# What Would It Take to Bring Back US Manufacturing?

## Part 2: Making American Manufacturing More Productive

Increasing US manufacturing will require increasing manufacturing productivity. We explore the existing technologies that can be transformative for US productivity, and what it will take for them to be applied at scale.

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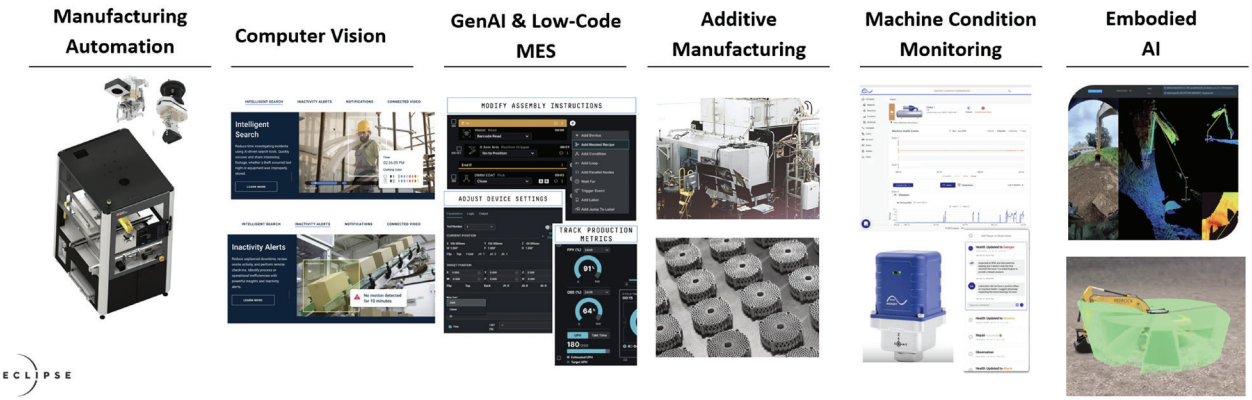
In Part 1 of this two-part series co-authored with Eclipse, we shared that the US is uncompetitive in many different types of manufacturing because of structurally higher costs, most notably labor, and because decades of offshoring have weakened the US industrial base, leaving limited capacity to support a self-reinforcing build-out of the manufacturing sector. Tariffs are unlikely to meaningfully close this cost differential or create manufacturing capacity for goods the US barely produces at all, such as apparel or consumer electronics.

At the same time, the US has a lot going for it: an incredibly large domestic consumer market, low energy costs, flexible labor markets, and a government that has clearly signaled its support for the manufacturing sector. Capitalizing on these advantages and overcoming the structural headwinds to US manufacturing to make it more competitive will likely require making manufacturing more productive, so that higher output justifies the higher production costs in the US.

**There are new technologies that have the power to be transformative and currently exist, but scaling them up will likely take the better part of a decade.** Targeted tariffs can work to lower the hurdle these new technologies have to clear in terms of reducing production costs and improving efficiency before it is profitable to invest in them and build out domestic manufacturing capacity.

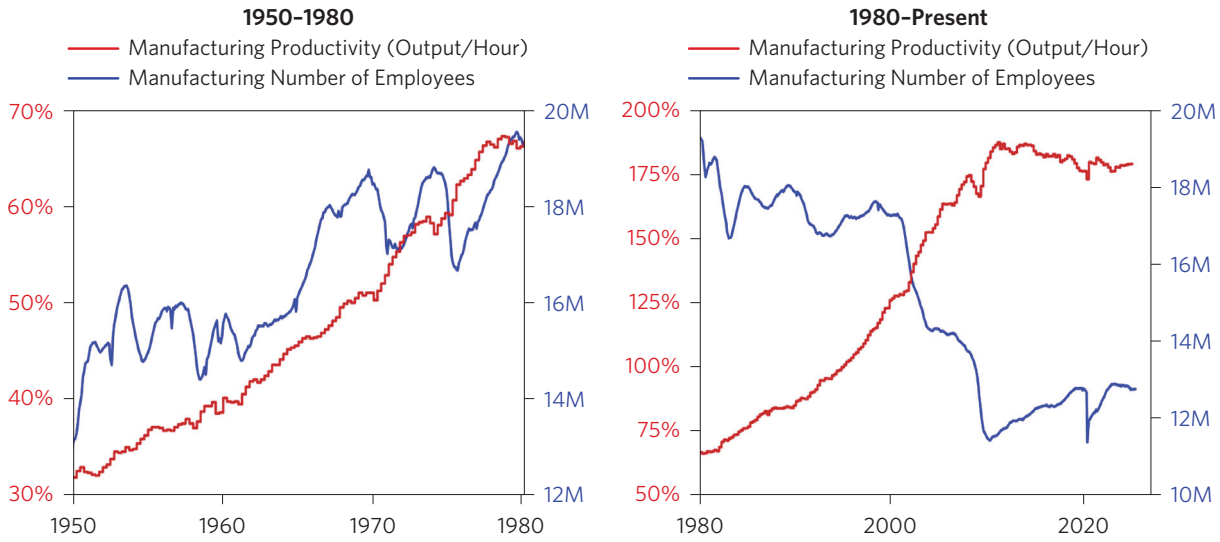
A copy/paste of the prevailing manufacturing processes from other countries will not satisfy the reindustrialization appetite of US policy makers, as it would be too costly, slow, and reliant upon the insufficient US labor pool of skilled and interested manufacturing technicians and trade workers. **To increase US onshore manufacturing productivity to a level where volumes could satisfy domestic demand, with a manufacturing capacity footprint limited by construction and installation timelines and low worker interest and qualifications, the US must leverage advanced technologies to increase productivity by one to two orders of magnitude.**

