



2024 MIT Houston Symposium

Future-Proofing Your Operations

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Conference Summary: 2024 MIT Houston Symposium

Future-Proofing Your Operations

Thought leaders from MIT gathered with local industry executives at the 2024 MIT Houston Symposium, Future-Proofing Your Operations, to gain valuable insights on navigating the dramatic changes driven by global economic forces, emerging technologies, and evolving government policies. The event explored the transformative power of artificial intelligence (AI), workforce development strategies, groundbreaking advancements in manufacturing, shifting international trade patterns, and the impact of recent U.S. legislation on industrial policy.

U.S. manufacturing is undergoing a transformative period, driven by advancements in technology, shifting geopolitical dynamics, and new public policies. Key industries, such as transportation, semiconductors, defense, energy, and materials, are embracing digitalization, resilience, and sustainability to enhance their operations. This transformation is further bolstered by emerging technologies like digital twins, which are revolutionizing manufacturing through real-time control, data analytics, and machine learning to optimize production and reduce waste.

While concerns about technology displacing jobs persist, experts argue that automation can actually improve job quality and productivity. Strategies for "positive-sum automation" are emerging, showing how firms and workers can both benefit. In parallel, cybersecurity challenges are intensifying with the rise of GenAI-driven threats, requiring organizations to adopt a more resilient, proactive approach to digital security. In this evolving landscape, the integration of cutting-edge technologies is reshaping the way products are designed, manufactured, and brought to market, creating new opportunities for innovation and growth.



Industrial Transformation: A New Era of U.S. Manufacturing

Elisabeth B. Reynolds

Professor of the Practice, MIT Department of Urban Studies and Planning (DUSP)

Former Special Assistant to the President for Manufacturing and Economic Development

Former Executive Director, MIT Task Force on the Work of the Future and IPC

𝗞 Biography

The U.S. is at a pivotal moment for transforming its industrial base.

A number of forces – supply chain vulnerabilities, threats of climate change, geopolitical tensions and income inequality – are all driving toward a new policy paradigm. Advanced manufacturing technologies are also creating a new era for U.S. manufacturing.

A few steps that should be taken to strengthen the industrial base include:

Scale up:

To support technological innovation and scale, significant investment in capital and infrastructure is essential. Scaling emerging technologies, particularly in energy and manufacturing sectors, often requires billions of dollars and extended timelines. The U.S. must explore ways to accelerate this process through public-private partnerships, tax incentives, and innovative funding models, such as first-of-a-kind funds and insurance solutions.

As global competitors like China heavily subsidize their industries, the U.S. faces the challenge of closing the "missing middle" gap in capital funding.

Workforce development:

Workforce development is a critical area for addressing the evolving needs of the economy. As new technologies reshape industries, there is a pressing need to invest in training and upskilling the workforce. A focus on technical training and vocational education can create pathways to middle-class jobs, even for those without four-year degrees. Studies show that 40% of students who start a four-year degree do not finish in six years, underscoring the importance of alternative career tracks. Additionally, states like Massachusetts are expanding vocational training programs to better match worker skills with industry demand.





In terms of work of the future, technological change, while creating new types of jobs, is also contributing to economic inequality. As labor productivity growth has increased, it has not led to broadly shared income growth. According to research, 60% of today's jobs did not exist 80 years ago, highlighting the extent of transformation driven by technology. However, the shift has resulted in a "barbell economy" where low- and high-skilled jobs have increased, while the middle-skill jobs have decreased. As such, addressing income inequality and ensuring workers can adapt to technological change remains a key challenge.

Call to Action:

To ensure the U.S. remains competitive and inclusive in the face of rapid technological advancements, policymakers, businesses, and educational institutions must collaborate to invest in the scaling of innovative technologies, bridge gaps in workforce development, and ensure equitable economic opportunities for all workers. The time to act is now—future economic success depends on how well we prepare for and manage the evolving workforce landscape.







Scaling New Technologies That Improve Work

Ben Armstrong

Executive Director, MIT Industrial Performance Center

𝗞 Biography

When companies adopt new technologies, jobs change.

