US
Center for
Advanced
Manufacturing

In collaboration with
the World Economic
Forum and Accenture

Playbook January 2024

Enabling Business Model Innovation in Manufacturing

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Future-Proofing Innovation

This playbook was built inside out

Insights from leaders for leaders

The manufacturing industry has been evolving at an unprecedented speed in recent years. To craft this playbook, we delved inside the minds of industry thought leaders who are navigating the multifaceted challenges that define the current manufacturing terrain. Developed against the backdrop of evolving industry dynamics, this playbook is a strategic compass to guide discussions about transformative technologies and innovative talent strategies that are imperative for shaping the future of manufacturing.

Over a span of twelve months, the US Center for Advanced Manufacturing, in collaboration with the World Economic Forum, Purdue University, and Accenture, engaged more than 30 manufacturing leaders to build this playbook. Ranging from plant managers to CEOs and encompassing a wide array of industry perspectives, the playbook's methodology involved conducting individual interviews and industry round-table discussions. These discussions explored a wide range of topics, including; the catalysts driving the need for business model transformation, priority technologies to enable business model innovation, opportunities, challenges, and barriers that keep innovation just out of reach.

In addition to input from industry leaders, this playbook leverages findings from a number of detailed studies, including *Industrial Speedsters Study,* and *Rethink, Reinvent, Realize: How to successfully scale digital innovation to drive growth*, as well as an examination of over fifty manufacturing technology trends. The goal was to pinpoint technologies that empower the manufacturing industry to elevate its competitive edge and enable business model innovation. Starting with the successes and lessons hard-won by industry innovators, we've reverse-engineered their approaches to achieve the same.

Cynthia Hutchinson
CEO,
US Center
for Advanced
Manufacturing

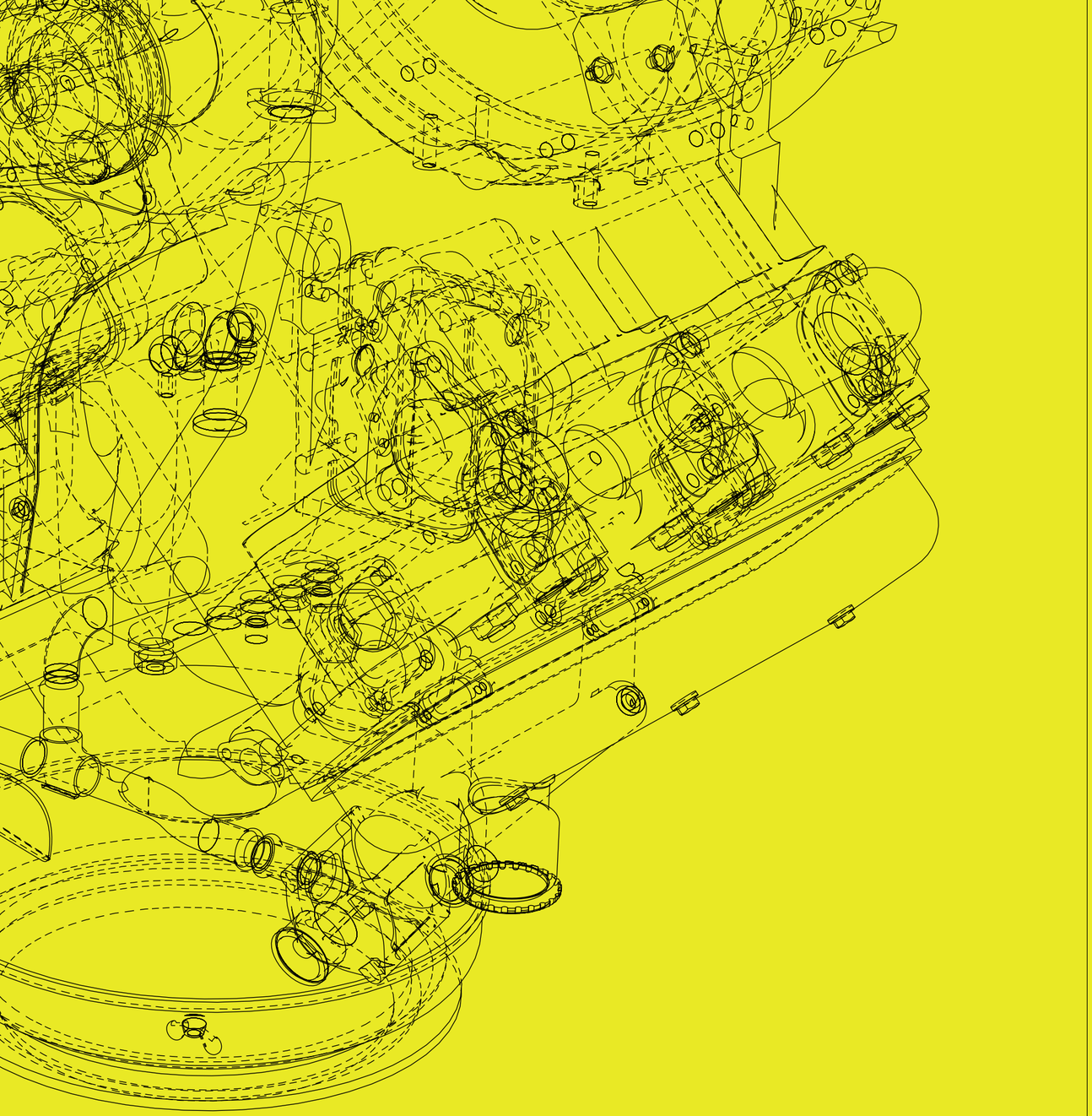
Executive Summary

The goal

This playbook aims to equip manufacturing executives and their teams with the tools and philosophies to build robust, repeatable innovation programs, to achieve business model innovation. The playbook explores a wide variety of topics relevant to manufacturing leaders.

This playbook includes the following key findings:

- **Organizations who innovate, and use new technologies well, can expect real benefits**, where organizations who don't, risk falling behind competitors. Innovation must be a priority now, due to rapidly evolving technology, and industry headwinds.
- **Manufacturers face a number of industry-wide challenges**, including; decarbonizing manufacturing operations, enhancing supply chain transparency and resiliency, speeding up scale up of new technologies, securing the future of the manufacturing workforce, and linking business value with social and environmental responsibility.[4]
- **New and evolving technologies are positioned to address these challenges**, including; digital twins, connected worked platforms, intelligent asset management solutions, blockchain and supply chain collaboration tools, plant control towers, robotics and autonomous guided vehicles.
- **Within organizations, leaders face barriers to pilot and scale innovation**, including; resistance to change, outdated infrastructure, difficulty proving value to scale, limited partnerships, talent shortages and inadequate workforce upskilling, limited cross functional collaboration, siloed data systems, and lack of strategic planning.
- **When considering innovation, be deliberate to honestly assess the organizations starting point** and digital readiness, to uncover capability gaps, predict challenges, and identify organizational strengths.
- **Ensure the right capabilities for innovation are present**, through hiring, talent development, and external partnerships. Partnerships with universities help organizations establish an on-campus presence, connect with students, and can be used to shape curriculums to provide the next generation of talent with in-demand skills.
- **Run innovation through a structured process** from idea to scale, with focus on rapid experimentation to test hypotheses, governance structures with defined funding stage gates, quantitative value tracking, and processes to scale successful pilots across the organization.
- **Create a culture of innovation** within your organization and continuously work towards amplifying enablers of innovation in order to succeed in the above.



The Imperative for Business Model Innovation

What this section covers

The Imperative for Innovation

Leaders in manufacturing stand at the crossroads of tradition and transformation. They face a pivotal decision: lean into innovation or defer investment and maintain business as usual.

While manufacturing continuous improvement is largely incremental, technology-led innovation, when focused, is disruptive and impactful. If it feels like the pace is accelerating, that's because it is. A composite measure of economic, social, and other factors show levels of technological disruption increased 200% from 2017 to 2022.[1] In large part triggered by the COVID-19 pandemic, organizations around the world are experiencing unprecedented technology adoption and consolidation cycles, known as the "S-curve," that show no sign of slowing. In a world where digitization, automation, and artificial intelligence (AI) are reshaping the foundations of manufacturing, relying on legacy technology equates to falling behind. Over 93% of companies are expanding their technology infrastructures, and half plan to invest in AI and cloud services in the near term.[1]

The Fourth Industrial Revolution isn't a distant future—it's here today. Leaders who seize opportunities to innovate position their organizations in the vanguard of this revolution, ready to harness the full potential of cutting-edge technologies that optimize efficiency and enhance productivity.

While challenging, innovation in manufacturing is achievable with the right approach. It's important for leaders and organizations to understand the common obstacles facing innovation and how to bypass them. Numerous technology providers compete for attention in the industry, making it difficult for manufacturers to navigate the noise and understand the right path for their organizations. The global, technological, and societal environment is evolving rapidly, creating challenges for manufacturers to stay competitive, meet changing consumer expectations, maintain profitability, and embrace sustainability.

Competition is fierce, and innovators who embrace reinvention as a strategy gain a distinct advantage. Whether it's streamlining supply chains, adopting sustainable production practices, or integrating smart manufacturing processes, innovation becomes a strategic differentiator. Organizations that innovate now will not only accelerate ahead of peers, but set industry standards, attract top talent, forge strategic partnerships, and establish positions as leaders in a dynamic market.

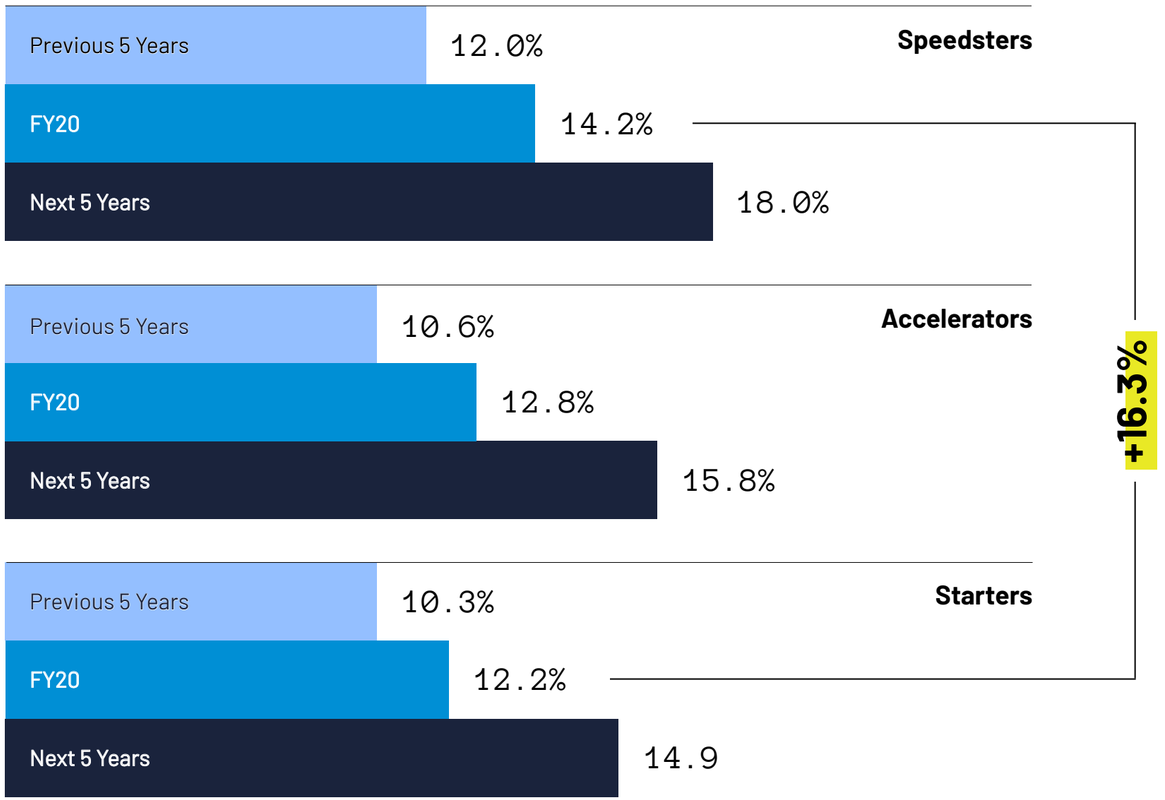
For leaders in manufacturing, innovation may seem like a choice, but it's not. Rather than thinking of innovation as discretionary, leaders must think of innovation as necessary, to keep their organizations future-focused and relevant. Benefits extend beyond immediate gains, shaping the trajectory of organizations, industries, and the future of manufacturing itself. The time for innovation is now, and leaders who answer the call will not only survive but thrive in the changing manufacturing environment of the future.

Scott Ellswoth
Managing Director,
Accenture

Organizations who innovate, and use new technologies well, see real benefits

In a robust study of 1,200 executives at global industrial companies, organizations deemed as "speedsters", or those most successful implementing innovation, are the most profitable and forecast higher profitability in 5 years.[2]

Average EBIT Margin[2]



Defining Business Model Innovation

A consistent definition of “business model innovation” provides a shared understanding, a shared understanding to inform the following content.

The **iterative process** of ideation, creation, and delivery to create new value and realize benefits.

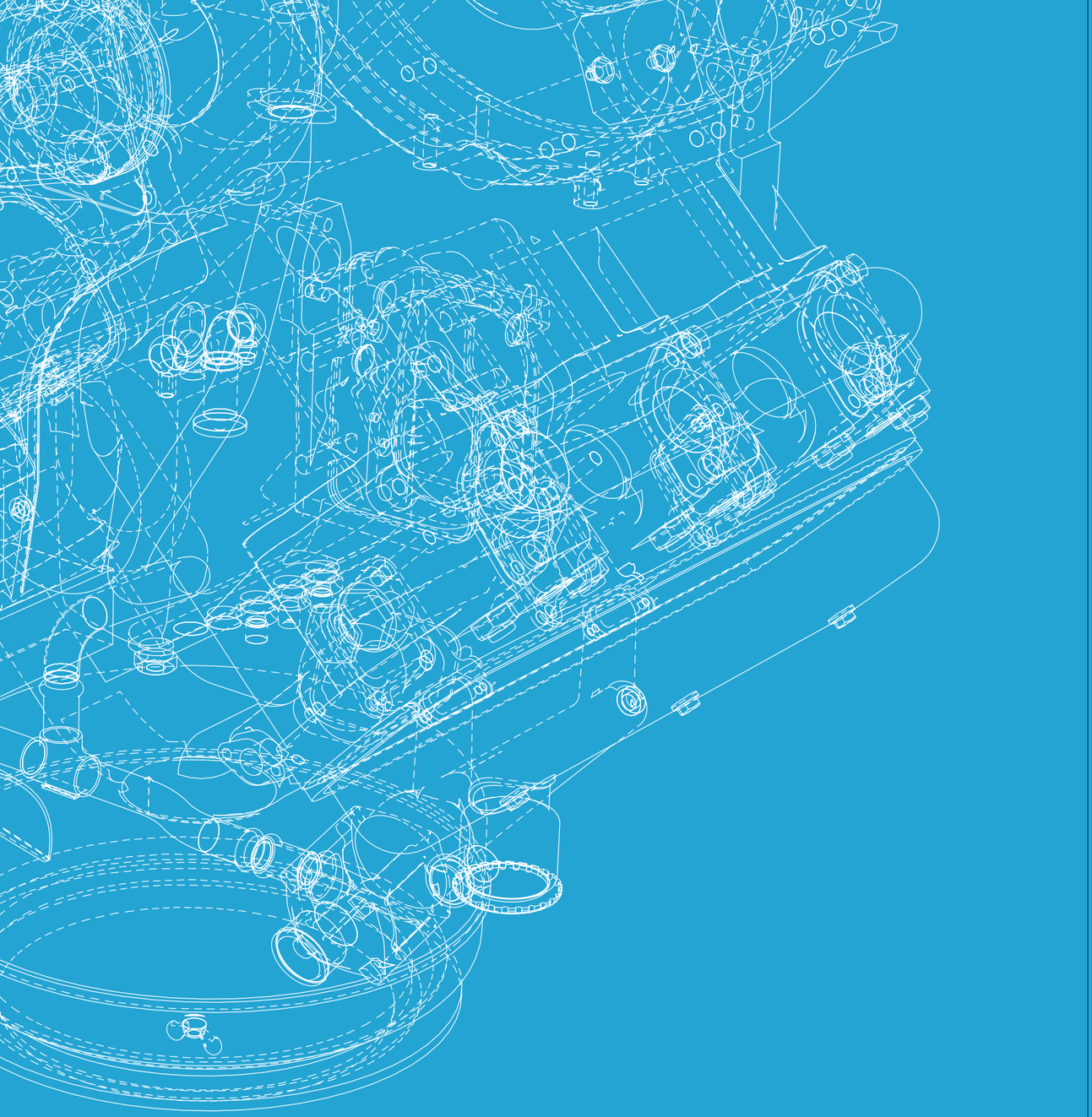
Gain a **competitive advantage** through organizational expansion of diversified and **compelling value propositions**.