Technologies that are both a) scale-ready and b) capable of moving the needle for US manufacturing productivity include automation, computer vision, additive manufacturing, and machine condition monitoring. Technologies that are in earlier phases of development but potentially even more transformative include generative AI (simulation and digital twinning) and embodied AI.



**A cursory glance suggests productivity in the manufacturing sector has stagnated since 2010, but a deeper look highlights a secular turning point of stagnation right around 1980.** In the decades leading up to 1980, steadily rising productivity growth in the manufacturing sector supported economic growth, more production, and, ultimately, more employment in the sector. But since 1980, the relationship between productivity growth and employment in manufacturing has been flipped, and manufacturing only got more productive as employment fell. This is because the US offshored the least productive manufacturing sectors (like apparel manufacturing), raising the average level of manufacturing productivity through process of elimination.

**US Manufacturing Sector Productivity vs Employment**




From 1950–80, improvements in manufacturing productivity facilitated steadily rising employment in the sector

**Since 1980, the relationship has been flipped:** the US manufacturing sector improved average productivity by offshoring the least productive jobs; **and since 2010, productivity in the manufacturing sector has stagnated**

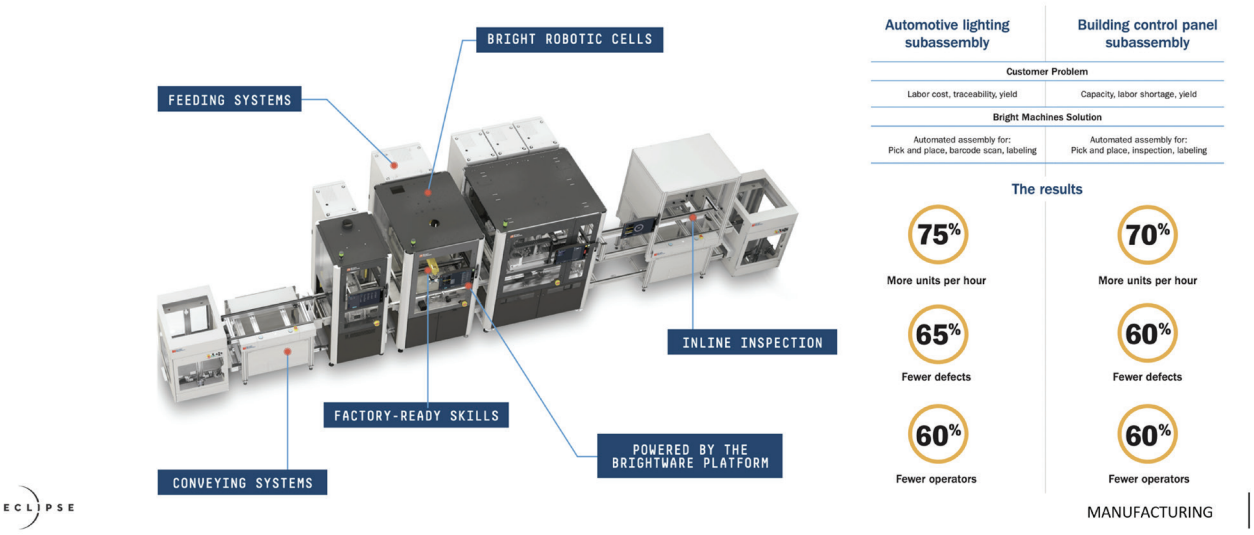
In the rest of this report, we share more detail on each of the technologies that could work to improve US manufacturing productivity and describe how the process of adopting these technologies will take time.

