2026 Blue Sky Competition

From Mass Production to Mass Innovation
Narrative Manufacturing

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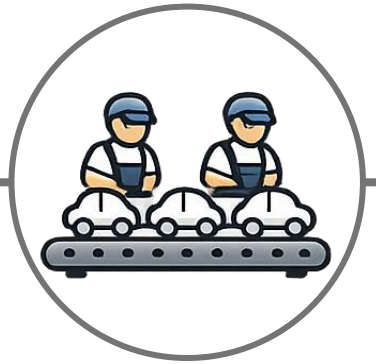
Path Toward Automation

Pre-Industry

- Craft Production
- Human Labor
- **Manual** design, fabrication, and inspection

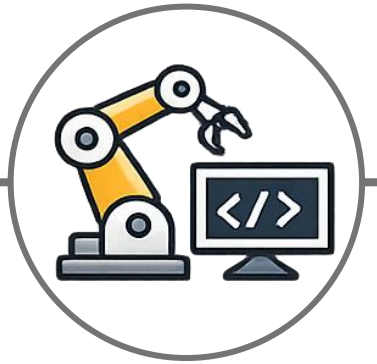
Industry 1.0

- Mechanization
- Machine power
- Steam engines partially **replace human labor**



Industry 2.0

- Mass production
- Assembly line
- Conveyor enables **standardized mass production**



Industry 3.0

- Limited automation
- Rule-based automation
- Automated systems **replace repetitive human tasks**

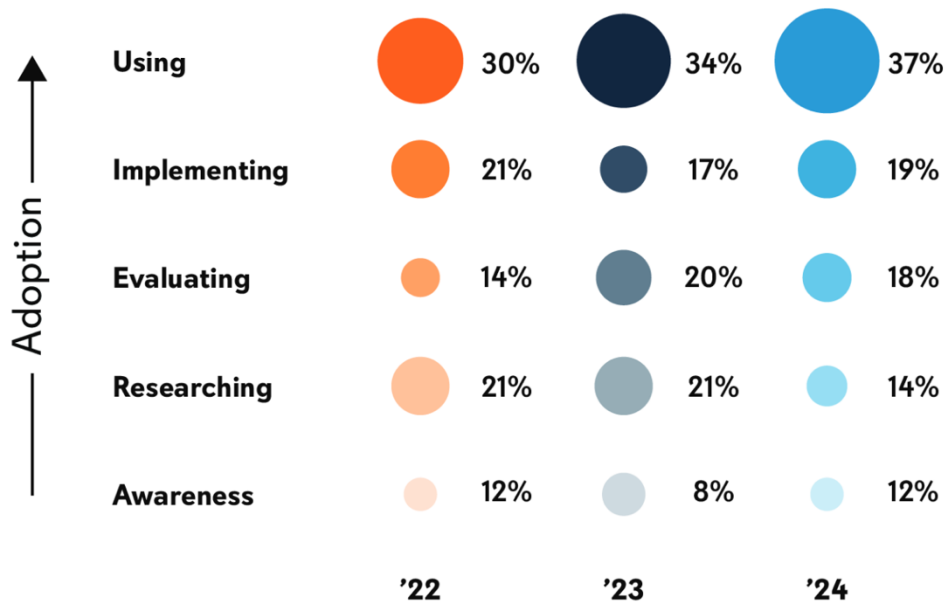
Industry 4.0

- Advanced Automation
- Smart manufacturing
- IoT, Robotics, and AI **enable autonomous decision-making**