Business Model Innovation is the creation of a **new** way to **generate, deliver, and capture substantially** more **value.**

This can mean new to the **world** overall, the **organization**, or the **consumer**.

Aim for **exponential delivery of value (e.g. 10x)** to fuel new ways of thinking and **deliver value that requires bold action**.

Generate and adopt new value for **consumers**, the **enterprise**, or the **supply network** at scale.



The Innovation Opportunity for Manufacturers

What this section covers

Grand manufacturing challenges

In its *The Future of Industrial Strategies: Five Grand Challenges for Resilient Manufacturing*[4] white paper, the World Economic Forum outlines challenges faced by manufacturing organizations amidst global disruptions and technological advancements. It addressed five grand manufacturing challenges driving the need for innovation and new business models:

01 **Decarbonizing manufacturing operations, production, and supply chains**

Manufacturing is vital, but its emissions threaten climate goals. Industrial reduction is complex because of diverse processes. Transitioning to green technology can be costly and complicated but essential for creating a sustainable industry.

02 **Enhancing supply chain transparency and resiliency**

Amid production shocks and inflation, balancing efficiency and resilience is crucial. Manufacturing is vital for national security and daily life. While lean practices increase profitability, they risk supply chain disruptions. Global events and cyberattacks necessitate adaptive, secure supply chains.

03 **Speeding up the scale-up and deployment of new technologies**

Innovation in manufacturing faces dual challenges: scaling new technologies and accelerating the deployment of existing ones. Adoption barriers hinder firms from using valuable technologies, especially those integrating digital technologies into legacy systems.

04 **Securing the future of the manufacturing workforce**

Manufacturers face pressing workforce challenges. While new technologies create jobs and debunk the "jobless future" myths, they demand advanced, multidisciplinary skills. Despite ample opportunities, talent attraction is being hindered from outdated perceptions, retiring workers, and fragmented education systems.

05 **Linking business value with social and environmental responsibility**

Organizations must balance corporate social responsibility costs with profitable opportunities. Beyond environmental responsibility, manufacturers face pressures for open governance, social development, and workers' rights.

Addressing these challenges has the potential to usher in a new era of strategic solutions and operational paradigms for the manufacturing industry.

Beyond novelties, manufacturers must have a strategic understanding of how these technologies can forge new business models built around a digital core where innovation is a competitive advantage. Such organizations embrace the edge computing, cloud-native applications, and security by design. They embed a mindset to continually reinvent themselves in their cultures to not only increase stakeholder value but to become more resilient to disruption.

Companies with a strong digital core grow their revenues faster than their less agile competitors, and those who take advantage of AI and sophisticated data analytics capabilities can find answers to questions they didn't know to ask.

The convergence of technology and strategy reveals a pathway for manufacturers toward a future where efficiency, sustainability, and resiliency intertwine seamlessly.

Adopting new technologies **addresses manufacturing issues**, **enables new business models**, and **allows for resiliency** in the face of constant change.

Leaders are prioritizing investments in tech to compete

What that means

Business leaders acknowledgment of the grand manufacturing challenges can be seen through investment in, and focus on, technology and innovation.

Manufacturing is on the threshold of realizing substantial gains from state-of-the art technologies, yielding favorable outcomes for stakeholders, customers, employees, and the environment.

94%

Of C-suite executives surveyed anticipate increasing technology spending in 2024.[1]

#1

Globally, the C-suite's top concern going into 2024 is adapting to advancements in technology and innovation.[3]

Leaders must prioritize investments in digital manufacturing transformation and technologies that reduce production time, cost and create new opportunities for the future.[14]

Dr. Samit Ghosh, Senior Managing Director, Accenture

96%

of executives agree that the convergence of digital and physical worlds over the next decade will transform their industry.[3]

6 technologies are positioned to help address manufacturing challenges

A study of 1,200 global executives in industrials identified technologies poised to drive cost reductions and time savings in the next 5 years for industrial organizations. Leveraging these technologies, and layering in input from a group of North American manufacturing leaders,

6 technologies were identified to help organizations overcome grand manufacturing challenges.[2]

The following section deep dives into the specific technologies and explores their impact to solving the grand manufacturing challenges.

01

Factory digital twins for simulation-based decision making

02

Connected worker platforms for workforce enablement

03

Intelligent asset management for improved asset health

04

Blockchain and supply chain collaboration tools

05

Plant control towers

06

Robotics and automated guided vehicles to enhance productivity and safety on the floor

The 6 technologies identified can be used to address the grand manufacturing challenges

What this means

Manufacturers face a number of grand challenges. Innovation can address these challenges, and create new opportunities for manufacturers to provide value to shareholders, employees, customers and the environment.[4]

Grand Manufacturing Challenges

Manufacturing Technologies	Decarbonizing manufacturing operations, products, and supply chains	Enhancing supply chain transparency and resiliency
Factory Digital Twin	Increased efficiency and reduced material consumption ✓	Increased resiliency of supply chains through real-time transparency enabled by IoT ✓
Connected Workers Enablement Platforms		
Intelligent Asset Management Solutions	Better asset monitoring and emissions management through analytics ✓	Improved asset reliability through intelligent forecasting and predictive maintenance ✓
Blockchain and Supply Chain Collaboration Tools	Emissions reductions through increased supply chain transparency ✓	Transparency across the supply chain allows for better planning ✓
Plant Control Towers	Reduction in energy, emissions and waste due to end-to-end plant visibility ✓	
Robotics and Automated Guided Vehicles	Increased asset efficiency, and reduction in carbon emissions ✓	

Grand Manufacturing Challenges (continued)

Speeding up scale-up and deployment of new technologies	Securing the future of the manufacturing workforce	Linking business value with social and environmental responsibility
Shortened time-to-market through simulations and optimization ✓	Improved worker performance through real time decision making ✓	
Increased worker productivity enabled by data ✓	Enhanced worker training to rapidly and continuously upskill tomorrow's workforce ✓	
		Increased traceability of raw inputs allows for more ethical sourcing ✓
Reduced time to implement new applications across the plant ✓	Empowered worker collaboration and interaction with complex factory systems ✓	
Increased efficiency of launching new technologies ✓		Increased worker safety through automation of high risk activities ✓

More information on grand challenges can be found in the World Economic Forum's "The Future of Industrial Strategies" report.

Digital Twins for Simulation-Based Decision Making

What is a digital twin?

A digital twin is a virtual replica of a physical object or system, that uses real-time data to simulate outcomes.

Digital twins can help organizations to simulate manufacturing processes to optimize production efficiency, reduce waste, minimize downtime, and identify problems before they occur.

Context note: A study of 1,200 executives at global industrial companies found that digital twins helped "speedsters", defined as organizations with the highest level of cost and time reductions in the past 5 years, realize 3.8% production time savings over the last five years, and are forecasted to save another 4.3% in the next five years. Similarly, digital twins saved 3.2% of production costs in the last 5 years, and are forecasted to save another 2.6% of production costs in the next five years.[2]

01

Value Proposition for Digital Twins

Better Workforce Decision Making

Digital twins present real-time simulations, offering workers intuitive visualizations and enhancing decision making. Workers receive actionable data promptly, allowing swift and informed actions.

Continuous Improvements

With digital twins, autonomous systems learn and adapt, forming intuitive closed-loop systems that can predict and respond to human behavior. As the technology matures, operators can focus on more complex tasks while routine operations are streamlined, fostering an environment of continuous improvement.

Predictive Analytics

Predictive analytics can guide actions to make smart decisions about machines, production, or maintenance and reduce costs and downtime.

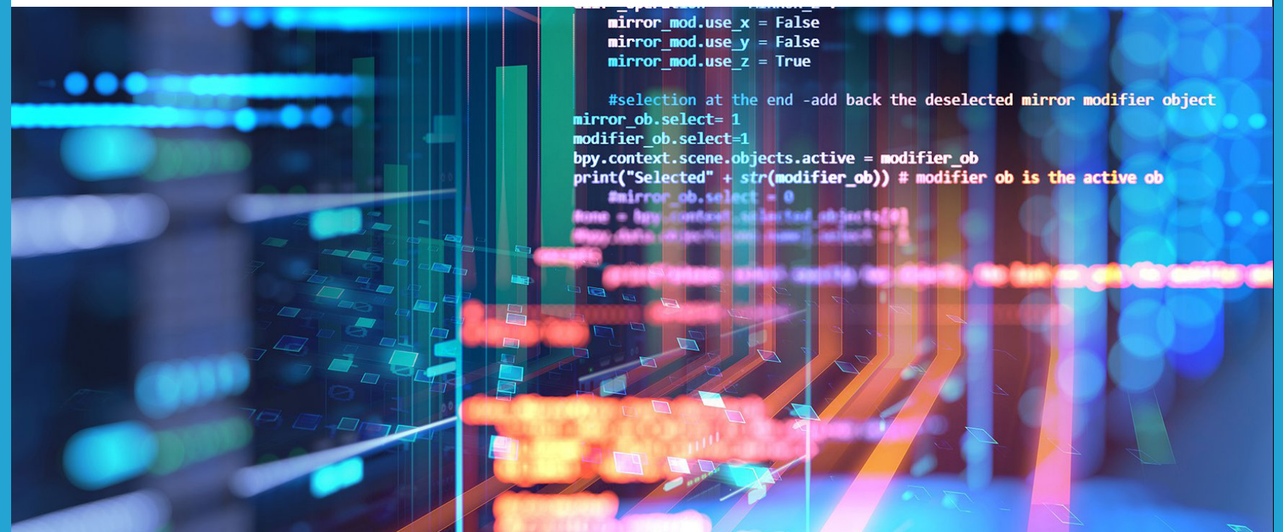
Grand Manufacturing Challenges Solved
Decarbonizing manufacturing operations, products, and supply chains
Enhancing supply chain transparency
Speeding up scale-up and deployment of new technologies
Securing the future of the manufacturing workforce

Barriers to Implement Digital Twins
Siloed data systems
Outdated infrastructure
Limited partnerships

Digital Twins in Action

Case Study: The Future of Manufacturing: Insights-Driven Factories Powered by Digital Twins

Mars, a global leader in food, pet care, and confections, faced challenges overfilling packages. Mars implemented a digital twin, which fed sensor data into a predictive analytics model, allowing operators to monitor and adjust the filling process in real time, leading to a 50% reduction in overfilling. Mars is now using digital twin technology globally to develop an insights-driven "factory of the future."[5]



Sample use cases of this technology in manufacturing:

Example 01:
An automotive OEM uses a digital twin of its manufacturing processes to test the effect of new tooling technologies on overall shop throughput to make faster production decisions.

Example 02:
A digital twin helps a toy manufacturer to predict product demand and simulate raw material supply chains to optimize order timing and quantities.

Example 03:
A food manufacturer uses a digital twin to simulate major agricultural events and weather-pattern effects on crop supply to manage warehousing levels and schedule product runs.

Take a moment to reflect on the opportunity digital twins create at your organization:

How might we use digital twins to improve efficiency and reduce downtime?

How might we virtually simulate changes in a plant to understand the impact a change would have?

Connected Worker Platforms

What is a connected worker platform?

Connected worker platforms helps to enable workers with data insights via portable tech to enhance productivity, safety, or reduce errors. Connected workers platforms can take many forms, including handheld devices, wearables, or extended reality technology.

Context note: A study of 1,200 executives at global industrial companies found that warehouse extended reality tools saved "speedsters", defined as organizations with the highest level of cost and time reductions in the past 5 years, 6.1% in distribution time in the last five years, and are forecasted to save another 6.1% in the next five years. Similarly, warehouse AR/VR tools saved 4.6% of distribution costs in the last 5 years, and are forecasted to save another 5.0% of distribution costs in the next five years.[2]

02

Value Proposition for Worker Platforms

Remote Assistance

Embrace the "over-the-shoulder" paradigm, where field workers receive real-time, remote support. This interactive guidance ensures swift and dependable resolution of challenges.

Enhanced Learning

Redefine the boundaries of workforce education by providing workers on-the-job coaching and training, increasing productivity and reducing nonproductive learning time.

Quality Control

Transcend traditional quality checks. Allow a digital-first approach that refines assurance, audit, and inspection protocols, reducing errors and the need for rework.

Plant Safety

Infuse digital prowess into safety protocols. With advanced digital reporting mechanisms for incidents and near misses, coupled with digital checklists, it's possible to reinforce compliance and preempt potential risks.

Grand Manufacturing Challenges Solved
Securing the future of the manufacturing workforce
Speeding up scale-up and deployment of new technologies

Barriers to Implement Worker Platforms
Resistance to change
Inadequate workforce upskilling

Connected Worker Platforms in Action

Case Study: Transforming Global Safety With a Connected Worker Solution

Cummins, an American multinational corporation specializing in diesel and alternative fuel engines and generators, leveraged Anvl's mobile app to design smart workflows, allowing technicians to communicate easily with managers about safety questions or concerns.

This new platform has promoted safety, improved efficiency, and motivated proactive safety changes with an overall 90% adoption rate across 5,000+ employees. As a result, leaders are now able to use Anvl's data to ensure compliance, make continuous improvements, access actionable metrics and analytics, and make informed, data-driven safety decisions.[6]

Sample use cases of this technology in manufacturing:

Example 01:
A chemical manufacturer uses wearable smart devices to warn workers about entering dangerous areas and then shuts down machines when risks are possible.

Example 02:
A manufacturer who provides post-sales service uses connected video cameras to allow field service technicians to connect with service centers for unknown or unfamiliar repairs, reducing rework and quickly upskilling field employees.

Example 03:
A manufacturer of consumer goods uses RFID scanners on parts bins to ensure operators obtain correct parts for product assembly, providing visual indicators for successful component selection.

Example 04:
A large machinery manufacturer's product development team uses virtual reality headsets to simulate challenging installation operations.

Take a moment to reflect on the opportunity connected worker platforms create at your organization:

How might we augment workers with technology to help them learn new skills and enhance their training opportunities?

How might connected worker solutions improve safety conditions at a manufacturing site?

Intelligent Asset Management for Improved Asset Health

What is intelligent asset management?

Intelligent asset management uses a combination of Internet of Things (IoT) sensors, data, and analytics to unlock trapped value from assets. Data is the bedrock of key enterprise initiatives, but successful adoption of intelligent asset management requires focus on the right data elements linked to prioritized use cases.

Context note: A study of 1,200 executives at global industrial companies found that connected machinery saved "speedsters", defined as organizations with the highest level of cost and time reductions, 4.6% in production time in the last five years, and are forecasted to save another 4.2% in the next five years. Similarly, connected machinery saved 2.0% of production costs in the last 5 years, and are forecasted to save another 2.6% of production costs in the next five years.[2]

03

Value Proposition for Asset Management

Maintenance Productivity

Monitoring assets with IoT sensors and predictive analytics reduces downtime and can make maintenance activities more productive. The ability to anticipate wear on machines allows organizations to schedule maintenance and workforce requirements for repairs. Predicting asset failures in advance reduces reactive maintenance costs and contractor costs.

Asset Sustainability

Effective asset management means better capital allocation for sustainable management of infrastructure and asset portfolios. Sourcing energy-efficient assets reduces energy overhead and drives resource efficiency.

Production Throughput

Unplanned downtime significantly affects overall equipment effectiveness. Increasing equipment uptime through better monitoring results in increased throughput and decreased waste.

Energy Usage and Emissions Management

Asset monitoring and analytics to detect energy usage increases visibility of greenhouse gas emissions across the value chain and equipment-level optimization to reduce energy intensity. Reducing emissions minimizes the environmental impact of manufacturing plants.

Grand Manufacturing Challenges Solved
Decarbonizing manufacturing operations, products, and supply chains
Enhancing supply chain transparency

Barriers to Implement Asset Management
Difficulty demonstrating value at scale
Inadequate workforce upskilling

Intelligent Asset Management in Action

Case Study: Preventative Maintenance

Automotive supplier Marelli implemented a innovative program within their factories to enhance capabilities and monitor asset efficiency. By doing so, Marelli empowered their manufacturing teams to more effectively schedule maintenance activities around asset health, rather than fixed schedules.[10]

Sample use cases of this technology in manufacturing:

Example 01:
A small job shop uses intelligent asset management applications to identify open capacity across their assets to determine availability for new business.

Example 02:
An industrial manufacturer uses intelligent connected tooling to predict machine failures, allowing maintenance to preorder replacement components and schedule resources, reducing spare parts inventory levels and shop downtime.