Often there is focus on what jobs are created and what jobs are destroyed. But there are also changes to the quality of jobs at the firms that adopt new technologies. At some firms, automation can improve productivity, but de-skill jobs, making work more routine and less skill-intensive. In other firms, the adoption of new technologies coincides with increased requirements for skill and problem solving, making work more interesting and higher paying.

The key question is under what conditions new technologies can support better work.

In early studies of the adoption of generative AI, it's unclear whether it's making work better. In one example, a large R&D organization that adopted generative AI to discover new materials, there were significant gains in the productivity of the researchers, but their tasks shifted from creativity and problem-solving tasks to ones that the researchers enjoyed less – and their self-reported job quality suffered.

> The key question is under what conditions new technologies can support better work.

Whereas headlines have focused on the dramatic potential impact of generative AI on work, early studies have not suggested dramatic changes in the near term. Instead, a more urgent challenge is a labor shortage in critical industries like manufacturing.

The labor shortage in manufacturing arises from a long-term decline in domestic manufacturing capability. For the past decade, manufacturing productivity has been declining, and wages have been flat.



One reason manufacturers have a difficult time recruiting new workers is because manufacturing jobs are no longer significantly better paying than alternatives. One reason manufacturers can't offer much higher wages to overcome the labor shortage is because they have not adopted new technologies to improve their productivity. This low-technology, low-wage equilibrium is the backdrop for the labor shortage. The labor shortage is a big problem because there is critical knowledge in how to make products that is being lost as highly skilled production workers retire. One of the key questions for policy and industry is how to mobilize the workforce development and technology adoption to address this problem. The one time that the United States has done this before was in 1940-1941 when the United States trained 3,000,000 workers to enter critical industries. This historical mobilization offers a promising example for current efforts to revitalize U.S. competitiveness.



Workers' perceived impact of automation on dimensions of their jobs





Panel Discussion: The Future of Work in the U.S.

Kathleen Kennedy

Executive Director, MIT Center for Collective Intelligence Senior Director, MIT Horizon

Panelists Elisabeth B. Reynolds

Professor of the Practice, MIT Department of Urban Studies and Planning Former Special Assistant to the President for Manufacturing and Economic Development Former Executive Director, MIT Task Force on the Work of the Future and IPC

Ben Armstrong

Executive Director, MIT Industrial Performance Center

Aurora Kennedy

TECH Recruiting, Training, and Development Manager, SLB

Cyrus Shaoul

CEO, Leela Al

Moderator

The panel discussed the future of work, highlighting the importance of adaptability, curiosity, and grit in future employees, along with the need for a balance between technology and human capabilities. They addressed misconceptions about AI, such as the idea that humans will be fully replaced by technology, and emphasized the ongoing need for human social cognition and creativity. The discussion also touched on generational trends, particularly younger workers' preference for job variety and the challenge of skill atrophy due to technology reliance. The panelists stressed the need for innovation in manufacturing, using advanced technologies to maintain U.S. competitiveness in a global market. Finally, they called for more cross-industry collaboration and education reforms to better align workforce skills with future needs, including expanding opportunities for diverse and underrepresented communities.

What's the one major misconception about the future of work?

A major misconception is that humans are replaceable by technology. Despite advances in Al, human qualities like social cognition and adaptability will remain crucial and irreplaceable in the foreseeable future.

How can companies keep people in the same profession for a longer period of time rather than just shifting roles?

Companies should offer variety and new challenges within roles, allowing employees to pursue diverse opportunities within the same organization to prevent them from seeking change externally.

How do you feel about the future of nomadic talent (job-hopping) and its effect on deep skill development?

Job-hopping is a response to the desire for new challenges; organizations should focus on providing diverse career paths internally to retain talent and support skill growth, rather than trying to stop turnover altogether.

What do you think about the idea of reshoring and the future of U.S. manufacturing, especially with the competition from Asia?

Key challenge in reshoring is competing with the lower labor costs in countries like China and other parts of Asia. Simply replicating old manufacturing models will not suffice, the U.S. must leverage advanced manufacturing technologies like AI, automation, and robotics to enhance productivity and reduce reliance on cheap labor. Investing in smarter, more efficient production processes that allow the U.S. to produce high-quality goods that can compete with international markets.