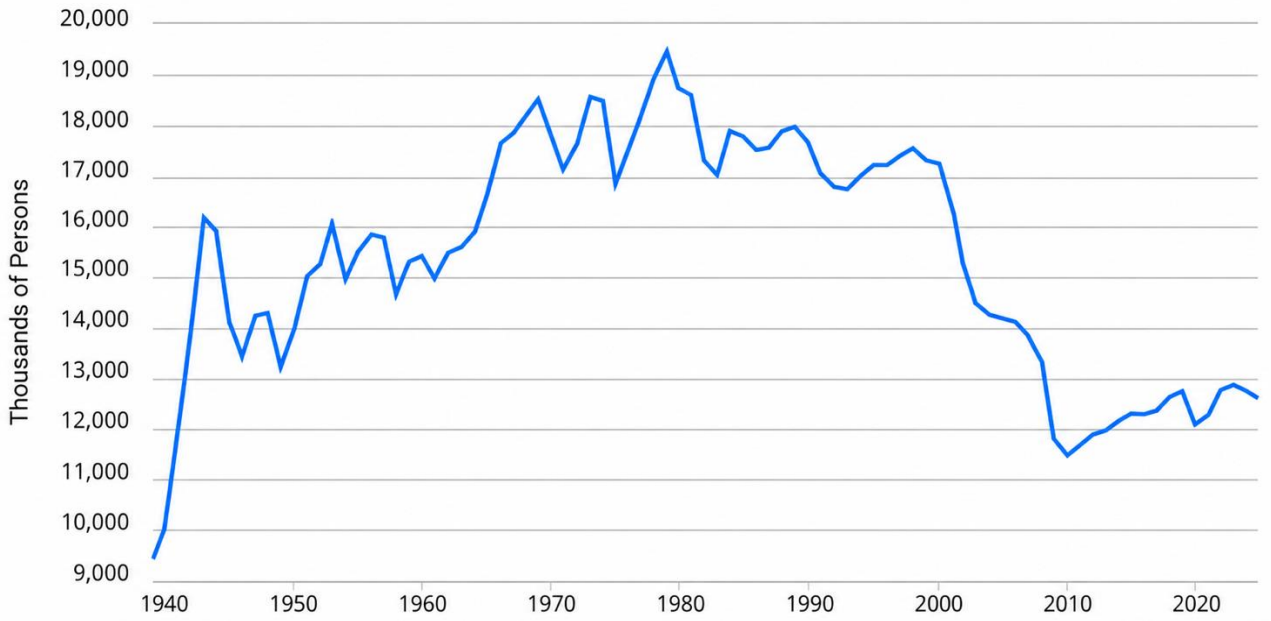
Manufacturing has continuously evolved toward **minimizing human intervention** and **maximizing automation.**

What Is the Human Role After Full Automation?