Example 03:
A manufacturer that performs high-precision turbine blade machining uses connected cameras to capture and alert production teams to dimensional trends to adjust processes before parts are built out of specifications.

Example 04:
A manufacturer of consumer packaged goods uses intelligent asset management applications to allocate capital investment to lowest performing assets rather than focusing on asset age, run rates, or product lines to maximize the impact of investment decisions.

Take a moment to reflect on the opportunity intelligent asset management creates at your organization:

How might we get the most out of the physical assets in my plant?

How might we monitor and address asset issues?

Blockchain and Supply Chain Collaboration Tools

What is blockchain and supply collaboration tool?

Blockchain helps to maintain records of transactions to allow real-time access to data on a decentralized leger. The distributed nature of blockchain ensures that revisions or alterations cannot be made without updating other records, providing a layer of security and trust not found in centralized systems.

Supply chain collaboration tools allow for better upstream and downstream communication, planning, and feedback. This allows organizations to more efficiently deal with suppliers and time input delivery.

04

Value Proposition for Blockchain & Collaboration Tools

Connected Supply Chains

Leveraging blockchain and multi-party systems enables the move from a linear supply chain to collaborative, many-to-many networks. Blockchain also enables multi-party collaboration and partnership around a single source of truth.

Verification of Raw Materials

Shared data constructs improve transparency and traceability across the entire supply chain—from producer to consumer. This allows manufacturers to better understand where inputs come from and to assess sustainability and ethical sourcing.

Improved Logistics and Transaction Processes

Greater visibility on dispatch, transport, and delivery of goods ensures less disputes, and reduces documentation for regulatory and financing purposes.

Grand Manufacturing Challenges Solved
Decarbonizing manufacturing operations, products, and supply chains
Enhancing supply chain transparency and resiliency
Linking business value with social and environmental responsibility

Barriers to Implement Blockchain & Collaboration Tools
Resistance to change
Inadequate workforce upskilling

Supply Chain Collaboration Tools in Action

Case Study: Enhancing Automotive Supply Chains With Blockchain

Renault partnered with IBM Blockchain Services to implement the eXtended Compliance End-to-End Distributed (XCEED) blockchain project. At one plant, this solution archived more than 1 million documents at 500 transactions per second. This solution allows customers to know that their vehicles meet regulations and provides regulators real-time compliance information, all while reducing manual efforts related to data storage, transfer, and use.[7]

Sample use cases of this technology in manufacturing:

Example 01:
A pharmaceutical manufacturer uses blockchain to share data across the supply chain, garnering extensive trust and protection for quality and regulatory requirements.

Example 02:
A luxury good manufacturer uses collaboration tools to match customers to their orders, ensuring transparency and authenticity of its luxury products.

Example 03:
An automotive battery manufacturer uses blockchain to track and procure ethically sourced cobalt for electric vehicle batteries.

Example 04:
An auto OEM uses supplier collaboration tools to synchronize delivery of inputs, reducing warehousing costs.

Take a moment to reflect on the opportunity supply chain collaboration tools create at your organization:

How might blockchain promote transparency across our supply chain?

How might we use supplier collaboration tools to optimize tracking and logistics processes?

Plant Control Towers

What is a plant control tower?

A plant control tower helps to monitor, analyze, and optimize plant performance. Leveraging the contextualized view enabled by digital twins, it allows companies to break data silos, get real-time, end-to-end visibility across their process performance, and equip production supervisors with the tools to drive issue resolution and operational improvements. Using a plant control tower, it becomes possible to rapidly identify issues in production, perform root cause analysis, and collaborate with colleagues to resolve the issues.

Context note: A study of 1,200 executives at global industrial companies found that control towers saved "speedsters", defined as organizations with the highest level of cost and time reductions, 3.9% of production time in the last five years, and are forecasted to save another 4.9% in the next five years. Similarly, control towers saved 2.9% of production costs in the last 5 years, and are forecasted to save another 3.3% of production costs in the next five years.[2]

05

Value Proposition for Plant Control Towers

Identification of Issues Before They Affect Performance

Using available data, it's possible to establish baselines and track performance to quickly detect and diagnose early warning signs.

Improved Collaborative Work

An increase in visibility of plant data across multiple teams and functions allows teams to have real-time access to data, resulting in stronger cross-functional collaboration.

Improved Sustainability

Control towers enable high-level, end-to-end visibility of plant operations to optimize operations for production by reducing energy, emissions, and waste.

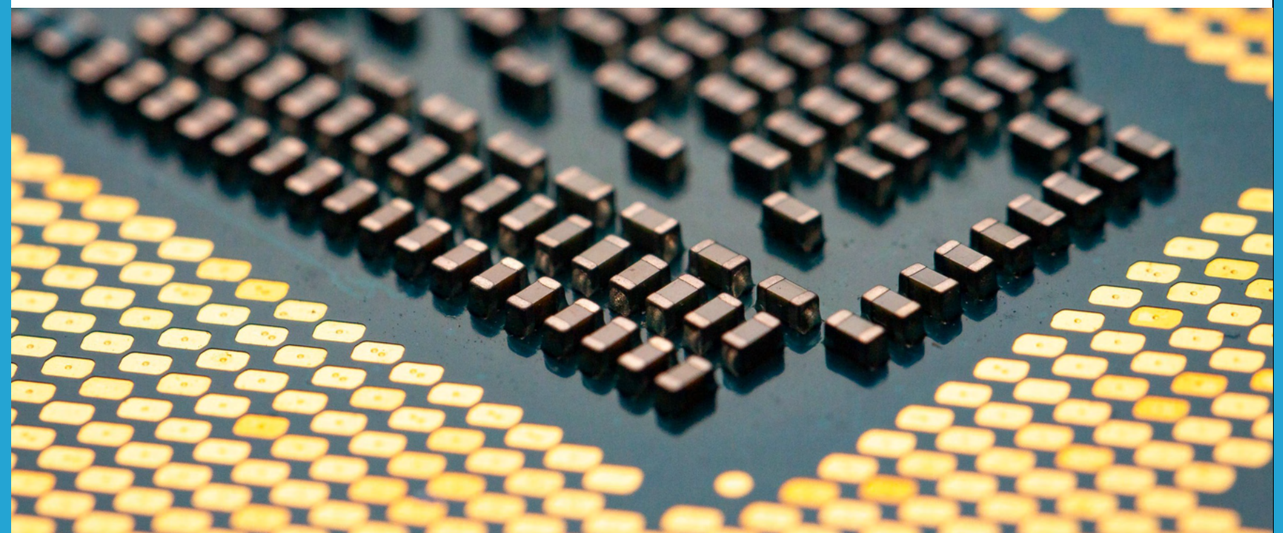
Grand Manufacturing Challenges Solved
Decarbonizing manufacturing operations, products, and supply chains
Speeding up scale-up and deployment of new technologies
Securing the future of the manufacturing workforce

Barriers to Implement Plant Control Towers
Siloed data systems
Limited cross functional collaboration
Outdated plant technology infrastructure

Control Towers in Action

Case Study: End to End Supply Chain Control Tower to Orchestrate and Optimize Across the Value Chain

Due to heightened supply chain uncertainty, Johnson & Johnson connected their siloed data sources to gain visibility across the value stream. This solution allowed Johnson & Johnson to better respond to changes in the supply chain, optimize production decisions, and identify obsolete inventory.[9]



Sample use cases of this technology in manufacturing:

Example 01:
A consumer appliance manufacturer uses control towers to navigate the microchip crisis caused by the COVID-19 pandemic by preemptively identifying shortages from suppliers and shifting production plans.

Example 02:
A material planning and logistics team at an automotive OEM uses a control tower to monitor stock levels of all subassemblies lineside to coordinate material delivery through a fork truck network.

Example 03:
A unionized farming equipment plant uses a control tower to view machine statuses in real time, allowing rapid deployment of skilled workers when downtimes occur.

Example 04:
Aircraft manufacturers use control towers to track real-time progress of airplane production to ensure on time delivery of new fleets to airlines.

Take a moment to reflect on the opportunity control towers create at your organization:

How might we improve data visibility across the factory?

How might we increase our response speed to rapidly solve problems on the plant floor?

Robotics and Automated Guided Vehicles to Enhance Productivity and Safety on the Plant Floor

What is robotics?

Robotics automate tasks typically performed by humans. Robotics have diverse applications ranging from automated guided vehicles (AGVs) to cobots, or collaborative robots, which are designed to work alongside humans to assist in repetitive work.

Context note: A study of 1,200 executives at global industrial companies found that AGVs saved "speedsters", defined as organizations with the highest level of cost and time reductions in the past 5 years, 4.9% in production time in the last five years, and are forecasted to save another 5.4% in the next five years. Similarly, AGVs saved 3.1% of production costs in the last 5 years, and are forecasted to save another 3.4% of production costs in the next five years.[2]

06

Value Proposition for Robotics & Automation

Increased Safety

Autonomous robots can maneuver through manufacturing sites with ease, helping workers avoid dangerous situations.

OpEx Reduction

The implementation of robots will often lead to faster and more efficient operations and quicker turnaround times, leading to significant cost reductions.

Improved Consistency and Quality

Functions and processes in manufacturing can be automated, leading to reductions in error rates and the need for rework.

Efficiency

Cobots that work side by side with humans can improve efficiency, reduce mistakes, and allow humans to focus on more strategic and mentally stimulating work.

Grand Manufacturing Challenges Solved
Decarbonizing manufacturing operations, products, and supply chains
Speeding up scale-up and deployment of new technologies
Linking business value with social and environmental responsibility

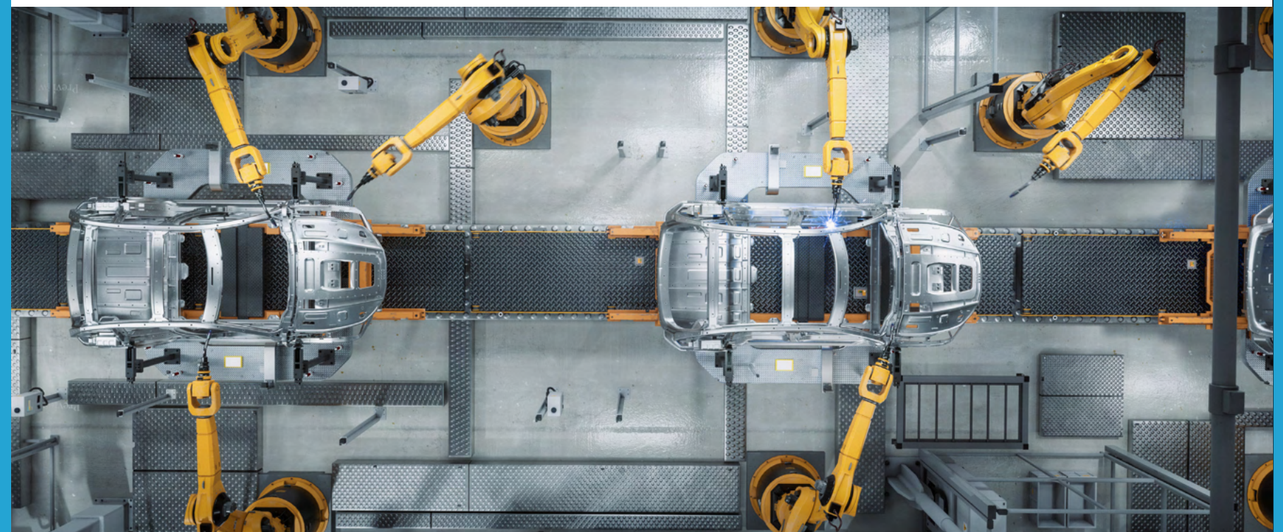
Barriers to Implement Robotics & Automation
Outdated plant tech infrastructure and brownfield space constraints
Lack of strategic planning
Resistance to change

Robotics and Automation in Action

Case Study: Advancements in the Development of Smarter and Safer Autonomous Robots

Qualcomm leverages 5G and AI to enable more effective robotics. 5G allows for real-time, high-volume data sharing, enabling AI to guide robots.

5G and AI enable new robotics use cases, such as robots traveling in traffic, air mobility, and autonomy in factory settings.[8]



Sample use cases of this technology in manufacturing:

Example 01:
A jet manufacturer uses robotics to speed up delivery and improve the quality of fuselage assembly.

Example 02:
A furniture manufacturer uses collaborative robots (cobots) to help partially automate repetitive or difficult tasks, increasing ergonomics and speed.

Example 03:
A packaged foods manufacturer uses autonomous material-handling robots to transfer finished products from warehouse shelves onto delivery trucks, improving order-fulfillment accuracy.

Example 04:
A manufacturer uses vision systems and robotics to pick and sort defective parts from production process, improving first time through metrics.

Take a moment to reflect on the opportunity robotics create at your organization:

How might we use collaborative robots to improve plant safety?

How might we use autonomous robots to move supplies around a plant?

Driving business model innovation creates opportunities for organizations

The six technologies outlined above are poised to impact the future of manufacturing, and provide a starting place for leaders to think about improvements to their operations. New business models, enabled by technology, can help organizations to unlock new opportunities, such as:

Leveraging technology to address market or climate change disruptions

Enhanced productivity and plant efficiency enable swift adaptation to market shifts. Improved asset health ensures resilience against disruptions like climate or geopolitical events. Despite rapid changes, consistent production quality maintains product integrity, while reliable worker safety ensures minimal downtime, enhancing overall operational resilience.[11]

Enabling agile, co-created innovation for new products, processes, and services

Boosted efficiency and productivity afford leeway for experimentation. Optimal asset health ensures machinery readiness for innovation. Continuous tech-driven feedback loops foster co-creation, engaging workers, stakeholders, and customers in collaborative innovation processes.[11]

Anticipating and meeting customers' new needs

Consistent quality ensures that evolving customer standards are met. Shorter lead times, driven by improved worker productivity, enable quicker production and time to market. Technology-driven insights facilitate trend spotting, keeping manufacturers ahead in predicting and meeting emerging customer demands.[11]

Developing new revenue models

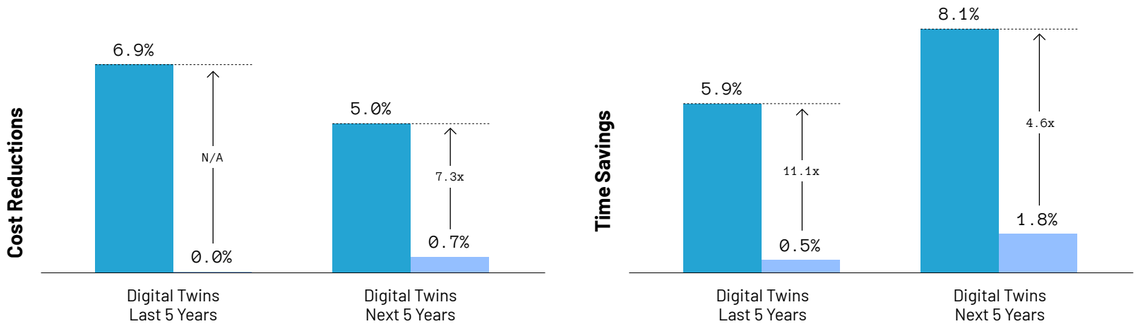
Data and experience from advanced operations can be monetized, introducing insights-as-a-service to other manufacturers. Reduced downtimes offer excess capacity services. Improved productivity and quality can unlock premium markets or new customization options, facilitating innovative pricing models and new business opportunities.[11]

Innovators capture value through technologies, via cost reductions and increased speed to market