# The Technologies That Could Make American Manufacturing More Productive

**1) Software-defined manufacturing and automation**

More than 80% of US warehouses today have no automation, with only 141 robots per 10,000 manufacturing employees. Automation can take many shapes and forms, and in manufacturing settings, humanoid robots are currently less efficient and effective than other automation solutions. At Tesla's manufacturing sites, for example, billions invested in robotic cells and manufacturing automation have streamlined production and increased gross margin.

For smaller electronics with advanced components like GPUs that are changing quarter over quarter, microfactories with programmable inputs are ideal for high-mix, low-volume assemblies. Increasing numbers of manufacturing automation players in the market are leveraging software and low-cost robotics to automate full lines for end-device and goods assembly, not just parts or subassemblies. For example, the below series of robotic cells can take a low-code/no-code set of commands paired with design files and produce many different types of quality-assured systems as outputs, from data center servers to hand drills, at increased throughput (75%) and fewer defects (-65%) than typical assembly processes.

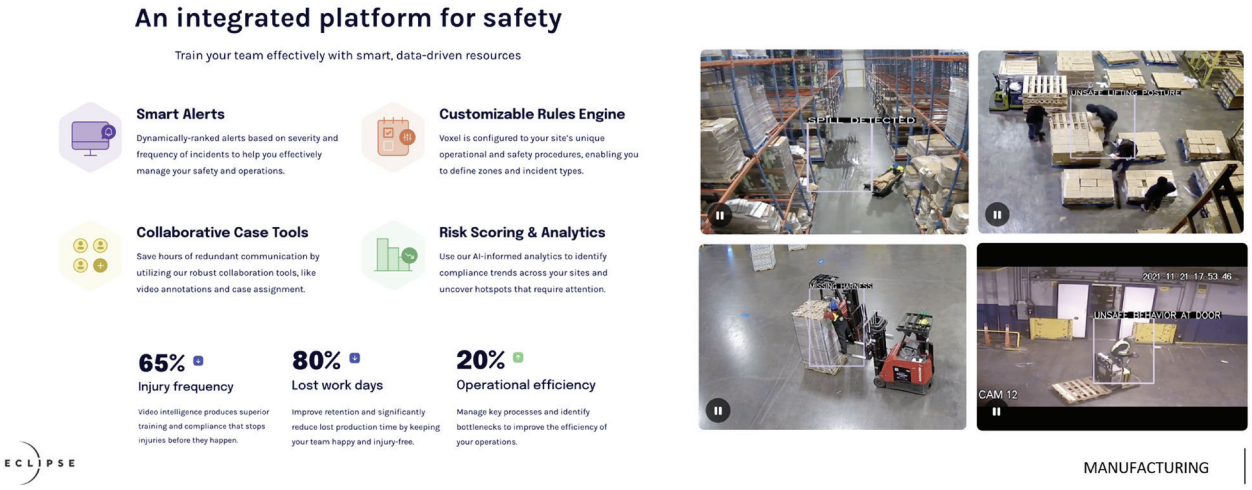



The US lags in industrial automation relative to the rest of the world, with low levels of industrial robot adoption in US factories compared to other developed economies. Government policy can play a role here. For example, Korea's government-led robotics industrial policy includes an investment commitment of $2.26 billion by 2030, streamlining of regulatory hurdles, and investing in skilled robotics training courses for 15,000 workers.

### 2) Computer vision

Advances in AI and computer vision, including vision transformers (ViT), which can detect objects 30% faster than convoluted neural networks (CNNs), and other forms of edge AI like Nvidia's Jetson processors, mean existing camera infrastructure can play a major role in nonintrusive operational productivity in industrial environments. Computer vision efficiency has the capacity to radically improve operational efficiency across multiple types of industrial environments, from retail, where real-time stock tracking via computer vision and RFID can reduce out-of-stock events by 40%, to certain types of manufacturing defect detection and lowering the frequency of industrial safety incidents.

Below, we show an example of computer vision being used to improve safety in an industrial environment. The presence of such systems (with a managerial feedback loop to operators on the ground) has proven to reduce incidents by 60-80% and increase operational efficiencies by around 20%.




### 3) Additive manufacturing

Additive manufacturing (also known as 3D printing) has evolved significantly, and major brands are beginning to adopt leading-edge solutions. Some solutions are 20x faster and a fraction of the carbon footprint of traditional fabrication techniques. Certain advanced additive technologies can rapidly produce even complex, durable designs such as fuel nozzles for jet engines or spinal implants. Advances in additive manufacturing are key to any near-shored supply chain strategy.