Automation Adoption Year-Over-Year



Employees in the U.S. Manufacturing Sector

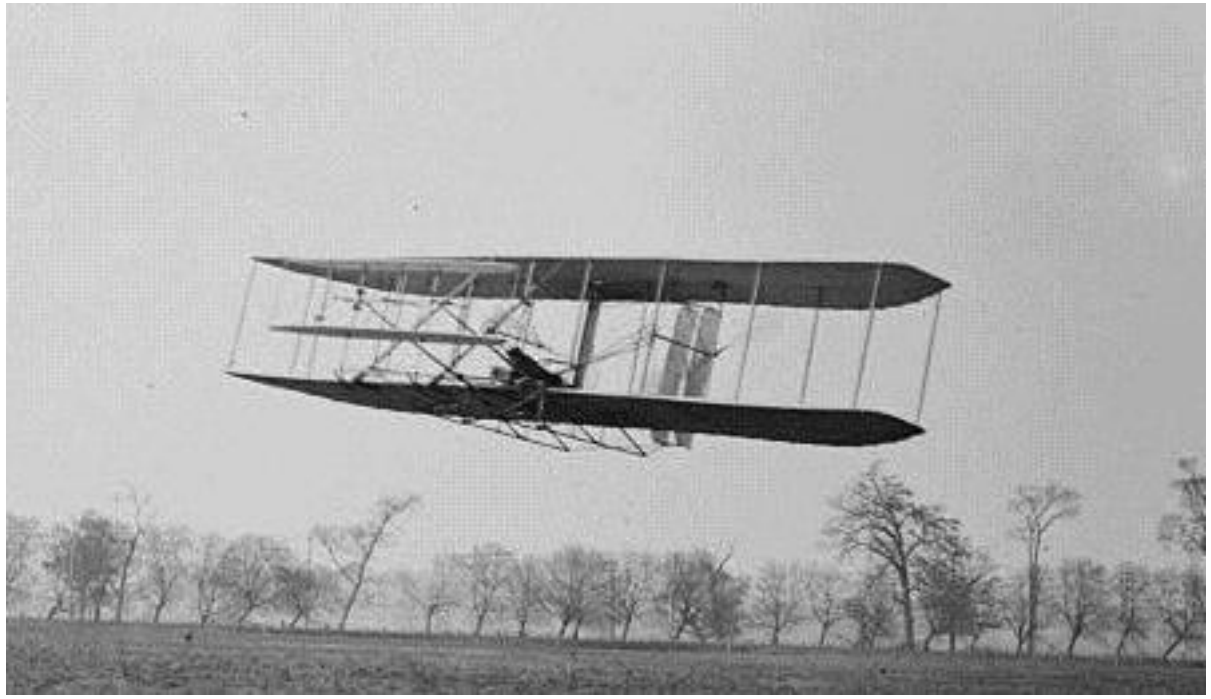


If manufacturing ultimately becomes **fully autonomous**,

WHAT ROLE REMAINS FOR HUMANS?

Smart Manufacturing Adoption Study, Auburn University, 2024
U.S. Bureau of Labor Statistics

Innovation Begins with Human Imagination



We imagine it. We create it.

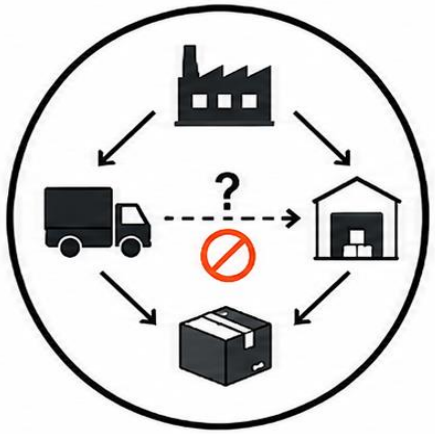
Creativity is the source of manufacturing.

https://medium.com/galleys/how-to-fly-a-horse-7e52f051d92b
U.S. Bureau of Labor Statistics

Factors Shaping Barriers to Manufacturing Entry

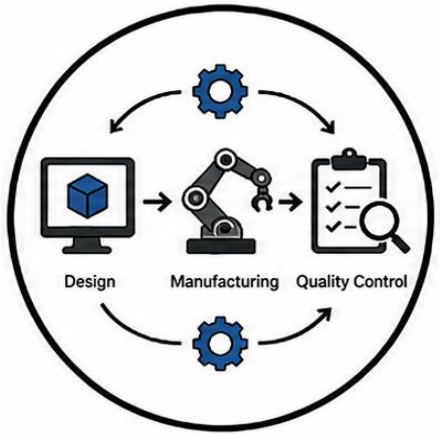
High-cost production equipment

- Modern production requires various machines, tooling, sensors, and their integration.
- Individuals without capital are incapable of accessing such equipment.



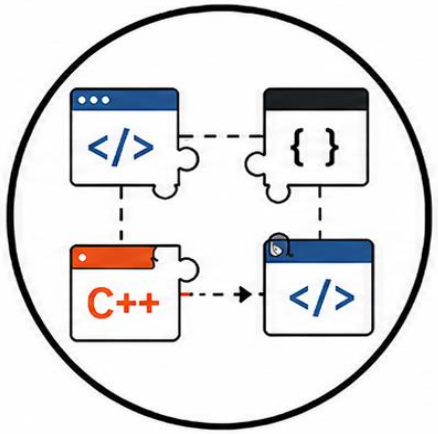
Rigid and opaque supply networks

- Supplier capability, cost, lead time, capacity, and quality records are difficult to access, compare, and reconfigure.
- This hinders supply-chain formation, reconfiguration, scaling, and resilience for individuals.