Digital twin in distribution

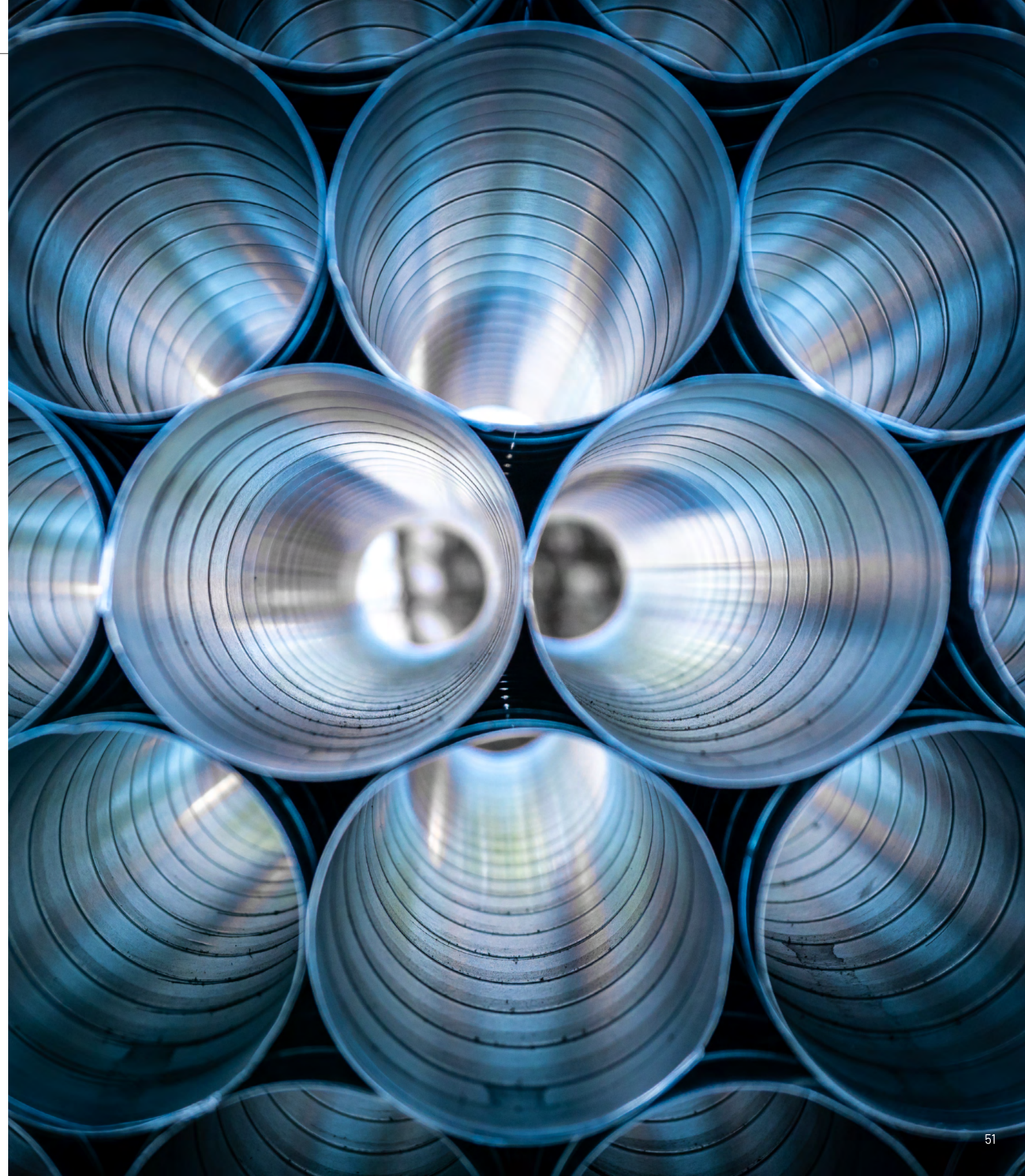
As an illustration, when digital twin technology is applied correctly by manufacturers, it is shown to improve cost of production as well as speed to market of new products.

As an illustration, when digital twin technology is applied correctly by manufacturers, it is shown to improve cost of production as well as speed to market of new products.



Source: Industrial Speedsters Study[2]
Note: Speedsters are organizations who realized the highest level of time and cost savings over 5 years

Speedsters Starters



8 barriers impeding technology-led innovation

The pursuit of technological innovation is both a driving force and a daunting challenge, particularly in manufacturing. The complex landscape hinders the seamless integration of cutting-edge technologies within the manufacturing process. From systemic challenges to organizational hurdles, understanding and dismantling these barriers is crucial for unlocking the full potential of technological innovation in manufacturing. However, navigating through these barriers requires a nuanced understanding of the intricate interplay between technology and existing manufacturing frameworks. Whether grappling with the complexities of digital twin implementation, navigating the intricacies of intelligent asset management, or ensuring the seamless coordination of connected worker platforms, the barriers must be understood and dismantled to pave the way for a future where these technologies redefine the manufacturing landscape.

Manufacturing executives participating in this program identified 8 significant barriers impeding technology-led transformation.

01 Workforce Resistance to Change

Reluctance to fully embrace digital transformation can impede the adoption of business models that take full advantage of emerging technologies.

02 Outdated Infrastructure

Brownfield sites with outdated systems hinder the integration of advanced technologies and innovative processes, impeding the adoption of modern manufacturing practices.

03 Difficulty Proving Value to Scale

Implementing new technologies comes with many unknowns. While success may be achieved in a pilot, additional challenges can surface when scaling innovation programs.

04 Limited Partnerships

Platforms and external partnerships are needed to build expertise in various technologies and capabilities. Doing everything in-house can cause challenges and delays for organizations.

05 Inadequate Workforce Upskilling

The rapid evolution of technology requires a skilled workforce, and there is a shortage of people with the necessary expertise. With large groups in the workforce approaching retirement, institutional knowledge is at risk, and it is becoming more difficult to attract new talent.

06 Limited Cross-Functional Collaboration

Siloed organizational structures hinder collaboration across different functional groups and plants, which is important for effective communication and breakthrough innovation.

07 Siloed Data Systems

Inconsistent data formats and siloed information systems can impede the efficient flow of information across the manufacturing value chain. This makes accessing and analyzing data difficult, which limits the effectiveness of data-driven decision making and hinders innovation.

08 Lack of Strategic Planning

Manufacturing organizations often prioritize short-term goals and immediate returns over long-term strategic investments.

Workforce Resistance to Change

Deep dive

With the global push for digital transformation, stakeholders, key investors, and organizations are exerting pressure to adopt new technologies. However, these conversations are often complex, with many manufacturers hesitant to fully embrace digital transformation. Those who choose to stay the course and invest in technology only when necessary risk being overtaken by their competitors, falling behind on innovation, and becoming unable to generate new value. The pace of technological change is accelerating, and manufacturers that struggle to execute transformational strategies risk being left behind. For many, by the time a transformational effort is approved, funded, and fully scaled, the authorized technology is already becoming obsolete.

Manufacturers making investments into these transformations are investing in their future to remain competitive, increase future ability to innovate, develop new offerings, and create the next frontier of manufacturing.

Digital transformation is necessary, and manufacturers that lack agility can experience problems.

Key statistics

66%

of manufacturers say digital transformation is a priority.[12]

30%

of manufacturers globally are facing technology paralysis due to the wide range of available systems and platforms.[13]

10%

of North American process and discrete manufactures have completed digital transformational projects.[12]

> Prioritizing pragmatic digitization is the single mindset change that an operations team needs to build the foundation for the next generation of cost and throughput improvement in manufacturing.[14]
>
> **Keith Gargiulo, Vice President, PTC via USC4AM Community Interview**

Outdated Infrastructure

Deep dive

"If it's not broken, why fix it?" is a common sentiment about legacy infrastructure and systems among many manufacturers. The drive to replace what's already functioning, however inefficient, has been low and difficult to move forward. For many, justifying investments in brownfield sites is hard, resulting in siloed infrastructure across plants. Holding on to legacy infrastructure is hindering integration of new technologies, limiting innovation, and impeding the adoption of modern manufacturing practices. While older infrastructure may be getting the job done, it can limit the success of innovation. Brownfield sites are often deprioritized with investments targeted at new technology. Additionally, greenfield sites are being brought online and using a mix of new and old technologies in an attempt to bridge the gap between sites. This results in mixed performance with neither the brownfield or greenfield infrastructures running at their full potential and no two plants being identical in technology and infrastructure.

Manufacturers need to develop strategies to activate use cases that use new infrastructure for both brownfield and greenfield sites. A world of possibility and opportunity waits for those who let go of yesterday's systems and embrace the systems of tomorrow.

Just because legacy infrastructure is sufficient today, doesn't mean it will be tomorrow.

Key statistics

88%

of executives plan to slightly increase technology spending as a percentage of revenue in the next year as compared with last year.[15]

55%

of executives are planning to prioritize investments in developing digital cores (e.g., cloud, data, AI, platforms, and security).[15]

91%

of industry leaders say technology is a key element of the competitiveness.[15]

"Do not leave your brownfield sites behind.[14]

Scott King, Information Technology, Ford via USC4AM Community Interview

Difficulty Proving Value to Scale

Deep dive

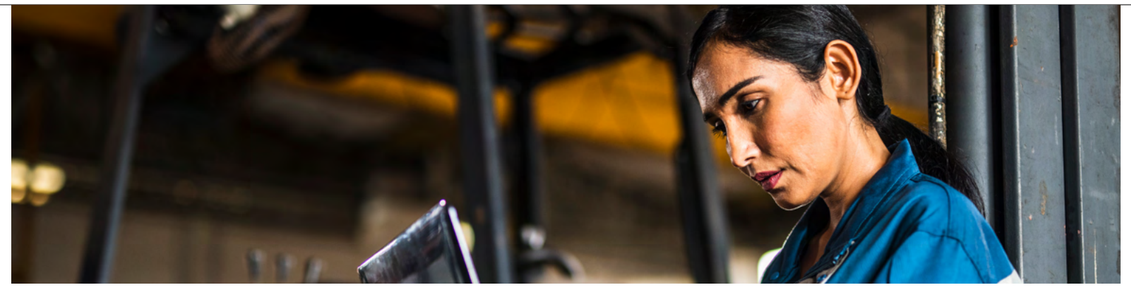
A major hurdle manufacturers face when pursuing innovation is gaining support and investment for a new technology. Key stakeholders want technology investments to solve a business challenge, help grow the business, and create new value for the organization. To gain adoption, the technology solution needs to be usable and prove it adds value that leads to new profit.

When implementing new technology, manufacturers face a variety of unknowns that they must navigate when piloting projects. Demonstrating proven value on a small scale will help illustrate the savings that can be achieved on a full implementation.

However, manufacturers are experiencing mixed results when scaling from pilot to full deployment as the manufacturing environment becomes more complex.

Each manufacturer and plant is unique, meaning a technology graduation and scaling program must be bespoke. Brownfield and legacy infrastructure that are decades old create additional complications and considerations for capturing value at scale. When planning greenfield sites, concessions are often made by scaling back on the amount of new technology employed because of difficulties in scaling throughout the organization.

Manufacturers experience mixed results when scaling from pilots, leading many to make concessions at scale.



Key statistics

80%

of surveyed manufacturers cited scalability as a challenge to executing strategies.[16]

83%

of surveyed manufacturers who have a smart factory strategy and different technology use cases to support their sites reported that technology and solution immaturity are challenges.[16]

> Focusing on the value and the ‘why’ helps your organization move faster.[14]
>
> **Elizabeth Hoegeman, Executive Director of Global Manufacturing, Cummins via USC4AM Community Interview**

Limited Partnerships

Deep dive

As manufacturers grow their operations, they often add new solutions on top of existing applications and infrastructure. Over time, this can lead to disconnects between platforms, inconsistent information, and inefficient, manual verification of data. Additionally, maintaining this infrastructure, including custom solutions, can become increasingly risky and costly when relying on a handful of personnel to effectively troubleshoot and resolve issues.

With the rapid acceleration of technological advancements, maintaining expertise across multiple technical domains has become difficult. Partnerships enable manufacturers to shift focus back to core activities, leveraging partners to fill hard to address capability gaps. These partnerships can provide stability, platform cohesion, and improved efficiency, paving the way for growth and new business developments.

Manufacturers who set out to pursue innovation on their own are missing out on opportunities to experiment with technology and influence the workforce of the future through strategic partnerships. By not pursuing strategic partnerships, manufacturers are placing themselves at a competitive disadvantage with other industries.

Manufacturers that try to keep up with technology by themselves lose core focus and miss opportunities to experiment and influence the future.

Key statistics

94%

of tech industry executives consider innovation partnerships a necessary strategy.[27]

“Industry and universities need to come together and build curriculum to help shape the workforce of the future.[14]

Matthew Wallace, DXM, CEO via USC4AM Community Interview

“Strategic partnerships are critical for technology adoption. Somebody has to lead the change. Most companies are not self-starters and need help.[14]

Keith Gargiulo, Vice President, PTC via USC4AM Community Interview

“Ford leverages Google Services and Google Cloud to accelerate deployment and improve sustainability.[14]

Scott King, Information Technology Program Leader, Ford via USC4AM Community Interview

Inadequate Workforce Upskilling

Deep dive

Attracting new talent to manufacturing is becoming increasingly difficult in North America. In contrast, a career in manufacturing for European university graduates is highly desirable. There, people look forward to being on an assembly line or helping manufacture a new product for society's benefit. North America's unfavorable perception of the industry must change to showcase the benefits of a career in manufacturing and how employees can take part in driving meaningful change.

Decreased interest in manufacturing jobs combined with workforce retirement has created a job gap across the industry. A knowledgeable manufacturing workforce is a core component of efficient operations, with refined skillsets, on-the-job experience, and deep manufacturing knowledge required for specific functions. Manufacturers are finding themselves at a loss when this workforce retires because these skillsets and institutional knowledge are difficult to replace. As a result, the industry is facing a shortage in the number of workers who have the relevant skills and expertise needed to operate manufacturing systems with the rapid evolution of technology.

Manufacturing organizations can partner with universities to build well-rounded curriculums and apprenticeship programs that can provide the future workforce with practical experience. Additionally, prioritizing investments in training for current employees to obtain the necessary skills and knowledge can strengthen their job performance.

Key statistic

25%

of the manufacturing workforce is over 55 years old.[17]

"The challenge is not only trying to fill the existing job openings but also rethinking new career models involving a high degree of automation, robotics, and AI.[14]

Camille Prost, Managing Director Industry X Workforce Transformation, Accenture via USC4AM Community Interview

Take steps now to fill workforce gaps caused by groups approaching retirement and challenges in hiring.

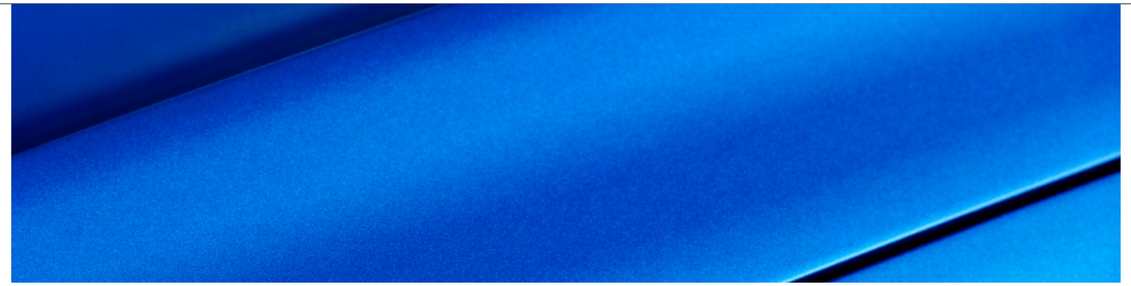
Limited Cross-Functional Collaboration

Deep dive

Lack of collaboration across different segments within an organization is a major inhibitor to transformation in manufacturing and leads to siloed processes and technology. Obtaining buy-in for innovation requires an organization-wide culture change to increase and incentivize collaboration. For example, when developing a solution for workers, a data scientist needs to collaborate with shop floor workers to understand the nuances of their roles and goals. Increasing cross-functional collaboration requires that frontline workers understand why new technology is being proposed and that technologists understand the challenges of the manufacturing environment.

Manufacturers are seeing a skillset disconnect across teams and functional areas where a portion of the non-plant workforce doesn't have visibility into manufacturing processes. This gap leads to incomplete solutions and creates tension between organizational groups. The lack of cross-functional skills and understanding within manufacturing organizations creates a fractured system that impedes organizational growth.

Innovation requires cultural change throughout manufacturing organizations to increase and incentivize collaboration.



Key statistics

44%

of workers' skills will be disrupted in the next five years, estimated by employers.[18]

40%

of industrial manufacturers cite managing legacy processes and process re-engineering as substantial challenges.[19]

> People who are doing data-related work need to be aware of what is happening on the manufacturing floor.[14]

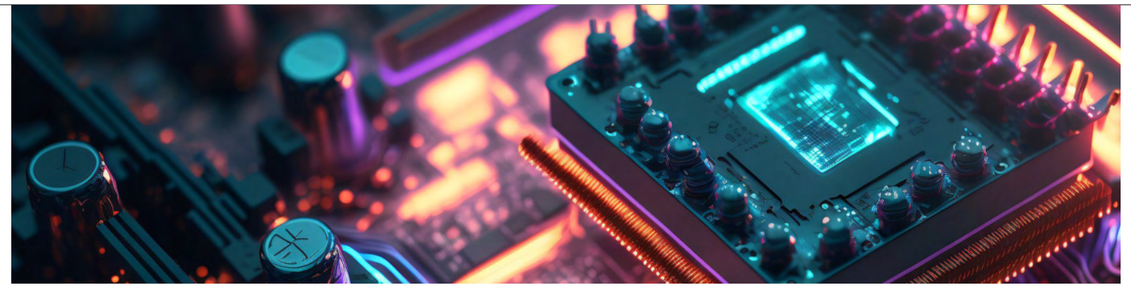
April Stevens, Global Director of Manufacturing Operation Excellence, Ford via USC4AM Community Interview

Siloed Data Systems

Deep dive

Many manufacturing organizations are dealing with inconsistent data formats and siloed information systems that hinder the efficient flow of information across the value chain. Due to fragmented data systems, leaders often have unpredictable and limited access to data, creating challenges in making data-driven decisions. Now more than ever, it's crucial for manufacturing leaders to invest in the right technology to enable data-driven decision making. Leading data systems propel transparency across the organization, allowing workers to optimize performance and generate greater results. They also create an advantage over competitors and enable innovation in manufacturing.