Below, we show key statistics reported by one industrial-scale 3D metal additive manufacturer based outside of Boston:

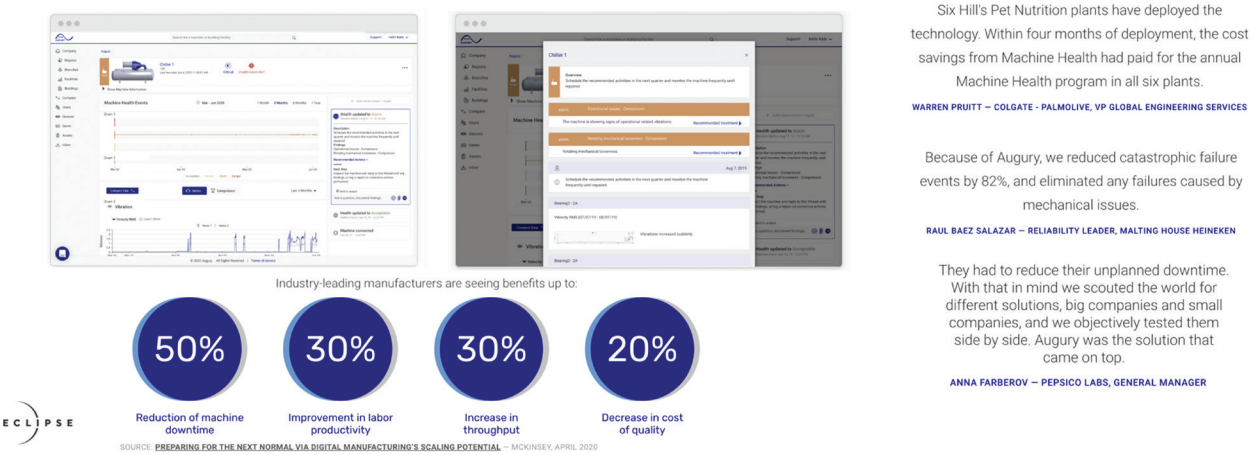

- Vulcan Forms is the world's most powerful laser powder bed fusion system. Each printer deploys **150 laser beams** projected from a gantry. MIT-patented technology.
- Each printer **is 20 feet high and 60,000 pounds**.
- Currently, customer industries include **aerospace**, **semiconductors**, **defense**, and **medical implants**.
- **Materials used:** titanium and other metals.
- **Process:** Additive layer by layer, each as thin as a human hair; up to 20,000 layers, depending on a part's design. Internal machine atmosphere is mainly argon.

ECLIPSE
MANUFACTURING

### 4) Machine condition monitoring

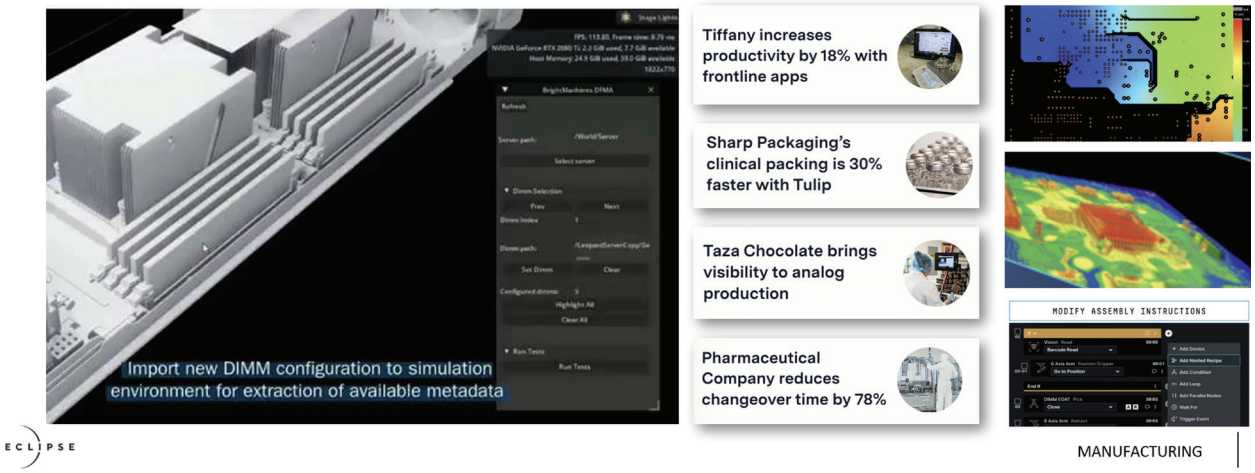
Mechanical issues account for 10-15% of losses in manufacturing productivity. Unplanned downtime is a significant loss-making scenario in manufacturing, and scheduled maintenance has historically been an inefficient but necessary evil. Today's machine-monitoring solutions offer not only constant monitoring and alerting across most equipment types, but also predictive maintenance capabilities and machine learning based on large datasets across many customers and machine types, and are capable of reducing unplanned downtime by more than 50%.