How can companies foster deep skills and long-term growth within their workforce, particularly in younger generations who often leave after a few years?

Companies can incentivize long-term engagement by offering career ladders, increasing wages, and investing in employee development to reduce turnover and deepen skillsets.

Is it realistic to benefit all stakeholders (engineers, management, workers) with Al tools?

Yes, it is possible to benefit all stakeholders if Al tools are used responsibly. Careful design and privacy protections can prevent misuse, ensuring that the tools improve productivity without exploiting or punishing workers.

How can organizations bridge the generational gaps in workforce expectations, like the younger generation's desire for new challenges every few years?

Companies can accommodate generational differences by offering variety, fostering career growth within the organization, and being open to new ideas from younger employees while maintaining long-term skill development.

What do you hope we'll be talking about five years from now regarding the future of work and technology?

In five years, the hope is to discuss how AI lived up to its promise, the importance of cross-industry collaboration, and the success of initiatives to energize younger generations and diversify the manufacturing workforce.





Cyber Resilience: Thriving in the Age of GenAl-Driven Threats

Keri Pearlson

Executive Director, CAMS (Cybersecurity at MIT Sloan)

𝗞 Biography

A Cyber resilience mindset is essential.

It goes beyond traditional cybersecurity protection. While a protection mindset focuses on defending against threats, cyber resilience emphasizes an organization's ability to respond to and recover from cyber incidents. This approach requires businesses to be prepared not just for protection, but for the inevitable challenges that arise when systems are compromised.

Cyber resilience integrates response planning, recovery strategies, and organizational adaptability into a cohesive approach to mitigate risks and ensure long-term business continuity.

A critical element of cyber resilience is the development of specific cyber crisis communication plans. Traditional crisis communication strategies often fail in the context of cyber incidents, where information may be limited or rapidly changing, or where stress is high and stakeholders are demanding a response. The unique characteristics of a cyber crisis-such as the uncertainty of the event and the need for guick, accurate communication require specialized planning. Companies must ensure their messaging is clear, consistent, and legally sound, while avoiding common pitfalls that can worsen the situation. For example, calling an event a 'cyber incident' could set up the organization for unintended consequences from key stakeholders such as litigation, unnecessary stress, costs, and hits to reputation. Planning cyber crisis communications is one component of a resilience mindset.*

> Planning cyber crisis communications is one component of a resilience mindset.



Building a culture of cybersecurity is another cornerstone of resilience. Training and awareness programs are not adequate to change behaviors. Instead a culture of cybersecurity creates the values, attitudes and beliefs that drive cybersecure and cyber-resilient behaviors.

Building a cybersecurity culture cannot be just the responsibility of the IT department alone. Every employee, from senior leaders to front-line workers, must understand their role in safeguarding the organization.

Embedding cybersecurity practices into the company's culture helps ensure proactive engagement and a collective responsibility for security.

Ultimately, achieving cyber resilience requires a shift in mindset from a focus solely on protection to a more holistic view that encompasses preparation, response, and recovery. This shift is crucial to fostering long-term security and resilience in an increasingly complex digital landscape.



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Data Analytics in the Smart Factory - From Digital Twins to Real-Time Control

Brian W. Anthony

Associate Director, MIT.nano Director, Immersion Lab Co-Director, Advanced Manufacturing and Design Program Technology Director, MIT Center for Clinical and Translational Research

N Biography

Digital twins are dynamic models that regularly integrate new data to simulate and predict system behavior. These models

continuously update based on live inputs, making them powerful tools for optimizing manufacturing processes and anticipating variations. A key advancement in leveraging digital twins is the blurring of lines between real-time feedback control and statistical process control (SPC).

Traditionally, real-time feedback control focuses on immediate, deterministic adjustments to maintain stability, while SPC analyzes long-term trends to detect and address variability. By combining these approaches, digital twins enable systems to dynamically adjust to immediate fluctuations while simultaneously learning from historical trends, bridging short-term operational goals with long-term process improvement. This integration enhances process efficiency and consistency, allowing manufacturers to respond proactively to variations and anomalies without manual intervention.