Manufacturing leaders must invest in technology to free the flow of information and unleash data-driven insights.



Key statistics

87%

of employees want leaders to reconsider the way they think about technology in the workplace.[20]

90%

of global executives agree that data transparency is becoming a competitive differentiator for their organizations.[21]

"It's not about having large data. It's about having the relevant data.[14]

Sudarsan Rachuri, Federal Program Manager, Advanced Manufacturing, US Department of Energy via USC4AM Community Interview

Lack of Strategic Planning

Deep dive

There are no shortcuts in the innovation journey; however, not all journeys yield immediate returns. Manufacturing organizations struggle to prioritize longer-term innovation initiatives, instead opting for quick wins against short-term goals. In the immediate future, these quick wins might generate temporary gains, but over time, they can lead to fractured infrastructure, incompatible systems, and set organizations behind their competitors.

When long-term investment is compared with short-term gains, investors frequently prioritize the short term because they're more cautious about investing in innovation. Finance poses a large barrier to innovation, especially when there isn't a central funding source to accelerate its progress.

Quantifying innovation pursuits is often a difficult task that leads to deprioritizing these efforts. Manufacturing organizations need to shift their perspectives to understand that many investments can be justified by hard business cases, but investment in long term innovation pursuits can be hard to quantify.

Manufacturers must embrace the long view and prioritize innovation, while balancing short-term, quick wins.

Key statistics

43%

of manufacturers cite budgets as a core constraint related to technology investments.[19]

42%

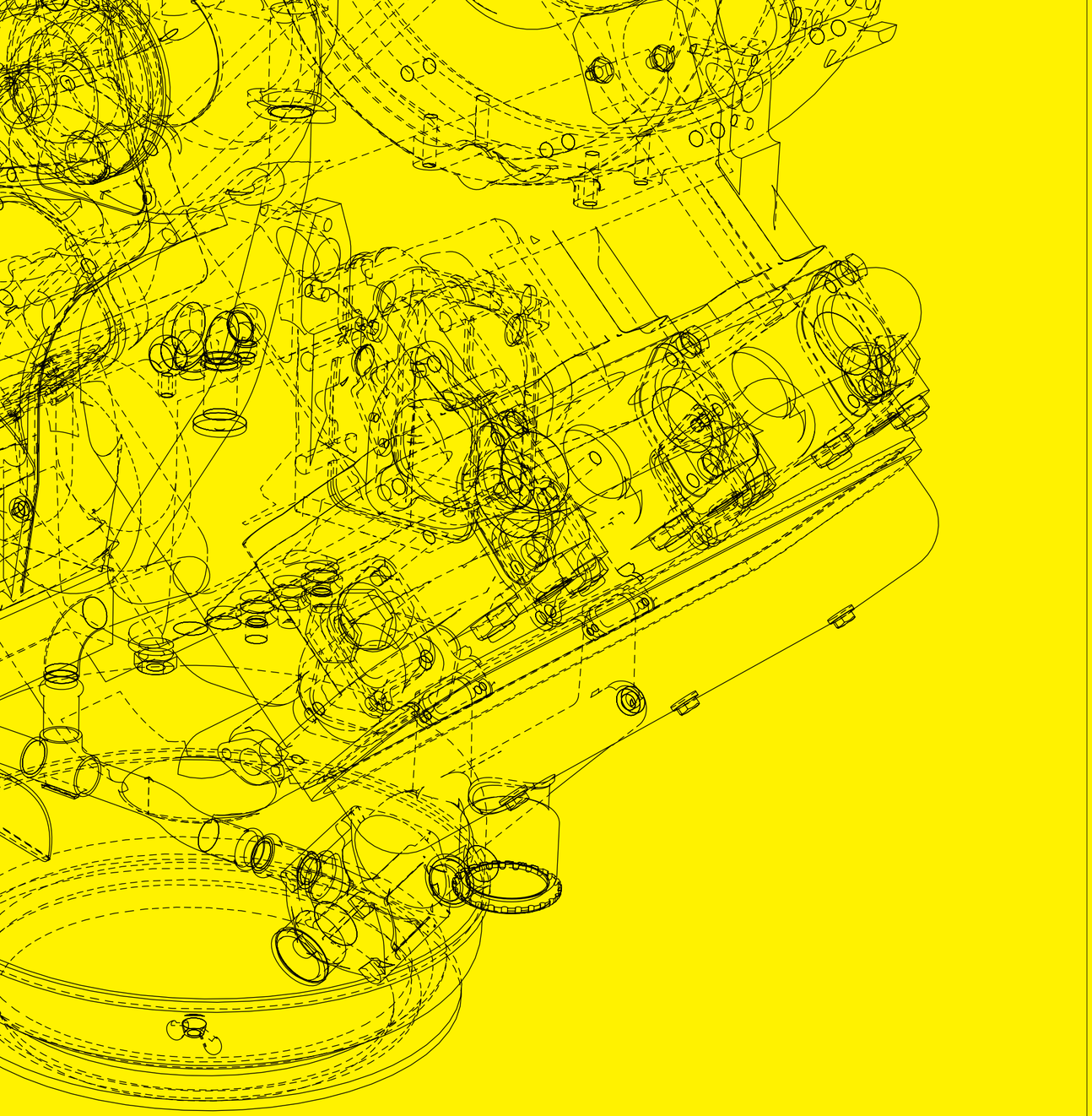
of industrial manufacturers have difficulty providing justifications for investment.[19]

"Companies can cancel projects that hinder hitting quarterly goals, even if they can be transformational over years.[14]

Matthew Wallace, DXM, CEO via USC4AM Community Interview

"You're either looking at a long-term investment or a short-term profit, and the short term always wins... At some point in time, you need to give these companies some breathing room to make these investments.[14]

Anthony Graves, Global Segment Lead, HP via USC4AM Community Interview



Strategies to Unleash Innovation & Unlock New Business Models

Manufacturing leaders need to answer key business questions to define transformation goals, starting point and innovation strategy

01 **Setting the Foundation**

What is the future of manufacturing, and how do I get there? Can I understand the capability needs and gaps across my manufacturing network?

02 **Building Capabilities**

How can I enable innovation with the right skills and capabilities, both internally and externally?

03 **Implementing Technologies to Drive Business Model Innovation**

How can I run and evaluate experiments? How can I scale innovation within the organization? How can I communicate change?

Eyes Wide Open

Given the impediments to technology driven innovation highlighted in the prior chapter, we explore strategies for manufacturers to realize change and innovation.

As we explored the challenges that impede the path of innovation as well as the promising technological opportunities that can propel organizations towards a transformative future, we now transition into examining proactive strategic initiatives, aiming to unleash innovation and unlock new business models. We navigate beyond the hurdles discussed earlier, seeking inventive pathways that lead to a paradigm shift in manufacturing.

This section explores the theoretical frameworks and tangible strategies that manufacturers can adopt to build an innovation forward organization, leveraging technological advancements and adopting new business models.

It is an exploration of possibilities, a guide for clear-eyed leaders ready to embrace the dynamic landscape of manufacturing with renewed vigor and ingenuity.

> Being more customer-centric, and sustainability, are the clear “why” for innovation.[14]
>
> **Matthew Wallace, CEO, DXM via USC4AM Community Interview**

Setting the Foundation

What this section covers

01 Knowing **where the organization sits** from an innovation perspective, beginning with a manufacturing technology readiness capability framework

02 Setting an innovation **North Star** and target state for the production network

03 Creating a **roadmap for innovation**, leveraging modern approaches in manufacturing

Understanding the current state

Technology readiness capability frameworks help leaders objectively evaluate their innovation starting position before planning or implementation

The development of new business models and adoption of new technology is a continuous challenge for the manufacturing industry. Insights gathered from North American manufacturing leaders for this playbook underscore the difficulty in securing stakeholder buy-in for fundamental innovation endeavors and strong organizational inertia to chase quick wins over long-term opportunities. Innovation is a challenge to justify in terms of ROI; however, it also holds the keys to unlock and enable growth.

In a study of 1,350 global industrial leaders, it is estimated that disconnects between top and middle management in scaling innovation contribute to a 8.4 percentage point gap from the total return on digital investment (RODI) opportunity. A similar 8.4 percentage point gap can be attributed to gaps in technology and architecture.[22]

Against these headwinds, how can manufacturers gain support for innovation initiatives?

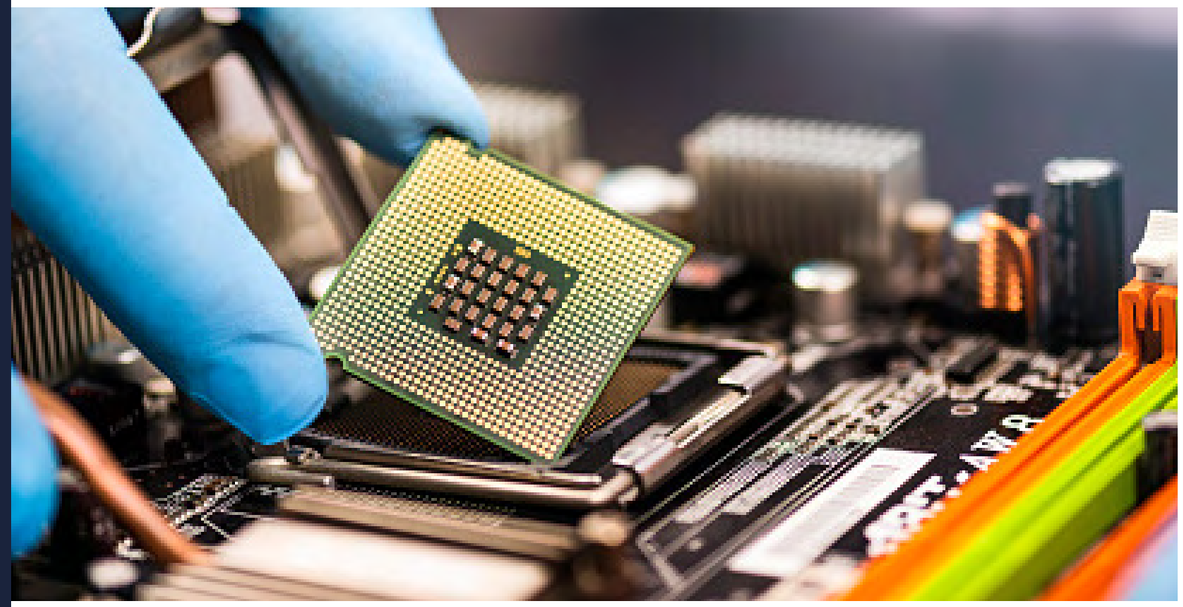
Meaningful technology implementations in a manufacturing environment require years of deliberate effort to realize the full potential across complex manufacturing networks. Early implementation efforts can fail if manufacturers fail to address foundational challenges with a clear view of existing enterprise capabilities.

It's crucial for leadership teams to begin the innovation journey by introspectively examining the current state of the organization. To enable this, it's incumbent on the manufacturer to initiate a "technology readiness capability model activity" to understand the organization, business, technology, and internal processes. By understanding the internal manufacturing environment, manufacturers can then identify the future vision, understand technological capabilities and gaps, and set the business priorities to align with innovation objectives. This internal assessment can identify both where innovation is needed and strong internal capabilities that will help deliver innovation.

Brownfield sites pose unique challenges to support the technology and data outputs from legacy generation assets, and as a result, can be sidelined from new technologies. Innovative manufacturers don't solely focus on new technology at greenfield sites—they seek to innovate at all sites.

A digital manufacturing readiness framework helps leaders understand the current state of play within their organizations before embarking on innovation programs. This guides leaders to understand where innovation is needed and where innovation will face major hurdles.

How to organize a digital manufacturing readiness framework



Where to start

To conduct a successful transformation, manufacturers require an honest assessment about where they are starting from, and what foundational capabilities are missing.

Without a clear understanding of these critical aspects, implementations are at greater risk of failure due to incorrect assumptions of the manufacturers baseline infrastructure. As an example, clearly defined data governance models are necessary to facilitate meaningful analytics, that provide downstream benefit to the organization.

Elements of a successful technology readiness capability framework:

Focus Area	Sample Questions to Ask	Risks of Not Assessing
Organization Review your organizational readiness for innovation	• What are our current team and workforce structures? • How do we approach change management, and where do we see success / challenges? • How do we manage future manufacturing skills within the organization? • Do we have agility in organization and design processes? • How able are we to scale and sustain innovation within the organization?	Innovation is perceived as forced, and organizations face challenges in adoption and scaling, such as lack of required skills, limited change capabilities, or difficulty to sustain innovation.
Governance Examine existing governance frameworks around innovation initiatives	• What are our Innovation success metrics and KPIs, and do these accurately reflect success? • How is innovation funded, and what are the funding stage-gates? • How do we deliver and manage innovation, from idea to scale? • Do we have clarity of roles and decision-making responsibilities?	Innovation lacks direction, clear leadership, and roles to drive success. Funding is not tied to outcomes, and less promising programs are not cut early, costing time and money.
Operations Assess operational practices	• Where are there bottlenecks, inefficiencies, and areas where manual processes are affecting fundamental operations within manufacturing operations? • What is the digital maturity of production processes and capabilities? • What digital worker enablement tools are in use? • How automated and flexible are assets or processes?	Innovation is not targeted towards areas that need improvements, and may focus on what's easy, rather than worthwhile. Workers, processes, and capabilities are not equipped to support innovation.
Data Assess data management practices	• How is data collected, stored, and used across OT and IT systems? • Are data security measures and compliance modern and robust? • How are analytics leveraged throughout the organization? • What capacity exists to simulate and predict outcomes?	Data is not structured in a way that supports certain innovation. Data insights aren't leveraged, and OT and IT systems don't communicate with each other.
Architecture Conduct comprehensive technology audits	• How efficient, easy to integrate with, and scalable is current factory technology infrastructure? • What is the organizations technological readiness, and adoption of Industry 4.0 technologies + digital tools? • What technologies are outdated and hinder productivity and innovation?	Technology architecture doesn't support new tools. The organization isn't ready to adopt new technologies, and the ones in place are outdated. Areas where innovation can upgrade existing technology stack are not understood.

Identifying an Innovation North Star

After completing a digital manufacturing readiness framework, a defined innovation vision guides future programs.

An innovation **North Star** allows organizations to simply articulate innovation ambitions. The following dimensions are a starting point to develop a north star:

Elements of a successful innovation North Star:

Innovation Dimension	Prompting Question	Example
Expansion of core activities	How can we encourage growth in our current markets and offerings?	Porsche used 3D printing to create an innovative full bucket seat. The bucket seats can be personalized to the driver, helping improve the driver experience.[23]
Net new growth opportunities	How can we realize growth through new markets and offerings?	CAT launched a telematics solution, as an opportunity for new growth, to help large and small operations to better understand machinery, perform preventative maintenance, correct operator behaviors, and improve decision making.[24]
New operating models	How can we transform internal functions for greater efficiency and enable new capabilities?	CVC Technologies, a manufacturer of packaging for pharmaceuticals, wanted to improve safety, optimize production, and create a digitized machine network. The company used solutions from Schneider Electric to digitize 100% of its machines to increase production output and reduce human error.[25]

Based on the north star, structured opportunity statements can be created, to articulate the case for innovation in specific areas. These statements must be:

- **Clear** about what needs to be solved, leaving no room for uncertainty
- Open for **multiple solutions**, rather than focused on one solution
- Backed by **data**, to support the challenge faced
- **Root-problem focused**, and articulate the outcome of solving the issue at hand.

For example:

✗ Our Toledo plant has had more downtime than anticipated this year

✓ Due to material shortages and incomplete preventative maintenance, our Toledo plant has decreased operational and equipment efficiency, including a 12% increase in total downtime, resulting in $36 million in lost production. If we can use new technologies to reduce downtime, we can expect to restore $3 million for every 1% improvement in uptime.