End-to-end production expertise

- Turning an idea into a product requires expertise across design, materials, process planning, machine operation, metrology, QC, and workflow integration.
- Individuals often fail to coordinate the full production process.



Fragmented SW and programming languages

- CAD, CAM, PLCs, MES, ERP, and machine and robot protocols rely on various tools and languages.
- Individuals can't seamlessly translate their intention into machine operation.

Workforce adaptation gap

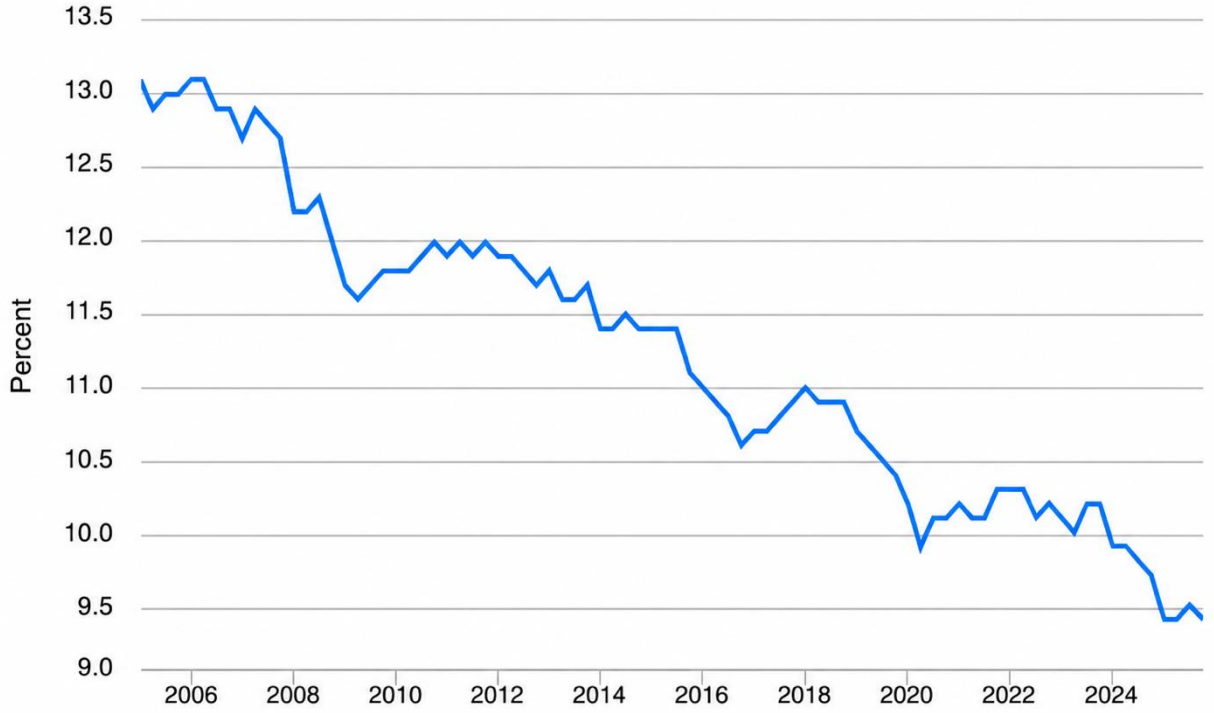
- Manufacturing technologies evolve faster than shop-floor roles, workforce structures, and training systems.
- This slows technology adoption and prevents from manufacturing innovation.