Decision trees are a simple, easy to interpret

ML tool. They are ideal for early adoption in manufacturing contexts where understanding model behavior is crucial. Decision trees work by asking sequential, information-rich questions about data features, making them intuitive and easy to visualize. This allows engineers and operators to identify actionable insights without requiring extensive technical expertise. In a predictive maintenance case example, decision trees efficiently analyzed operational data, such as torque signals, to detect machine wear, demonstrating how straightforward tools can deliver impactful results when combined with domain knowledge and proper data preparation.

Training a neural network is akin to fitting a

curve to data, where the network learns patterns and relationships within the data to make predictions. In the context of manufacturing, neural networks can predict the functional performance of mechanical parts using data collected during assembly operations. For an engine manufacturing case, inputs included torque vs. time curves for bolts, component dimensions, and assembly gaps, while outputs consisted of functional test results such as vibration behavior and torque resistance under pressurization.

The neural network effectively modeled the complex, non-linear relationships between these inputs and outputs, enabling accurate predictions of test outcomes. This approach reduced reliance on costly and time-consuming functional tests, while providing actionable insights to improve quality control. The case underscores the ability of neural networks to handle high-dimensional data and intricate relationships, empowering manufacturers to enhance efficiency and optimize processes.

Deep reinforcement learning (DRL) integrates real-time process control and long-term statistical learning within a unified framework, making it a powerful tool for advanced manufacturing. In the context of fiber manufacturing, DRL was employed to maintain consistent fiber diameter despite variations in raw materials and environmental conditions.

The system dynamically adjusted parameters such as temperature and pulling speed in real time while simultaneously leveraging historical data to refine and improve control strategies over time.

This approach effectively bridged the gap between short-term deterministic adjustments and long-term trend analysis, enabling continuous adaptation and optimization of the manufacturing process. While DRL showcased its potential to significantly enhance process efficiency and product quality, the study highlighted the **critical need for robust foundational practices, including precise instrumentation and reliable data collection**, to fully harness the capabilities of such advanced machine learning techniques.

Twins are Models ... models that serve

Twins are Digital Models fed by a rich data thread.

· And used to predict outcomes

Twins are not new.

But technology is rapidly developing

Twins are not identical.

· The ability to predict the physical is the value





... models that serve as **REALTIME** digital counterparts of a physical object or process.



Many type of twins:

- Of process
- Of a machine
- Of a factory
- Of a supply chain





Panel Discussion: The Future of Operations

Moderator	Kathleen Kennedy Executive Director, MIT Center for Collective Intelligence Senior Director, MIT Horizon
Panelists	Keri Pearlson Executive Director, CAMS (Cybersecurity at MIT Sloan)
	Brian W Anthony Associate Director, MIT.nano Director, Immersion Lab Co-Director, Advanced Manufacturing and Design Program
	Technology Director, MIT Center for Clinical and Translational Research
	Robert Scott Managing Director of the Americas, Technip Energies
	Erik Lee

Senior Director, Halliburton

The panel discussed the challenges and opportunities of integrating advanced technologies like AI, the metaverse, into industries, particularly focusing on how they impact safety, trust, and efficiency. A key point was the importance of building trust mechanisms proactively, to avoid losing customer and employee confidence after a crisis. The panel discussed the balance between hype and reality. For example, while the metaverse holds potential for specialized applications like safety training, its costs and limited scalability have hindered broader adoption in industries like oil and gas. Looking ahead, they hope that cybersecurity will become seamlessly integrated into everyday operations, enabling organizations to focus on strategic technology applications like AI and quantum computing for competitive advantage.

How do we start rebuilding trust?

Rebuilding trust requires transparency and proactive efforts to build trust mechanisms before an incident occurs, such as appointing a Chief Trust Officer, creating trust advisory boards, and fostering open communication to ensure stakeholders feel secure even when crises arise, and engaging and incentivizing the entire workforce to commit to best cybersecurity practices. Transparent, proactive communication with customers and employees before an incident happens is key.

What do you think is preventing the metaverse and 3D environments from delivering real business value? Is the metaverse useful for industrial applications?