Creating an Innovation Roadmap

Where to go

A prioritized roadmap of innovation programs provides a path to achieve innovation.

Once there is a shared view of the current state from the technology readiness capability framework, and an agreed upon innovation north star, a prioritized roadmap of innovation initiatives helps to drive the innovation strategy. Without prioritization and road mapping activities, organizations can misallocate funds, focus on non-priority opportunities, and misidentify dependencies rolling out innovation.

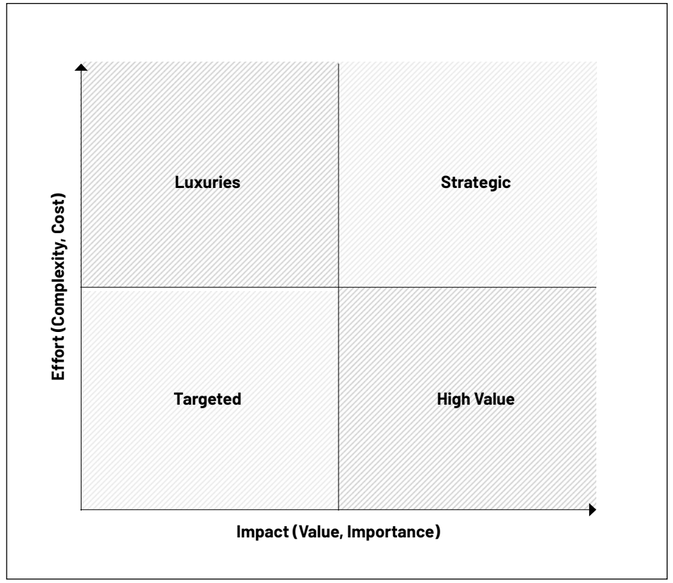
Step 01:
Initially prioritize innovation opportunities. One way to do this is using an effort impact matrix:

Luxuries example: automating infrequent, complex processes

Strategic example: collaborative robotics applications

Targeted example: small scope vision systems

High value example: connected worker enablement program



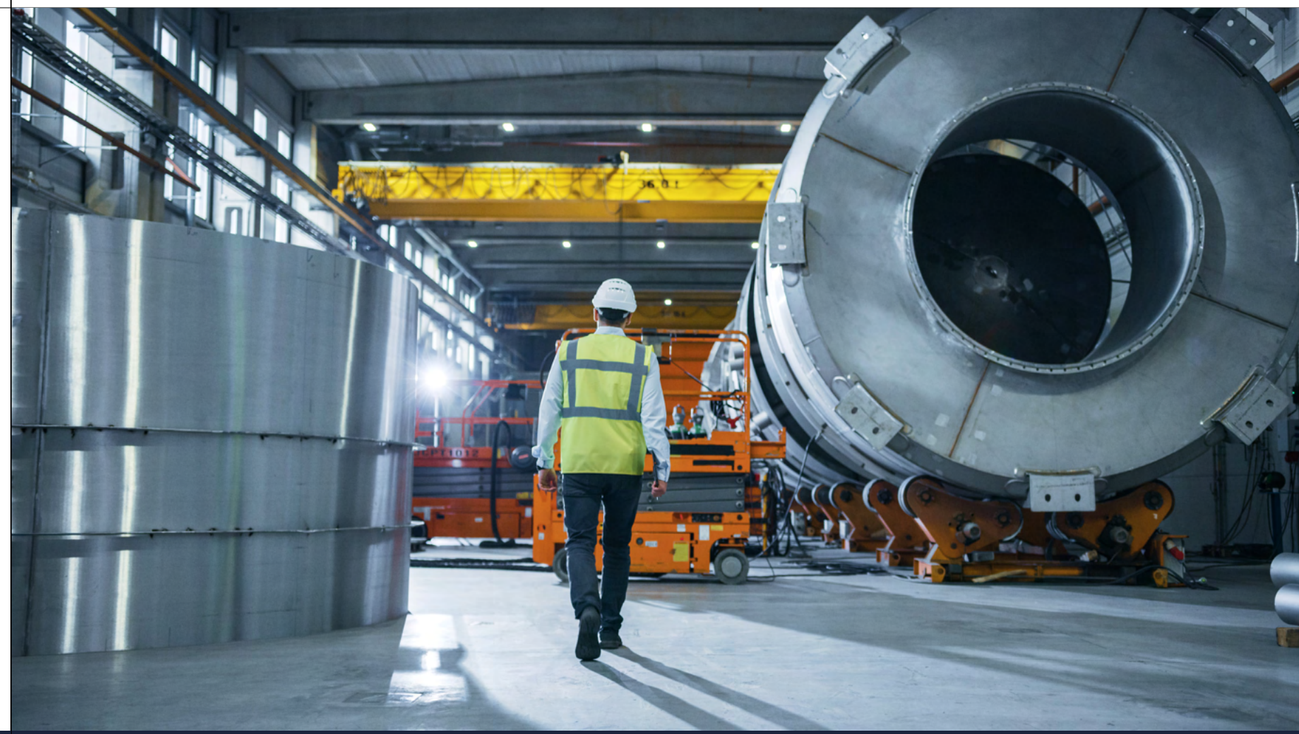
Step 02:
Once opportunities are prioritized, create an innovation roadmap in service of the overall organizational strategy, a sample roadmap could look like:

Sample Corporate Strategy Pillars		2024	2025	2026
Automate Processes	Goal: address challenges faced from manual input in processes			
Modernize Data Systems	Goal: provide access to data across the organization across IT and OT systems			
Enable the Workforce	Goal: empower the manufacturing workforce with digital technologies			
Other	Goal: support other manufacturing innovation opportunities			

Best practices for forging a path to innovation

The path to innovation isn't a straight line, but similar themes exist at organizations that succeed.

After a digital manufacturing readiness activity is complete, high-level opportunities are identified, and an innovation roadmap is developed, it's important that the momentum for innovation continues through dedicated teams. Top innovation programs are tailored to the specific needs of an organization, dynamics of an industry, and existing internal mandates. Manufacturing organizations that successfully innovate generally exhibit a few themes. Consider the following as you reflect on how your organization is managing innovation:



Evaluate innovation programs based on impact to the business

By identifying a north star and overarching opportunities, manufacturers can direct innovation. Prioritize innovation programs based on metrics that are relevant to the business—for example, ROI (where possible), workforce outcomes, quality, or efficiency.

Innovation has clear ownership, and the right groups must support it

Innovation at an organization can fail for a number of reasons, and organizations that innovate successfully generally have clear ownership of innovation, which the required stakeholders support to ensure collaboration across the organization.

IT and OT collaboration is a priority

Both information technology and operational technology teams must work together, with shared data sources to allow for real-time, data-driven decision making.

Experimentation is encouraged, and losses are cut often and quickly

It's important to realize that some innovation programs won't succeed, but they need to be tested to find out. Embrace rapid testing of hypotheses while framing failed programs as learning opportunities to allow for a test-and-learn approach to innovation.

Realistic innovation timeframes

Innovation in manufacturing, especially in the plant environment, can take significant time and effort, and setting realistic timeframes allow organizations to plan for innovation roll-out.

Short-term gains, are balanced with long-term value pursuits

Strike a balance between delivering value quickly, and pursuing long term high value programs, show success while focusing on big picture value.

Build

Capabilities for Innovation

44%

of worker's skills will be disrupted in the next five years, employers estimate.[18]

What this section covers

01 Upskilling, attracting, managing **innovation talent**

02 Creating ecosystem partnerships for access to **talent and capabilities**

Develop the New Manufacturing Workforce

To deliver innovation successfully, and adapt to Industry 4.0 changes, develop the skills of the current workforce.

There is a growing disconnect and skills gap emerging across manufacturing, between core manufacturing skills and new digital skills. In addition to hiring for new technical skills, focused upskilling programs and initiatives help broaden the skillsets of their current workforce. If left unaddressed, organizations will fall behind in Industry 4.0 skills, and limit competitiveness in the market. A study of 1,350 industrial leaders estimates that the industry wide return on digital investment (RODI) achieved despite a gap in innovation skills is 9.7%, whereas the RODI opportunity by overcoming skills gaps is 16.2%. In other words, 6.5 percentage points of RODI are at stake due to the skills gap.[22]

> Jobs remain the same but roles are changing. Digital skills are required in the roles more and more.[14]
>
> **Dr. Ragu Athinarayanan, Purdue University via USC4AM Community Interview**

Actions to develop a manufacturing workforce for the future:

Identify Opportunities for Employee Upskilling

Gather input from employees and management across all functions to build a comprehensive view on the upskilling needs of each area. Cross training of office employees in plant processes can help non-production staff to better grasp the plant environment.

Develop Digital Skillsets

Prioritize equipping employees to manage both physical processes, and digital applications. Becoming fluent in both physical and digital operations will empower a more dynamic, adaptable, and capable workforce. In the future, leaders and the workforce will be increasingly required to blend functional manufacturing skills (ex: injection molding), with new technical skills (ex: analytics).

Accelerate Skills Development

To expedite employee reskilling and upskilling, identify internal champions in technologies and foundational skills to conduct peer to peer coaching. These programs encourage mentorship, team cohesion, and help to transfer institutional knowledge.

Create Pathways For Employee Progression

As the manufacturing industry continues to evolve and leverage new technology, the fundamental skillsets for employees expand. Identify required skillsets for each position with a guide for career progression. Encourage employees to share their career aspirations and goals and have ability to pursue growth opportunities.

> Factories are not usually in beautiful locations and some of the roles that had been traditionally viewed as site roles are no longer required to by physically present to perform their jobs. Opening HUB offices in cities where it is easier to find and attract talent has allowed a regional organization to support multiple locations in a hybrid-consulting model.[14]
>
> **Eric Waters, Director of Planning and Logistics, Cummins via USC4AM Community Interview**

> Work to create a more macro type of certification program in U.S. Paint manufacturing, in a new light, with the impressive technologies factories have to offer and expose the next generation of workers to additive manufacturing. As an industry, we should drive more campaigns and gamify experiences.[14]
>
> **Rich Garrity, Chief Industrial Business Officer, Stratasys via USC4AM Community Interview**

Use technology to support employees close to retirement

To mitigate risk of knowledge loss due to retirement, use technology to support employees close to retirement to extend careers, and capture institutional knowledge

Long tenured workers provide significant value to manufactures, who benefit from their knowledge, experience, maturity, and low turnover rate. With a large portion of the manufacturing workforce approaching retirement, organizations must act now to prepare for, and mitigate challenges from, retiring workers.

> Providing training opportunities to the existing workforce is very important. Using XR-based headsets for virtual training creates more immersive and engaging training experiences.[14]
>
> **Savi Soin, Senior VP, Qualcomm via USC4AM Community Interview**

78%

of organizations surveyed were concerned about their aging workforce.[26]

Technology is poised to help mitigate adverse outcomes from retiring workers, including:

Remote Assist

Provide workers with less tenure opportunities to receive remote assistance from experts, enabled through technology. Remote assist roles are an opportunity to provide experienced workers with an opportunity for different career opportunities, to share specialized knowledge, and provide less physically demanding roles.

Digital Knowledge Repositories

Digital knowledge repositories can capture valuable, institutional knowledge, to be shared across the organization, before it's lost through retirement.

Generative AI for Search

Generative AI applications can help organizations search through large amounts of data for answers. Generative AI can be used to support less-experienced employees, and allow for easy access to knowledge stored across the organization, playing a portion of the role of an experienced mentor.

Extended Reality Training

Integrative training technologies allow organizations to provide immersive training experiences, and the ability to explore unique training scenarios, allowing organizations to upskill workers not approaching retirement, to mitigate knowledge loss from retiring employees.

Ergonomic Job Design

Enterprises can implement technologies such as cobots or other job aides to reduce the demand on workers nearing retirement. By investing in the current workforce, careers can be extended.

Create Academic Partnerships

Organizations have the opportunity to create novel partnerships with academic institutions, to shape curriculums, and to access top talent, augmenting workforce development.

Partnerships between industry and academia address challenges manufacturers face attracting qualified talent. These partnership can shape academic curriculums, to blend Industry 4.0 digital skills, such as analytics, architecture, and application development, and core manufacturing skills, such as stamping, injection molding, and machining together.

When done right, partnerships with academia are a win-win, and provide mutual gains for the organization, the university, and the students. Together, manufacturers and academia can shift perspectives on the industry, position their organization as a top employer on campus, shape curriculum to focus on in-demand skills, and create unique educational experiences.

To begin creating these partnerships, identify current, high yield talent pipelines, and reach out to faculty at these institutions, to discuss what a mutually beneficial partnership may look like.

> Partner with universities to develop tailored programs and build specific curriculums by industry.[14]
>
> **Matthew Wallace, CEO, DXM via USC4AM Community Interview**

> Create internship opportunities where young minds can experience what it's like to work at a plant and be exposed to the emerging automation technology they would have the opportunity to work with as they embark on a career in the manufacturing industry.[14]
>
> **Tom Clary, Strategic Alliances & Partnerships Lead at Schneider Electric via USC4AM Community Interview**

Desired outcomes from academic partnerships:

01 For academic institutions

- On campus employer presence and higher employment rates of graduates
- Industry support for on campus activities
- Integration of industry knowledge, insights, and experience into student curriculum

02 For the organization

- Strengthened on campus employer brand and access to top manufacturing talent with Industry 4.0 skills
- New ideas and fresh perspectives
- Access to talent, faculty expertise, and test bed environments to try new ideas

03 For the candidates

- Enhanced opportunities to interact with leading manufacturers
- Hands-on practical application and exposure of new technology reshaping manufacturing
- Co-op placements, internships, and post graduation job opportunities

Case Study: Purdue University Smart Manufacturing Lab

Purdue, and industry partners, created a best-in-class partnership, which can be replicated by other manufacturers.

Overview of the partnership

In 2019 Purdue University began to collaborate with U.S. manufacturing leaders and industry experts to address the growing skills gap emerging across the manufacturing landscape, preparing the future manufacturing workforce with new knowledge, skills and technologies. This partnership enabled manufactures to proactively partner with academia to inform curriculum to be relevant to their operations.

Purdue partnered with organizations such as CAT, Microsoft, Accenture, and Rockwell, and built two major opportunities for students:

1. Purdue Smart Manufacturing Facilities, including a Smart Factory, Smart Foundry, Industrial IoT Laboratory, and Intelligent Continuous Process Laboratory.
2. Bachelor of Science Degree in Smart Manufacturing Industrial Informatics (SMII), featuring 12 new courses and the development of multiple facilities on campus showcasing Industrial IoT to Smart Factory technology. The new curriculum is anchored around the integration of digital information technology with physical operational technology, leveraging IoT, AI/ML, Cloud/Edge Computing, AR, Robotics and more.

Partnership outcome

For the **university**, the results of this partnership has helped position them as a leader in smart manufacturing, as well as created a strong on-campus presence of potential employers.

For **students**, the joint collaboration between Purdue and their manufacturing partners has rejuvenated interest and excitement around manufacturing, while giving students hands on experience with next generation technologies.

For **manufacturing partners**, the partnership has created a new candidate pool of qualified and trained applicants, ready to face the challenges of the current manufacturing environment, with Industry 4.0 technology experience.

Learn more about the Purdue Smart Manufacturing Lab here.

Leverage Ecosystem Partnerships

Build ecosystem partnerships to augment talent acquisition and development activities, for access to in demand skills and capabilities.

Ecosystem partnerships, when built correctly, can become innovation accelerators for manufacturers, and provide tangible benefits. A study of 1,350 industrial leaders estimates that industry wide return on digital investment (RODI) achieved despite a partnership gap is 9.7%, whereas the RODI opportunity by overcoming a partnership gap is 15.7%, meaning 6.0 percentage points of RODI are at stake due to the partnership gap.[22]

Partnerships enable manufacturers to access specialized skillsets without having to hire full time employees, expand infrastructure capabilities, or facilitate access to new markets, opportunities, and ideas. Partnerships also allow manufacturers to shift their focus back to their core business and transfer ownership, maintenance, and risk from specific capabilities to their ecosystem partners.