Stagnant Manufacturing Innovation

Largest manufacturing companies by revenue

No	Company	Headquarters	Establishment
1	Apple	United States	1976
2	Volkswagen	Germany	1937
3	Toyota	Japan	1937
4	Samsung Electronics	South Korea	1969
5	Hon Hai Precision Industry / Foxconn	Taiwan	1974
6	General Motors	United States	1908
7	Ford Motor	United States	1903
8	Stellantis	Netherlands	1810~ (merge, 2021)
9	China Railway Engineering Group / CREC	China	1950
10	Mercedes-Benz Group	Germany	1926
11	BMW	Germany	1916
12	Honda Motor	Japan	1948
13	Nvidia	United States	1993
14	Hyundai Motor	South Korea	1967
15	China Baowu Steel Group	China	1978
16	Mitsubishi	Japan	1870~
17	Hengli Group	China	1994
18	Huawei	China	1987
19	China Minmetals	China	1950
20	BYD	China	1995
21	Nestlé	Switzerland	1866
22	Bosch	Germany	1886
23	**Tesla**	**United States**	**2003**

Share of Manufacturing in U.S. GDP



High barriers. Few new leaders. Shrinking economic share.

Reviving manufacturing through new foundations for human creativity.

https://en.wikipedia.org/wiki/List_of_largest_manufacturing_companies_by_revenue

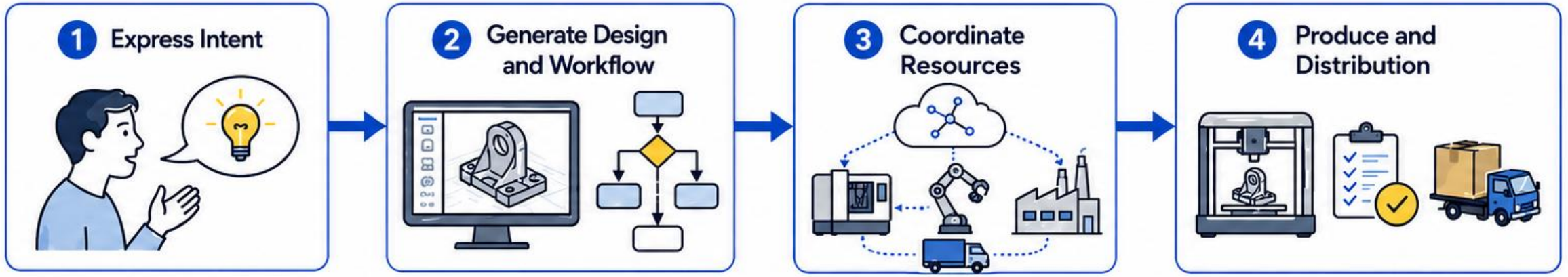
U.S. Bureau of Labor Statistics

New Manufacturing Paradigm

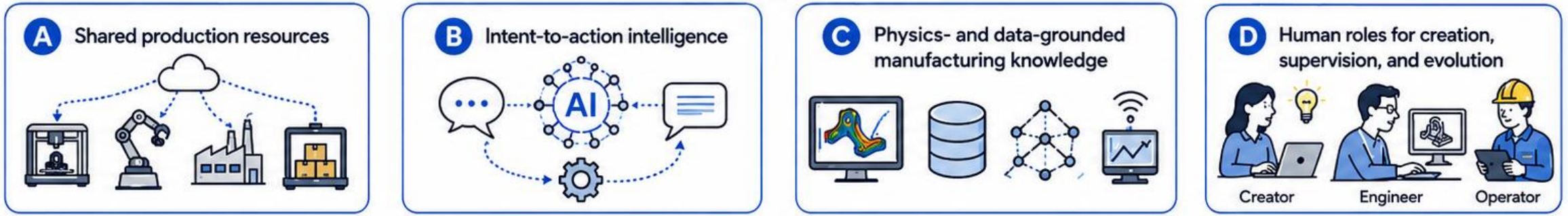
Narrative Manufacturing

Transforms human ideas into product design, production plans, resource coordination, quality control, and distribution through bidirectional narrative with engineering intelligence.

