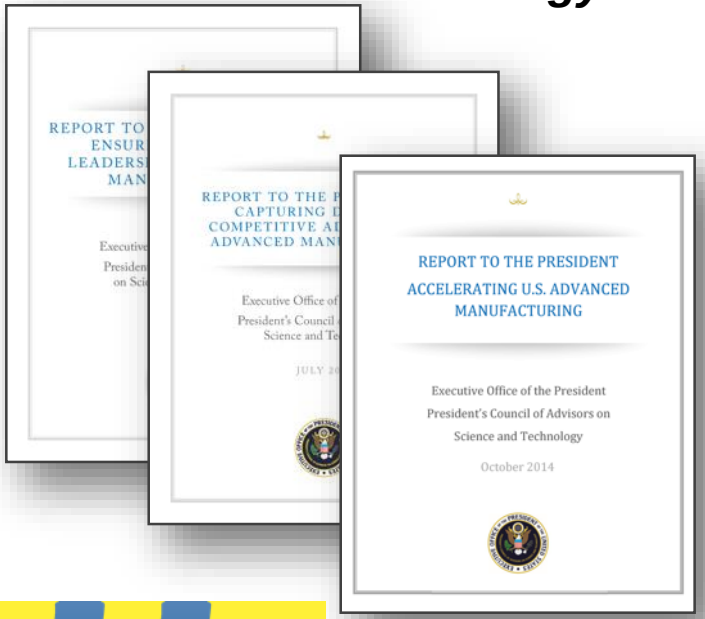
National Manufacturing Initiatives

- Advanced Manufacturing Technology Consortia
- MForesight: The Alliance for Manufacturing Foresight
- Hollings Manufacturing Extension Partnership (MEP)
- Investing in Manufacturing Communities Partnership
- Materials Genome Initiative
- National Export Initiative (NEXT)
- National Nanotechnology Initiative
- Manufacturing USA (NNMI)
- National Robotics Initiative
- SelectUSA (to attract FDI)
- Sustainable Manufacturing Clearinghouse

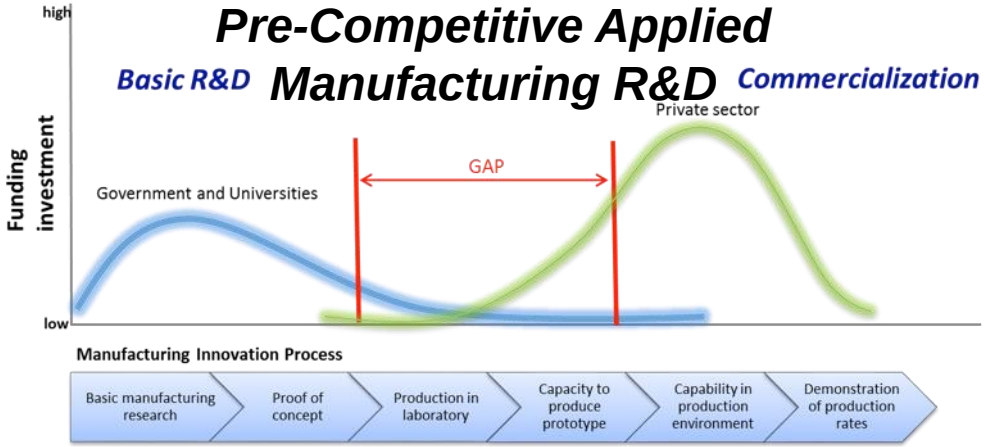
Manufacturing USA: a National need

Source: Mike Molnar @AMNPO

President's Council of Advisors on Science and Technology



Market Failure in Pre-Competitive Applied Manufacturing R&D



National Network for Manufacturing Innovation creates the space for industry and academia to work on industry-relevant problems

- Addresses the market failure of industry underinvestment in "pre-competitive" applied R&D
- Focuses on "de-risking" new technologies and materials to scale-up for U.S. manufacturers

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Manufacturing USA Strategic Goals

Source: Mike Molnar @AMNPO

Vision

- U.S. global leadership in advanced manufacturing

Mission

- Connecting people, ideas, and technology to solve industry-relevant advanced manufacturing challenges, thereby enhancing industrial competitiveness and economic growth and strengthening our national security

Program Goals

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Competitiveness		
Technology Advancement	Workforce Development	Sustainability

NATIONAL NETWORK FOR MANUFACTURING INNOVATION PROGRAM STRATEGIC PLAN

Executive Office of the President
National Science and Technology Council
Advanced Manufacturing National Program Office

February 2016

https://www.manufacturingusa.com/resources/national-network-manufacturing-innovation-nnmi-program-strategic-plan

Manufacturing Institute Framework

Source: Mike Molnar @AMNPO

Applied Research + Education/Workforce Skills = Development of Future "Manufacturing Hubs"

- Federal funding is the **catalyst** to bring stakeholders into shared space to de-risk innovation.
- Focus is on **industry-relevant problems** impacting commercial production, MRL 4-7.
- Institutes must be **self-sustaining** after federal startup investment ends.
- **Workforce training and development** is an essential component in institute focus.