> Be open with partners on how you operate to avoid surprises.[14]
>
> **Eric Waters, Director of Planning and Logistics, Cummins via USC4AM Community Interview**

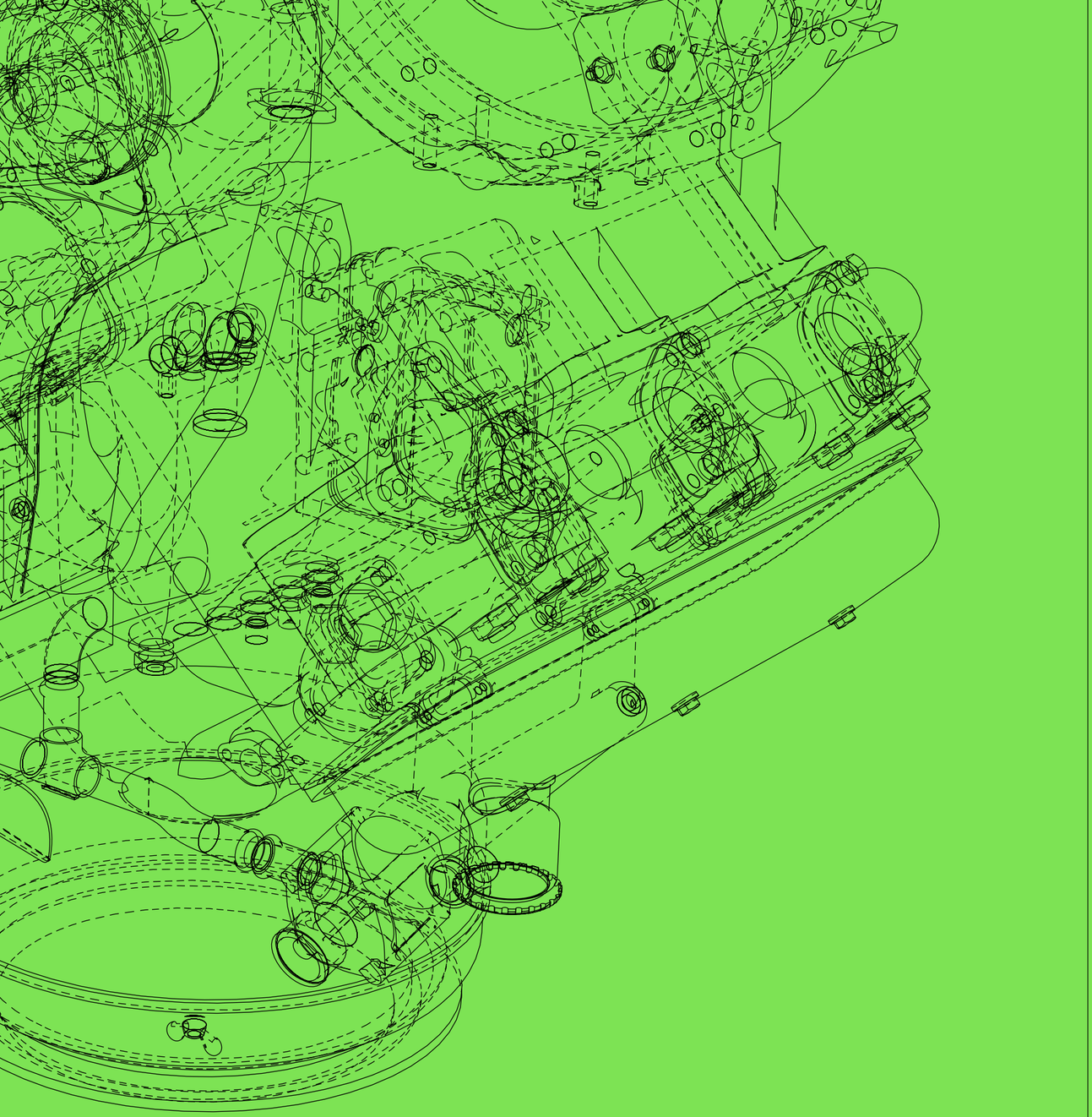
Before embarking on a new ecosystem partnership, the following must be considered:

- **Gather input from stakeholders** throughout the organization to understand needs for a partnership, and impacts to the plant environment
- Define **clear objectives, outcomes, roles and responsibilities** for ecosystem partners and understand how they will interplay into the new organizational dynamics
- **Communicate changes** to all relevant parties, to reduce disconnect about the goals of the partnership
- Understand how the new partner will **collaborate** with existing partnerships, teams, and processes

Case Study: The World Economic Forum's Global Lighthouse Network is Helping to Shape the Next Phase of the Fourth Industrial Revolution

The Global Lighthouse Network is accelerating a more inclusive adoption of advanced technologies in manufacturing with a platform that develops, replicates, and scales innovations in manufacturing. The network includes 132 sites from across 30+ countries across many industries, as of December 2023.

More information on the Global Lighthouse Network here.



Implement

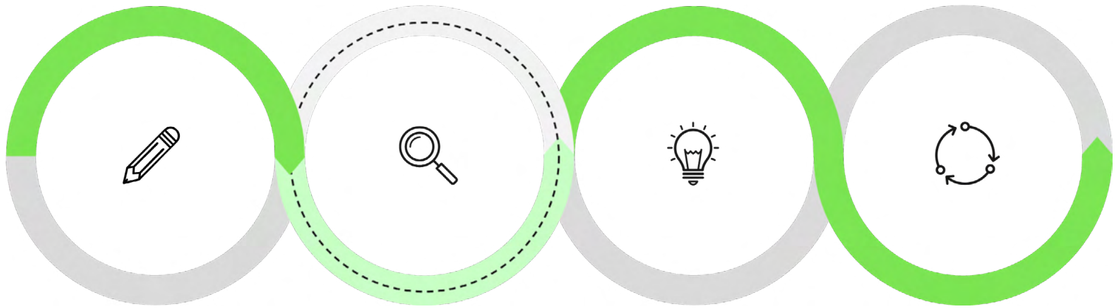
Technologies to Drive Business Model Innovation

What this section covers

01 How to **experiment** for innovation

02 How to **scale** innovation programs

Implementing Innovation, Step by Step



01
Identify and Shape

Leveraging the innovation north star, and input from business units, identify opportunities across the organization for innovation. Work with cross functional stakeholders to build on the opportunities, determine funding, and create teams.

02
Experiment

Identify hypotheses to be tested, and work to prove or disprove these hypotheses. Test to prioritize opportunities which show promise and be focused around capturing learnings. Update and repeat experiments, until the opportunity is ready to move on as a pilot or be deprioritized and learnings are shared across relevant teams.

03
Run Pilots for Successful Experiments

For successful initiatives, develop pilot programs to test at scale with a trial group. This will study the effectiveness of the solution, and uncover considerations for scaling across a larger segment of the organization.

04
Scale the Solution

Take successful pilots, and scale these to other business units or areas. Engage relevant stakeholders when scaling innovation, and build around the input of end users of the technologies.

Illustrative example:

01 A semiconductor manufacturer identifies several opportunities, including the use of VR training to reduce defects. A business case is created and a team is funded to investigate.

02 Limited tests are run with a minimum viable product to determine if VR is feasible and worthwhile to be used in this context.

03 The team responsible for packaging is identified as an area open to innovation, and a good early adopter of VR training. The concept is piloted with this teams line managers.

04 Once success has been observed in the experiments and pilots, funding is secured, a business case revised, and the product is developed, scaled, and launched.

Encourage Experimentation

Run experiments, and transition promising concepts to pilots, to rapidly test hypotheses.

Experimentation uses a scientific approach to address critical business questions. If done correctly, experimentation can test hypotheses that underpin opportunities for organizations, however if done incorrectly, can cost the organization time and money.

For experimentation to be worthwhile, focus on testing hypotheses, with learnings as an outcome. The goal of running pilots in an experimentation model is to validate if a proof-of-concept is likely to succeed at scale, but the overall experiment is also considered a success if learnings are recorded and incorporated in future pilots.

The rise of experimentation within organizations has the potential to transform organizational decision making, but needs to be implemented correctly.

Companies that invest in disciplined experimentation can experience real advantages when adopting new technologies.

Experimentation model:

01
Develop a Hypothesis

Start with specific questions around that can be answered through testing.

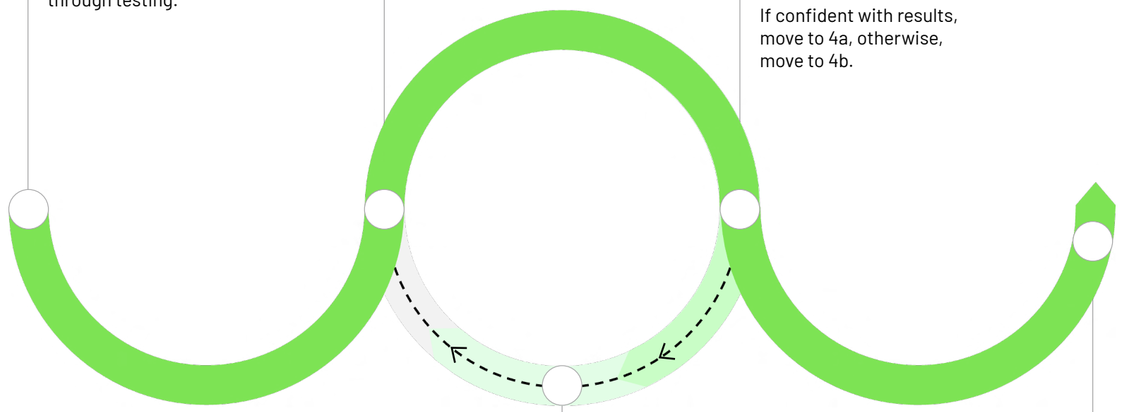
02
Design the Experiment

Define test objectives and KPIs, which will dictate success.

03
Run the Experiment & Analyze Outcomes

Evaluate the outcome of the experiment against the KPIs defined.

If confident with results, move to 4a, otherwise, move to 4b.



4a
Iterate from Proof of Concept to Pilot

Continue to rollout functionality as you test with larger groups of users.

Ensure to keep a hypothesis driven mentality.

4b
Refine Hypothesis and/or Test Parameters

Restart the process to continue to test hypothesis.

Disciplined Experimentation Best Practices

Experimentation can be difficult for manufacturers to get right. Focusing on value, creating clear success criteria, gaining leadership buy-in, and prioritizing learnings can help organizations make experimentation more successful.

Best Practice	Description	Steps Leaders Can Take to Achieve This
Focus on value	Keeping a close eye on value from innovation is critical. Value must be defined early on, and revisited periodically, to ensure innovation programs are building towards organizational value.	✓ Coach teams to think about value when identifying opportunities, running experiments, and scaling programs ✓ Tie innovation targets to business value
Create clear success criteria	Inform experiments by budgets and timelines, but measure innovation against clear success criteria.	✓ Set indicative budgets and timelines, but provide flexibility for teams to test hypotheses ✓ Use measurable success criteria to evaluate experiments
Gain leadership buy-in	Gain leadership buy-in though the experimentation process, to help accelerate buy-in required to scale a solution.	✓ Convene the right governance committees, with representation from cross-functional groups ✓ Have leaders share funding for innovation programs, to increase buy-in from the business
Track and share learnings	Define success for experiments based on learnings, regardless of if a hypothesis was correct. Share learnings from experiments which don't prove a hypothesis, to avoid additional spend on this opportunity across other teams.	✓ Redefine success for the experiment away from proving the hypothesis, and towards gathering learnings ✓ Involve cross functional teams in experiment design, execution, and analysis to encourage diverse perspectives ✓ Create ways to track and store learnings for future teams to build upon or fine tune as technology and capabilities expand

Innovation Measurement

Use structured methodologies to quantitatively evaluate innovation programs.

Innovation value can be difficult to quantify, however successful organizations track impact from innovation against overall strategic pillars. Tracking innovation success allows leaders to monitor value from innovation, and provide a basis for funding decisions.

A study of 1,350 industrial leaders estimates that industry wide return on digital investment (RODI) achieved despite a measurement gap is 10.6%, whereas the RODI opportunity by overcoming a measurement gap is 14.7%, meaning 4.1 percentage points of RODI are at stake due to the measurement gap, underscoring the need for strong measurement frameworks.[22]

While innovation value metrics will differ across industries and organizations, here is a sample of 4 major innovation strategy pillars, with corresponding innovation value metrics:

Sample Evaluation Scorecard

Illustrative Innovation Strategy Pillars	Evaluation Metrics
Financial Outcomes Improving financial impact from manufacturing operations	↑ Innovation ROI ↑ Expected revenue ↑ Expanded product lines/capabilities ↓ Expected costs ↑ Diversification of revenue sources
Manufacturing Excellence Improving manufacturing capabilities	↑ Manufacturing throughput ↑ Process capability (Cp and Cpk) ↓ Defect rates ↓ Scrap & material consumption ↓ Plant & machine downtimes ↓ Carbon intensity
Digital Adoption and Modernization Adopting new technology and embracing digital skills	↑ Adoption rates of new technologies ↑ % of workforce with digital literacy skills ↑ # of programs digitalized ↑ Innovation program participation ↑ Process automated
Workforce of the Future Supporting workers through change, and enabling the workforce	↑ % of workforce enabled by connected worker applications ↑ % of workforce with cross functional skills ↑ Employee job satisfaction ↓ # of hours lost due to accidents ↓ Employee turnover

Organizational gaps to scaling innovation

When scaling innovation, organizations who close gaps achieve higher return on digital investment.

Manufacturers express that scaling innovation programs, and extracting value at scale, is a major challenge. Few organizations scale innovation well, with only 22% of industrial companies researched achieving a return on digital investments that exceeded expectations.[22]

A recent study of 1,350 senior industrial executives identified a number of headwinds to scaling innovation, and quantified the incremental return on digital investment (RODI) at stake.[22]

> Being able to scale is a major component of an opportunity, which helps us determine which IoT partners to select.[14]
>
> **Brent Ruth, Lean Digital Transformation Leader, Caterpillar via USC4AM Community Interview**

Organization Gaps[22]	Industry-wide RODI achieved despite challenges (a)	Industry-wide RODI opportunity by overcoming challenges (b)	Industry-wide incremental RODI at stake (percentage points) c = (b-a)	Industry-wide incremental RODI at stake (multiple) d = b/a
Alignment: Lack of alignment between top and middle management on the definition of digital value, and on the right ways to leverage talent, assets and ecosystems to create the same	9.4%	17.8%	8.4%	1.9x
Infrastructure: Inadequacies in technology architecture which hinder collaborative innovation or make it hard to manage complex integrations of services with products	8.8%	17.2%	8.4%	2.0x
Skills: Lack of the skills required to identify, articulate, and innovate value through digital technologies and platforms at scale	9.7%	16.2%	6.5%	1.7x
Partnership: Lack of a shared view on how to build and scale data-driven, digital value among partners	9.7%	15.7%	6.0%	1.6x
Measurement: The absence of processes and metrics to systematically track returns on digital investments and inform innovation decisions	10.6%	14.7%	4.1%	1.4x

Source: *Rethink, Reinvent, Realize: How to successfully scale digital innovation to drive growth*

Gaps to scaling innovation

Gaps to scaling innovation can be addressed through playbook assets, as follows:

Legend

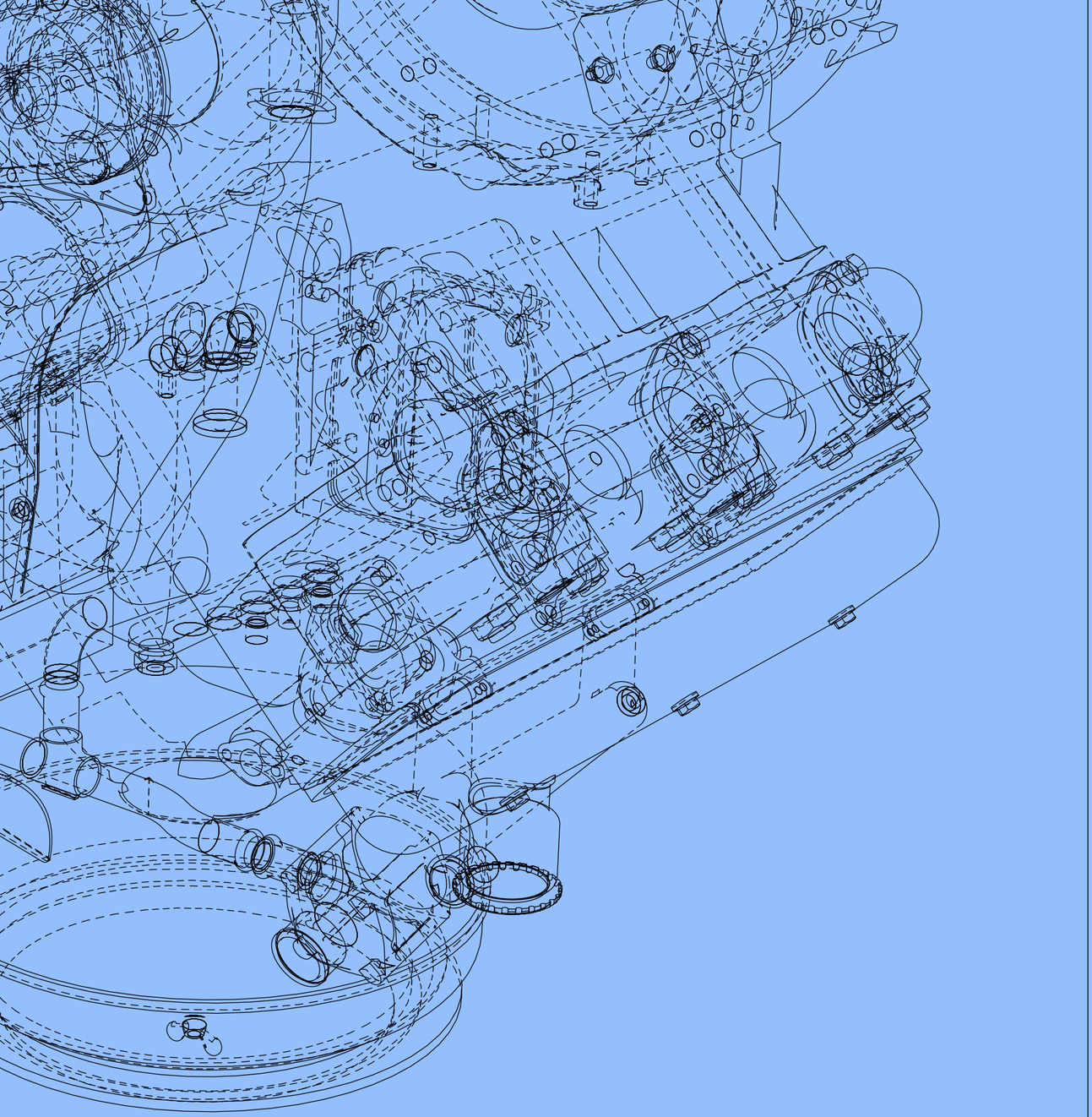
ⓘ	Inform solution
✓	Positioned to close gap