Mechanism



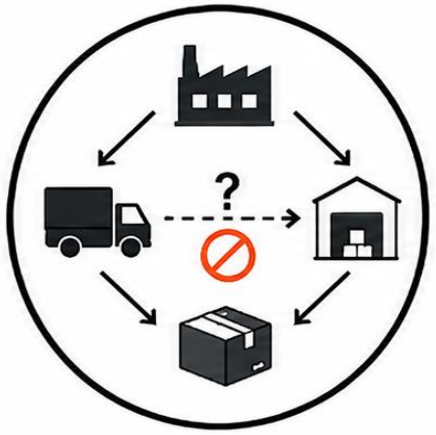
Core Component



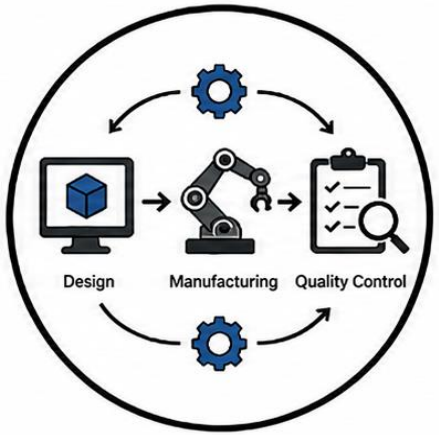
Rebuilding Manufacturing for Mass Innovation

Infrastructure Layer	Intelligence and Interface Layer	Workforce layer

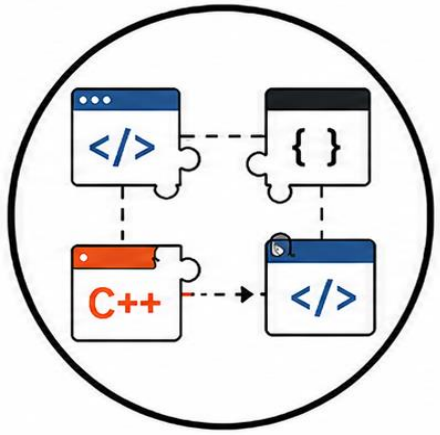
High-cost production equipment



Rigid and opaque supply networks



End-to-end production expertise



Fragmented SW and programming languages

Workforce adaptation gap

- Shared manufacturing infrastructure
- Dynamic production networks
- On-demand access to manufacturing capability

Manufacturing infrastructure for individuals

- Natural language-driven manufacturing workflows
- Bidirectional interaction across humans and machines
- Seamless translation from ideas to production

From expertise-driven operation to intent-driven creation through natural language

- Workforce structures designed for a new manufacturing paradigm

New human roles for future manufacturing

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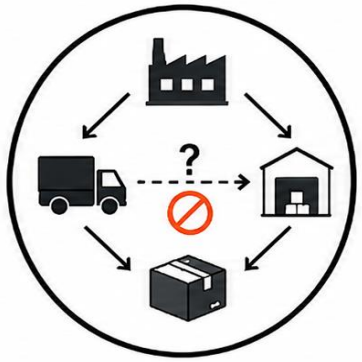
Narrative Manufacturing Infrastructure

High-cost production equipment



Rigid and opaque supply networks

Narrative manufacturing infrastructure

Cloud Manufacturing

- On-demand access to manufacturing capability
- Reduces barriers to equipment ownership

Challenges

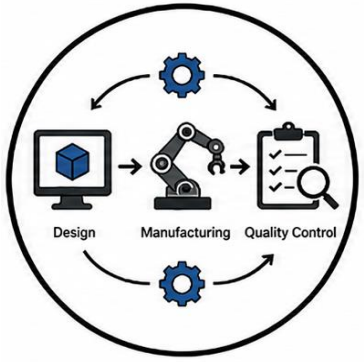
- Who builds the infrastructure before a viable market exists?
- How are manufacturing resources transformed into usable systems?
- How do people access and operate manufacturing infrastructure?
- Who operates, maintains, and evolves the ecosystem?