Below, we show UI and results by machine condition monitoring company Augury:




### 5) Generative AI and low-code/no-code modern design tools

Traditional manufacturing execution systems (MES) were built for stability and meant to last but have struggled to keep up with the fast-paced, complex market demands and disruptions of today. An increasing number of technologies have targeted manufacturing design simulation and MES integrations that enable technicians to make modifications without complex programming or expensive change orders. Generative AI is increasingly usable in the design and simulation of new systems (mechanical, electrical, thermal, and full system integration), enabling a radical reduction in cost and speed to market, as we show below.

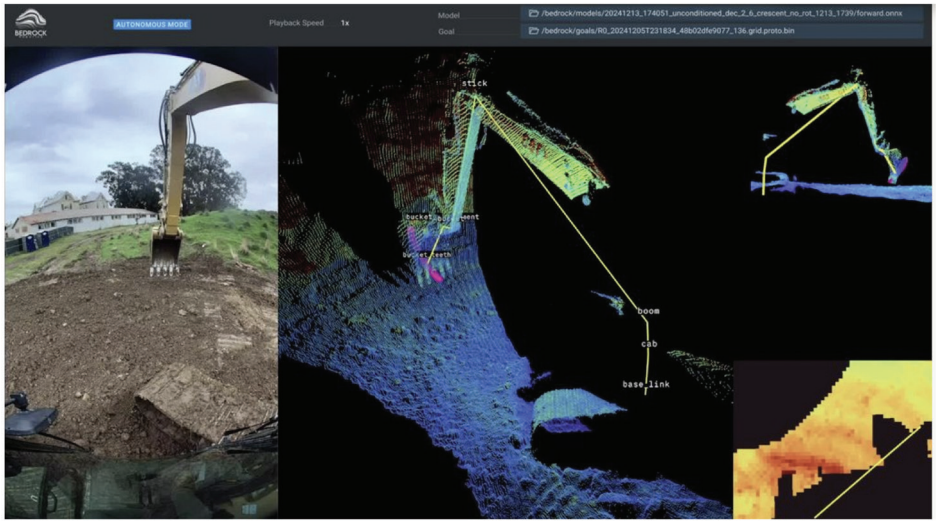


### 6) Embodied AI and robotics

As evidenced by Waymo's self-driving cars expanding across geographies, today's robotics tech stack has advanced far beyond what seemed possible even just a few years ago. Self-supervised learning (SSL) models and large models (language and video) are revolutionizing robotics. Each AI era—ImageNet for vision and transformers for language—is defined by its toughest data challenges. The next frontier—embodied AI—is a term for advanced, applied robotics, like Waymo vehicles, and is already taking hold across industrial and manufacturing environments. The lessons from the first million autonomous miles driven at Waymo can now be applied to adjacent industries (such as construction and other heavy equipment operations, as pictured below).

Adding industrial capacity (building plants, fabricating tooling, producing steel, and other key inputs) is as important as improving manufacturing throughput, and embodied AI's capabilities to support large-scale, foundational industrial workloads in construction, warehousing, agriculture, and manufacturing may be critical to the generational transformation needed for a broader-scale US manufacturing capacity build-out.

**An Autonomous Excavator & Visualization of Its Point Cloud, Operating in Phoenix, AZ**




*Source: Eclipse Ventures*

# The Process of Adopting These Technologies Will Take Time, Making the Revival of US Manufacturing a Process That Will Likely Take a Decade, If Not Longer

The United States is a decade away from the scale and scope of "lights-out" manufacturing that could enable it to rival the rest of the world's manufacturing output to satisfy the US's own end-to-end demand, at a similar or lesser cost.

While the current scale and impact of advanced technologies in American industrial production is low outside of low-volume defense manufacturing, several key technological advances are having a positive impact on US industrial productivity. Unfortunately, 98% of manufacturers in the United States are small-to-medium enterprises and are relatively underpenetrated by technologies capable of driving significant growth in manufacturing productivity.

Essentially, the low levels of deployment of these increasingly mature technologies in the US today are limited not by technical readiness or maturity, but by commercial adoption and willingness to invest in advanced capabilities and improved manufacturing throughput.

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