Gaps to Scaling Innovation[22]

Tools Provided in the Playbook	Alignment Gap	Infrastructure
Digital Manufacturing Readiness Framework	ⓘ	ⓘ
Barriers to Innovation Analysis	ⓘ	ⓘ
Roadmap, Prioritization, North Star	✓	
Innovation Evaluation Scorecard	✓	
Innovation & Experimentation Frameworks	✓	
Technology Analysis		✓
Ecosystem & Academic Partnerships		✓
Change & Upskilling Frameworks		

Gaps to Scaling Innovation (continued)[22]

Skills Gap	Partnerships Gap	Measurement Gap
ⓘ	ⓘ	ⓘ
ⓘ	ⓘ	ⓘ
		✓
		✓
✓	✓	
✓		



Future-Proofing Innovation

What this section covers

Enablers of Innovation

Innovation inherently comes with change, and managing change is an important factor to getting innovation right

To encourage innovation at an organization, there are a number of items for manufacturers to 'get right'.

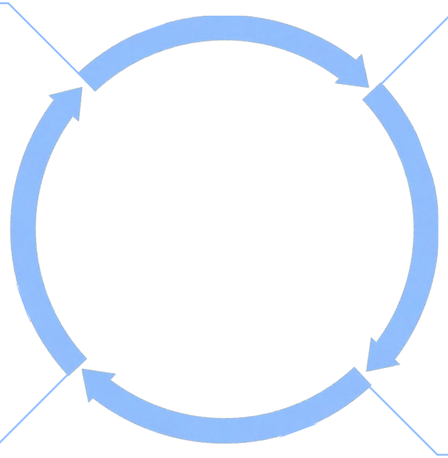
	How to get this right?
The right **problem** to solve	Solving the right problem is critical to seeing success through innovation, and keeping innovation spend targeted. A disciplined innovation process, where programs are tied to business value, incorporate end users in development, and take a test and learn approach helps organizations deliver high value innovation programs.
The right **governance** structures	Setting the right guardrails help to manage programs and increase ROI on innovation. Strong governance structures will give innovation teams leeway to experiment, but provide logical stage gates for funding, and hierarchies for decision making. Effective governance structures will also help to prioritize and deprioritize programs early, saving investments in unsuccessful opportunities.
The right **leadership**	Effective innovation leadership allows programs to be given appropriate priority and can provide legitimacy when collaborating across the organization. Having both the right seniority of leadership, as well as representation across all relevant functions, helps programs to gain momentum and buy in.
The right **people** and **skills**	Leadership may enable innovation; however, the team will drive innovation. It is recommended that manufacturers focus on having people with the right innovation mentality, and skills from the domains impacted by innovation, to enable success. A mix of traditional manufacturing knowledge, paired with next generation skills, such as analytics, help keep programs grounded and aspirational.
The right framework to track and measure **value**	Value tracking, and performance metrics keep innovation programs outcome oriented. Mature key performance indicator frameworks, that are routinely measured, evaluated, and reported on help to prioritize high value innovation programs.

Managing change across levels

Include all levels of the organization in shaping innovation, and change management activities, helps increase solution relevance and adoption rates.

Cross-Functional Project Teams

Cross functional innovation teams are often the teams initiating or driving change programs. Team members who are well versed in innovation methodologies and human centered design, will design solutions that are adopted easier by the workforce. Include change management skillsets in delivery, to actively plan for rollout and adoption.



Functional Leaders

Engage leadership in programs to work hand-in-hand with innovation teams, to guide solution development. It is necessary to have this buy in, so functional leaders have ownership over the solution and have conviction in the larger strategy innovation drives. A model where unit leads fully or partially fund innovation programs helps to ensure leaders are invested in the program, and will enable innovation to achieve wider business goals.

Plant Workforce

Engage champions from the plant workforce when designing innovation programs, to design solutions in a human-centered way. Identify change champions to help drive the change across their peers.

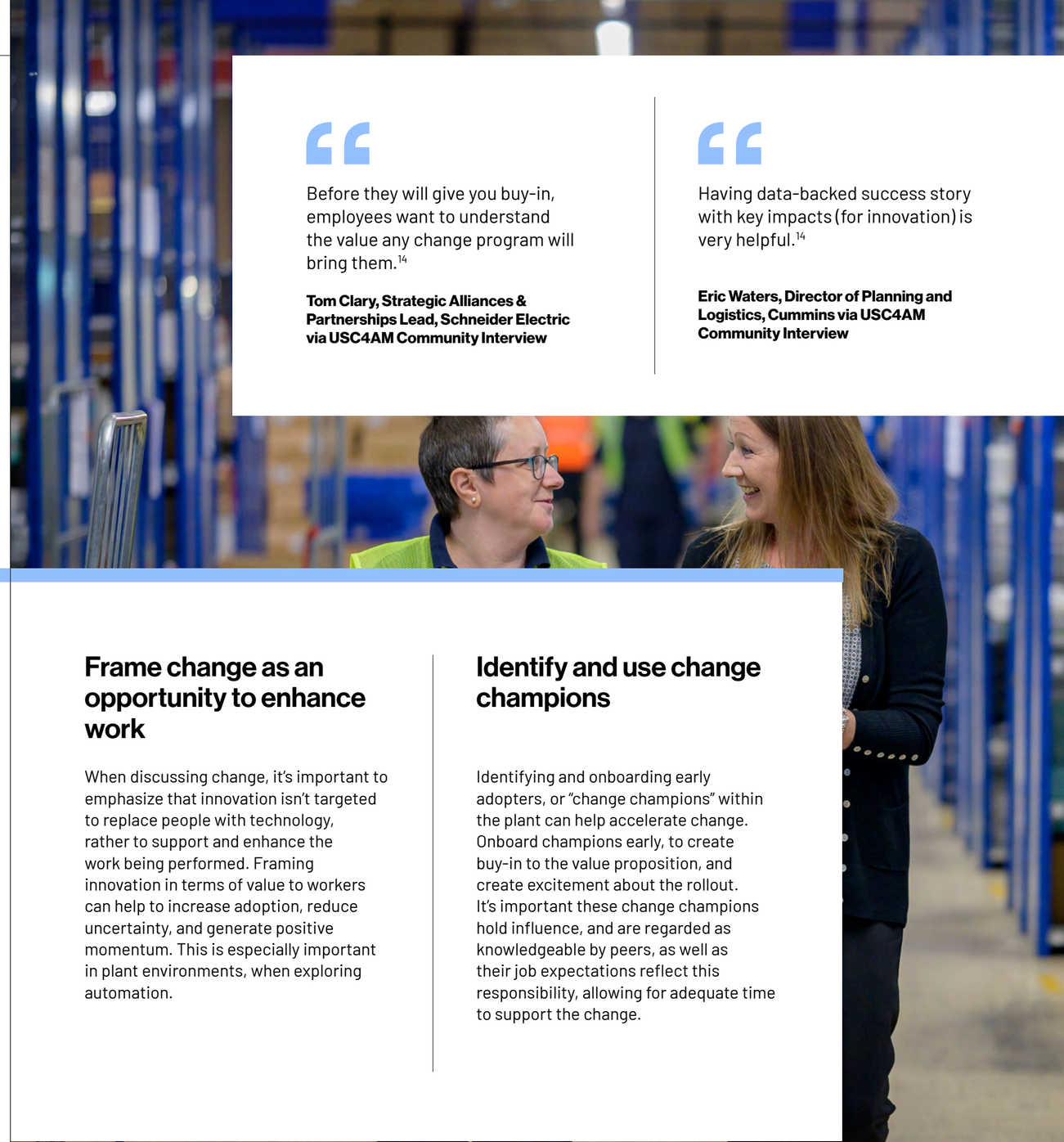
Managers

Plant managers help to facilitate change across the workforce. Ensure managers are well versed in the solution, and have a good understanding of the purpose of the change, to provide change support within their teams. It is helpful to frame the change to managers in terms of their teams success.

> Technology, its selection, and its deployment are usually not the biggest challenges. Understanding how you will change procedures at enterprise scale so that people enjoy adopting the technology-enabled ways of working is usually your biggest challenge. This is almost entirely a problem of will more than skill.[14]
>
> **Keith Gargiulo, Vice President, PTC via USC4AM Community Interview**

Communicating Change in Plants

Change, specifically in the plant environment, can be difficult to get buy-in for, and long tenured employees can be skeptical of new technologies and shifts in how work is performed.



> Before they will give you buy-in, employees want to understand the value any change program will bring them.[14]
>
> **Tom Clary, Strategic Alliances & Partnerships Lead, Schneider Electric via USC4AM Community Interview**

> Having data-backed success story with key impacts (for innovation) is very helpful.[14]
>
> **Eric Waters, Director of Planning and Logistics, Cummins via USC4AM Community Interview**

When communicating change in plants, consider the following best practices:

Engage workforce in shaping the change

When shaping, building, testing and deploying innovation programs within manufacturing organizations, put emphasis on the end user, to understand how work is currently done, perceived barriers to innovation, and where value may be realized. When communicating the change, it's important to explain that this change was done with input, not despite it.

Communicate change in a way employees are used to it

Understanding how information is transmitted on-site is vital to reducing friction in change communications. Employees used to receiving information in person during daily huddles, face challenges if communications come through emails. Matching how employees want to receive information will help dictate success of change programs.

Frame change as an opportunity to enhance work

When discussing change, it's important to emphasize that innovation isn't targeted to replace people with technology, rather to support and enhance the work being performed. Framing innovation in terms of value to workers can help to increase adoption, reduce uncertainty, and generate positive momentum. This is especially important in plant environments, when exploring automation.

Identify and use change champions

Identifying and onboarding early adopters, or "change champions" within the plant can help accelerate change. Onboard champions early, to create buy-in to the value proposition, and create excitement about the rollout. It's important these change champions hold influence, and are regarded as knowledgeable by peers, as well as their job expectations reflect this responsibility, allowing for adequate time to support the change.

Creating a Culture for Innovation

To help innovation succeed within in an organization, develop a culture of innovation at all levels.

> The status quo is the biggest hindrance to innovation.[14]
>
> **Rich Garrity, Chief Industrial Business Officer Stratasys via USC4AM Community Interview**

Encourage experimentation at all levels

The ability to experiment, at scale, and at pace, sets innovation leaders in manufacturing apart from the rest. It is important for leaders to build a culture which encourages innovation, rewards experimentation, and treats learnings as successes. A culture that only rewards successful experiments can discourage teams from transformative innovation and refocus teams towards less innovative, safer opportunities.

Establish strong executive sponsors for innovation

By leading through example, leaders can set an example for the culture they want to see within the organization. Establish formal executive sponsorship through an executive or office tasked with overseeing the company's emerging technology agenda, such as a Chief Innovation Officer, to ensure there are sufficient time, resources, and cross team collaboration.

Invest in new technologies and support adoption

Investments in innovative technologies, trainings and pilots shows leadership support in innovation and continuous improvements. When these changes impact worker experience for the better, it can drive changes in workplace culture towards innovation.

Emphasize innovation led communication

Strong communications are required to change culture towards innovation. Message change with care, to illustrate the need for change, and to outline the benefits of such change. Strong communications allow employs to feel aligned with changes, and empowered to make improvements themselves.

Key Takeaways

As manufacturers envision their organization's future over the next 5, 10, 15 years, it becomes clear that technology will play a pivotal role in defining the competitive landscape and enabling new business growth. This playbook is designed to provide manufacturing leaders a starting point to think about how to harness technology to enable new business model development.

From navigating the technology landscape to shaping workplace culture, major playbook takeaways include:

Innovation Isn't Always Huge

The term Innovation is often synonymous with large breakthroughs. For example; implementing a digital app to replace a tired paper-based system may not seem innovative, however it is an important step forward towards a digital transformation and workplace culture shift.

Investigate New Technology

Manufacturers need to stay up to date on the evolving technology landscape, understand use cases, and explore how these technologies are positioned to impact their business, production, and the competitive landscape.

Address Barriers To Innovation

Breaking free of the taboos plaguing the industry, manufacturers need to identify and address the various obstacles stifling growth and establish realistic innovation ambitions.

Conduct Introspective Analysis

Before pursuing innovation programs, manufacturers first must assess technological capabilities, challenges, and opportunities within their organization through a technology readiness capability framework, to identify capability gaps and opportunities.

Define an Innovation North Star

Identify and codify a north star and innovation roadmap, to guide technology investments that drive new business value.

Address Brownfield Sites

When pursuing modernization, explore bringing legacy infrastructure inline with new greenfield sites.

Keep Greenfields Green

When building greenfield facilities, be wary of legacy infrastructure which is outdated, and use the latest technology and digital systems to remain competitive into the future.

Close Gaps & Build on Success

As manufacturers better understand their operational landscape, it is critical to not only identify the areas of improvement but also capitalize and build upon what is going well.

Balance Short Term Gains With Long-Term Vision

Build a strategic roadmap that prioritizes lower effort, higher return opportunities that build upon each other to enable the completion of higher effort, high return goals.

Experiment Often

Encourage frequent experimentation, taking a hypothesis to proof of concept, with appropriate checks and balances to cut experiments early when not meeting defined criteria.

Keep the Business Value Front and Center

While planning for, and delivering innovation programs, track and evaluate based on value to the business and customers.

Meet Needs of Future Workforce

From innovative technology to improved workplace programs and offerings, manufacturers need to understand the drivers of the next generation workforce and make their organization attractive as an employer.

Upskill and Empower Current Workforce

Use technology to support the current workforce to gain both core manufacturing skills, and next generation digital skills, and use technology to help workers be more effective in their roles.

Build Robust Talent Pipelines

Focus on developing talent pipelines, including partnerships with universities to shape curriculum and develop the next generation of manufacturing workers and leaders.

Build Robust Partner Ecosystems

Explore leveraging ecosystem partners to augment capabilities and provide access to new opportunities.

Build Culture of Innovation

When approaching change, focus on creating a strong culture of innovation to encourage adoption of new technologies.

Navigate Challenges with Resilience

When faced with challenges towards implementing innovation, encourage resilience, experimentation, and adaptability.

Develop Cross-Functional Dynamic Teams

Enable a workforce that not only understands business operations but responsibilities across teams and builds expertise in both OT and IT functions bridging skills from physical and digital worlds.

Where to go from here

The World Economic Forum has been developing immersive pieces of thought leadership to help guide manufacturing leaders on their innovation journey. Below are some of the pieces that provide additional context to the playbook topics:

Unlocking Business Model Innovation through Advanced Manufacturing

The Future of Industrial Strategies: Five Grand Challenges for Resilient Manufacturing

Advanced Manufacturing: A New Narrative

The Global Smart Industry Readiness Index Initiative: Manufacturing Transformation Insights Report 2022

The Data-Driven Journey Towards Manufacturing Excellence

Measuring Digital Trust: Supporting Decision-Making for Trustworthy Technologies

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Endnotes

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