Narrative Manufacturing Ecosystem Beyond Cloud Manufacturing

- Public manufacturing infrastructure
  → Leverage universities, national labs, and regional hubs
- Build modular production cells and supply chains
- Novel intelligence and interface layer
  → Connect and orchestrate the resources
- Redesign the workforce configuration
  → Operate, maintain, and evolve the ecosystem

Li et al. Cloud manufacturing: a new service-oriented networked manufacturing model. Computer Integrated Manufacturing Systems CIMS 2010;16(1):1–7

Natural Language-driven Manufacturing Intelligence



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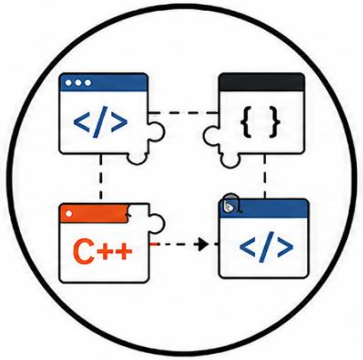

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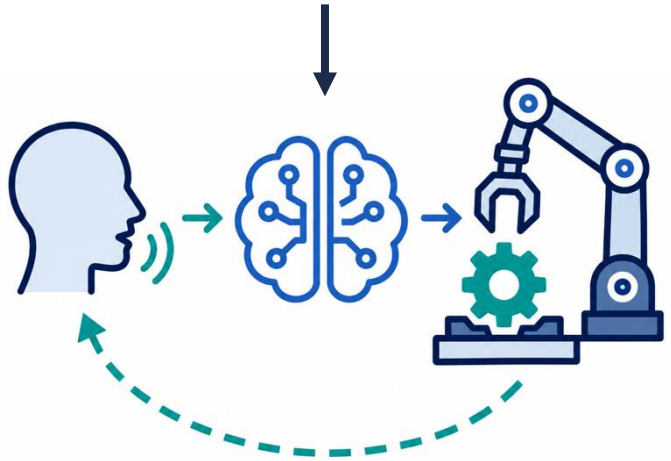


Large Engineering Model for Manufacturing (LEM^2)

Large Engineering Model for Manufacturing (LEM^2)

- Connects human and manufacturing through natural language
- Human intent → Operation/Feedback → Human understanding
- Coordinates the full lifecycle of manufacturing
- Orchestrates machines, software, sensors, and supply chains