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Federal startup investment: minimum $70M/institute over 5 years
Institute Consortium owners must have minimum 1:1 co-investment

Manufacturing USA

Regional Hubs with National Impact

Source: Mike Molnar @AMNPO

- **DMDII** — Digital Manufacturing & Design — *Chicago, IL*
- **REMADE Institute** — Sustainable Manufacturing — *Rochester, NY*
- **AIM Photonics** — *Albany, NY Rochester, NY*
- **biofabusa** — Regenerative Manufacturing — *Manchester, NH*
- **affoa** — Advanced Fibers and Textiles — *Cambridge MA*
- **NEXTFLEX** — Flexible Hybrid Electronics — *San Jose, CA*
- **Clean Energy Smart Manufacturing Innovation Institute** — Smart Sensors and Digital Process Control — *Los Angeles, CA*
- **RAPID** (Transforming Process Industries) — Modular Chemical Process Intensification
- **NIIMBL** — Bio-pharmaceutical Manufacturing — *Newark, DE*
- **lift** — Lightweight Metals — *Detroit, MI*
- **America Makes** — Additive Manufacturing — *Youngstown, OH*
- **iacmi** (The Composites Institute) — Advanced Composites — *Knoxville, TN*
- **aim** — Advanced Robotics — *Pittsburgh, PA*
- **PowerAmerica** — Wide Bandgap Semiconductors

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Third Party Assessment Findings & Program Progress

Source: Mike Molnar @AMNPO

Key Findings - Manufacturing USA Spurs R&D Innovation

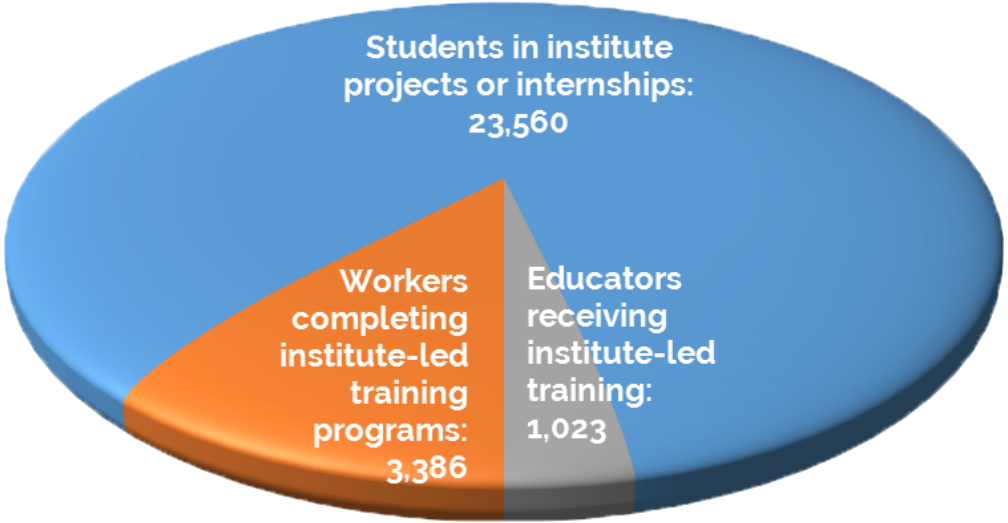
- The Program is a highly effective ecosystem convener
- Institutes are demonstrating the potential to deliver 5x leveraged value for members
- Institutes are successfully planning for sustainability independent of U.S. government influence

Progress to Date

- As of today, 14 institutes launched - $1 billon federal investment matched by over $2 billion non-federal
- Of Eight active institutes: 1,300 members, over 240 technology development projects.
  - Members include two-thirds of Fortune 50 U.S. manufacturers
  - 8 out of the 10 top-ranked research and engineering universities.

Development of an Advanced Manufacturing Workforce

Source: Mike Molnar @AMNPO



- Nearly 28,000 participated in institute-led workforce programs, including
  - **23,560 students** in institute research and development projects, internships, or training
  - **3,386 workers** completed institute-led certificate, apprenticeship, or training programs
  - **1,023 teachers** and trainers in institute-led training for instructors