The high cost of building and maintaining metaverse technologies and the lack of significant value generation make it difficult for organizations to justify large-scale investments, especially when the return on investment is not clear or immediate. The metaverse could be valuable in simulating dangerous situations for safety training, allowing workers to experience real-time decision-making without the risk of actual disaster, although these applications remain niche and still face significant scalability and adoption hurdles. It has not yet proven to deliver substantial business value or scale effectively in industries like oil and gas due to cost and technical challenges. Perhaps, the application of metaverse will be revisited once the cost goes down.

What are the biggest misconceptions about AI?

Al can replace people (in reality, humans provide context), Al has all the answers (a dangerous misconception that can lead to unintended consequences).

How do we manage technologies at scale?

Effective management of technologies at scale requires focusing on sharing lessons learned and supporting workforce transitions as technology evolves. A strong organizational culture and support system will be crucial for managing these changes as well as clear communication on what these new tools are doing to create value. Companies need to prioritize where they invest money and they chose solutions that create value internally and externally, as oppose to choosing the cool tech. Transparency about what the new technologies can and cannot do is important.

How do we manage people doing new roles in the workforce as we scale new technologies?

Building systems that support workforce transitions is key, along with fostering a culture that encourages adaptation to new roles. Clear role definitions and expectations will be crucial as technology scales. Developing workspaces where humans are in the loop. Upskilling the human so that they can use the technologies in a collaborative way to get a better outcome than the outcome we have today.

What do you think we will be talking about in five years?

How scalable technologies enhanced safety and efficiency on dangerous work sites, promoting more sustainable yet affordable practices. The hope is that cybersecurity is expected to become seamlessly integrated into operations, allowing companies to focus on leveraging emerging technologies such as quantum computing and AI for strategic business advantages. The shift in focus will be towards using these technologies to drive innovation and create competitive advantages at scale.



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Presenting Startups





Ali Merchant Founder & CEO, iQ3Connect **% ig3connect.com**

Immersive 3D Learning & Collaboration Platform

iQ3Connect is revolutionizing how complex industries, like aerospace and advanced manufacturing, train and collaborate through highly scalable 3D virtual environments. Our platform allows companies to digitize intricate products and processes, making them accessible in real-time to teams globally, reducing the need for physical interactions and enhancing workforce development. With seamless browser-based access and minimal training, iQ3Connect is transforming how organizations approach design, training, and operational efficiency at scale.



Shiv Bhakta Co-Founder & CEO, Active Surfaces So activesurfaces.xyz



Lightweight, Flexible Solar Technology Accelerates Adoption in the Built Environment

Active Services is revolutionizing solar energy with a lightweight, flexible, and cost-effective solution that can be deployed anywhere, from building facades to rooftops. Unlike traditional silicon-based panels, our technology uses locally sourced materials, offering faster installation, 10x lighter form factor, and no dependency on global supply chains. With our MIT-developed technology, we're making solar more accessible and sustainable than ever before, accelerating solar adoption globally at a fraction of the cost.





Andy Wang CEO, Prescient Devices

Scaling Data and AI for Energy

We help companies overcome their biggest data challenges by building large-scale, AI-powered data solutions that streamline and accelerate data processing. Using graphical workflows, we create real-time data pipelines and operational digital twins that convert massive raw industrial data into actionable insights. Our innovative technology reduces engineering time by up to 95% and optimizes data processing at low compute cost, helping organizations improve operations, reduce costs, and scale rapidly across hundreds of sites.





Cyrus Shaoul CEO, Leela Al

⊗ leela.ai

AI that Improves Safety and Performance in Manufacturing

Leela Al leverages a novel approach to machine vision to track and analyze human-centered operations in manufacturing environments, providing real-time insights into quality, safety, and operational efficiency. By using off-the-shelf cameras and a visual causal learning engine, we capture detailed metrics on interactions between people, tools, and equipment, enabling managers to identify inefficiencies and mitigate safety risks instantly. With both cloud and on-prem solutions, we help companies improve performance without needing to invest in new machinery or personnel, driving clear ROI through enhanced operational intelligence.



MIT INDUSTRIAL LIAISON PROGRAM

The MIT Industrial Liaison Program (ILP) provides facilitated access to MIT resources and expertise. Approximately **200 global member companies connect with MIT** through this program, the oldest and the largest program of its kind in the world.