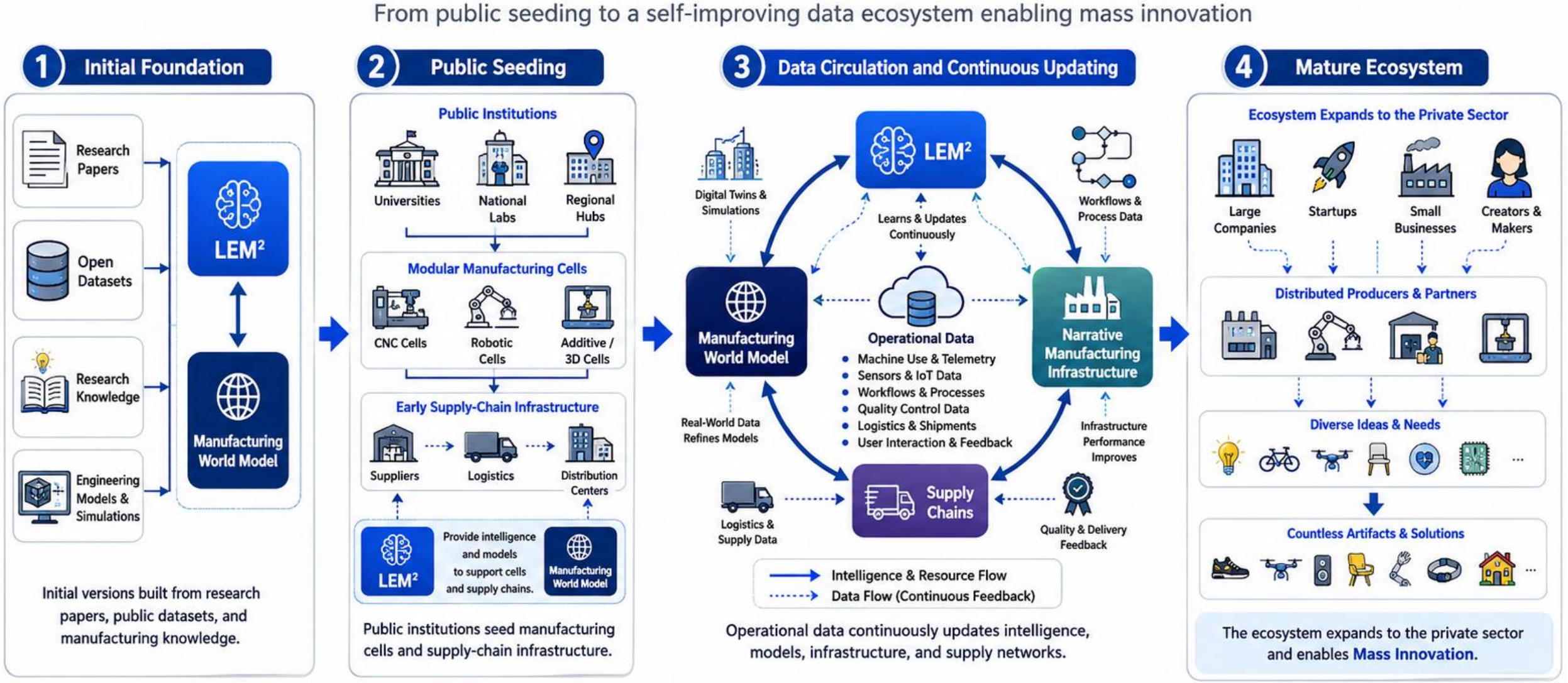
Manufacturing World Model (MWM)

- Unified representation knowledge, physics, and resources
- Links decisions to predicted physical outcomes through digital twins, simulations, and historical execution data

Closed-Loop Self-Evolving Manufacturing Intelligence

- Execute → Observe → Improve
- Human intent, feedback, shop-floor sensing, and simulation
- Autonomously update LEM^2 and MWM over time

Evolving Ecosystem for Narrative Manufacturing



Redesign Workforce & Education Systems

Workforce adaptation gap

Creator

Engineer

Operator

Three Types of Workforce in Narrative Manufacturing

- Creator: Turns ideas into products through natural language
- Engineer: Builds and evolves infrastructure, intelligence, and interface
- Operator: Maintains, replaces, and upgrades infrastructure

Education System for Narrative Manufacturing

- K-12: Narrative manufacturing literacy for everyone
  → Use maker projects and natural language-based design tools
- Community Colleges: Operators pathways
  → Offer certificates for digital manufacturing operations
- Universities: Creator-Engineer hybrid education
  → Teach students to move from intent to design, planning, and launch
- Graduate Schools: Engineer and research leadership
  → Develop experts to advance the core technologies
- Lifelong Learning: Continuous workforce adaptation
  → Keep the workforce aligned with next-generation manufacturing

Example of Narrative Manufacturing

Broader Impacts

1. **Manufacturing Democratization**
   - Enable every individual to become a creator
   - Lower barriers to equipment, software, expertise, and production networks

2. **Accelerate Innovation and Entrepreneurship**
   - Shorten the path from idea to product
   - Enable the long tail of diverse, personalized, and locally relevant products

3. **Workforce and Education Transformation**
   - Redefine human roles for the post-automation era
   - Build new pathways for creators, platform engineers, and operators

From Mass Production to Mass Innovation

Not the end of human participation. The beginning of manufacturing for everyone.

THANK YOU!

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