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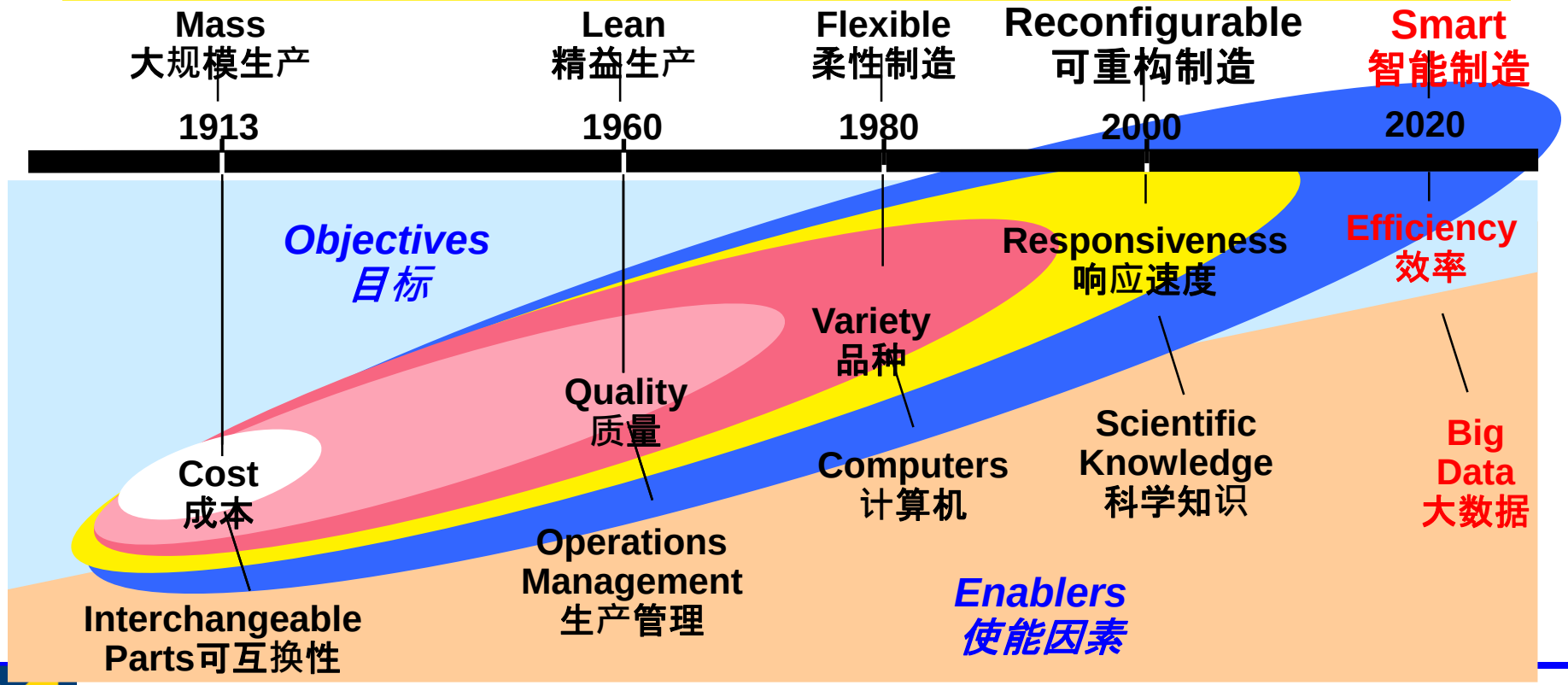
Vision for Smart Manufacturing Systems

Evolution of Manufacturing Strategies



Vision for Smart Manufacturing Systems

Smart Manufacturing Systems should have the following major characteristics:

-4Rs (responsiveness, resilience, reconfigurability and reusability) in addition to quality, cost, flexibility, efficiency有

-Self-aware and self-adaptive machines that can evaluate their condition degradation and make necessary compensation

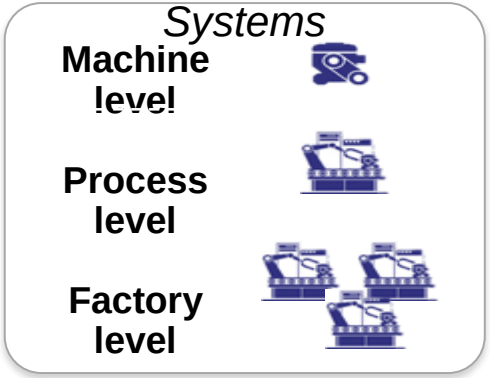
-Zero defect with predictive automatic root cause identification

-Near-zero downtime (NDT) system performance with engineering immune capability

-First time right and every time right (FT/ET right)

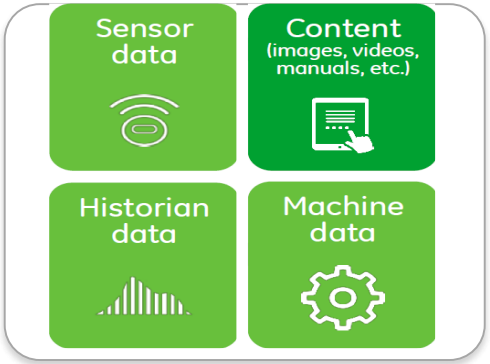
Smart Manufacturing Systems for Industry 4.0

Smart Manufacturing Systems



- Self-aware and predictive capability of equipment condition
- Resilience to uncertainties and disruptions
- Near-zero defect and downtime performance

Industrial Big Data



- Massive and complex data
- Incomplete or imperfect data
- Multi-stream/multi-source data

Advanced Analytics

- Physics-based
  - First principles
  - Dynamics
- Data-driven
  - Statistical models
  - Machine learning
- Hybrid analytics
  - AI
  - Engineering models

- Greater asset reliability
- Lower operating costs
- Worry-free production

Summary

1. Global competition drives future manufacturing to achieve “First time right, and every time right”.
2. Big data era is exciting for advanced manufacturing and maintenance.
3. There are significant scientific and technical challenges to fully realize the potentials of smart manufacturing systems.
4. There are great potentials to improve the competitiveness through manufacturing innovations.