The ILP is designed to help companies with a broad range of needs and interests.

Typically, companies come to MIT to:

- Anticipate and prepare for disruptions in technology and business models
- Gain cohesive multi-faceted understanding of the rapidly changing global landscape
- Discover and monitor new technology developments
- Discover new market opportunities
- Validate or invalidate key investment decisions
- Recruit top talent

ILP membership services include:

A dedicated program director

A professional who learns your needs and interests to help navigate the complex and decentralized MIT ecosystem

Meetings with faculty

Identifying relevant experts and arranging meetings with MIT faculty, consortia, labs, and centers

MIT Startup Exchange

We connect you with over 800 MIT-connected startups for partnerships

Conferences / webinars

Free access to over 20 ILP conferences and webinars arranged by the ILP at MIT, around the world, and remotely via Zoom and live streaming

Research workshops / executive briefings On emerging or disruptive technologies, or other areas of interest

Recruitment opportunities
 For internships and employment

Identify opportunities

Assistance with identification of opportunities for sponsored research, consortium membership, visiting scholars, and IP licensing

Continuing education

Guidance and discounts to MIT continuing and professional education programs

Knowledge base

Access to our database of MIT research and projects



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MIT STARTUP EXCHANGE

MIT Startup Exchange supports MIT-connected startups to grow, expand, and solve the world's great challenges by fostering partnerships and collaboration with industry members of MIT's Industrial Liaison Program (ILP), the MIT Innovation Ecosystem, and beyond.

MIT Startup Exchange has a customized approach to exposing and connecting startups to a global network of industry leaders.

MIT-connected startups are (co) founded by MIT alumni, faculty, or staff, based on MIT-licensed technology, and are vetted and supported by MIT peers. Currently, the MIT Startup Exchange network has about 800 technology-based startups.

Startups eligible for the program are mostly B2B and are in or past the pilot stage. They may be working in any sector and located in any country. The industry side of the Exchange is represented by over 200 ILP member companies. Companies use the ILP to help monitor MIT research developments, identify MIT resources of interest, arrange face-to-face and remote meetings with MIT faculty, advise on research sponsorship and technology licensing opportunities, and engage with startups part of the MIT Startup Exchange. MIT Startup Exchange and the ILP are integrated programs of MIT Corporate Relations.

Shortening cycles of innovation is mission-critical for technology-based companies, and many are collaborating with startups to fast-track disruptive, game-changing products and services. Partnering with high-caliber MIT talent is especially effective in pioneering solutions and applications for complex technologies.

Every year over 600 highly curated interactions are facilitated to expose and connect startups to industry.

MIT Startup Exchange has a customized approach to exposing and connecting startups. Once startups join the program, they move at their own pace. Startup Exchange doesn't have boot camps, deliverables, or deadlines. It doesn't charge any fees or take equity.

The program focuses on founders, offering them advice and unique, on-campus and oversees opportunities to help them engage with industry and explore collaborations and partnerships. Throughout the year, founders have curated access to:

- A global network of industry Exclusive calls for startups leaders coming from 200+ ILP member companies
- 1:1 meetings with key players
 Pitching sessions and of innovation ecosystems
 - Founders network

exhibits

based on challenges

industry is facing

- Conferences and speed-networking events
- Training

As a result, startups work together, leveraging expertise, assets, infrastructure, and capabilities. Typically, success cases include proofs of concept, pilots, scaling operations, and access to new markets.



For more information on MIT Startup Exchange, contact:

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STEX25 is a group of startups within the MIT Startup Exchange network that receives tailored support throughout one year. The group comprises 25 "industry ready" startups referred by MIT peers of Startup Exchange. Each startup is interviewed to assess fit. Selected startups are then assigned to a Startup Exchange team member who coordinates support, which includes increased visibility and introductions to ILP members. At the end of the twelve months, startups leave STEX25 and can stay in the MIT Startup Exchange program for as long as they are a startup.

MIT-connected startups are periodically referred for STEX25 by leaders of MIT's startup ecosystem, including faculty, the Martin Trust Center for MIT Entrepreneurship, E14, Sandbox, the Venture Mentoring Service, and Engine Ventures.

Connections, Relationships, Global Impact

