AXA VENTURE PARTNERS

White Paper

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# Revolutionizing Manufacturing Through Software

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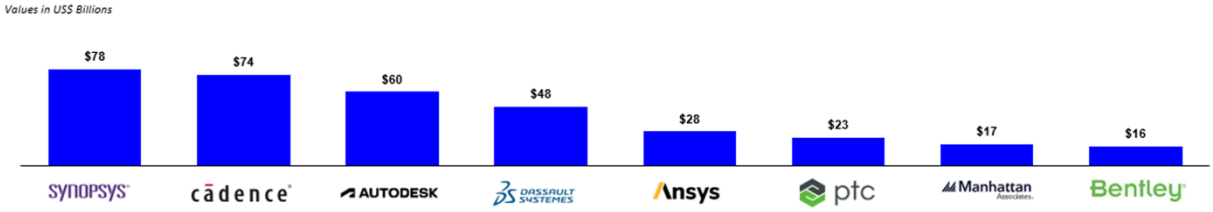
## Background

Innovation and the efficiency of production in manufacturing rapidly accelerated during the Industrial Revolution, when production mechanization laid the foundation for future advancements in one of the largest and most critical industries of our economy. Several significant developments have occurred since the 18th century, highlighted by the invention of the modern assembly line by Henry Ford in 1913, the introduction of the first industrial robot by Unimation in 1961 and the creation of the first 3D printers by Dr. Hideo Kodama in 1981. More recently, the focus of manufacturing innovation has been centered around a new wave of software solutions, which has led to faster, more cost-effective and operationally efficient production processes. The opportunity for further disruption through software innovation has never been more apparent.

The major players in the manufacturing software industry each offer a set of specialized tools and solutions designed to improve various production processes, ranging from design and simulation to maintenance. These manufacturing software businesses that were founded beginning in the 1970s built flagship products that have been widely adopted by extensive customer bases and fueled strong financial performance, which led to their large market capitalizations. Given the age and size of these organizations, they are slower to adapt to new advancements in technology and often manage their businesses to minimize the risk of disrupting the current market equilibrium. However, there is a slew of start-ups that have embraced innovation and created truly disruptive products that have shifted the status quo for manufacturing. While most of the large incumbents in the industry have advanced solutions, they suffer from long implementation timelines, require technical users to integrate and operate, and often solicit higher price points than startup offerings. This leaves ample whitespace for new entrants in the software landscape that offer more innovative solutions, are easier to implement, are more affordable and are focused on addressing a specific issue or vertical.

### Founding Timeline of Manufacturing Software Incumbents


### Market Cap. of Manufacturing Software Incumbent




*Note: Does not include manufacturing software businesses with hardware; as of Oct-8-2024.*

These established companies have typically relied on M&A to grow, sustain market share and remain competitive. In the first 9 months of 2024 alone, there have been numerous acquisitions by major players, including Synopsys' announced acquisition of Ansys, Cadence's acquisition of BETA CAE and Autodesk's acquisitions of (a) Wonder Dynamics, (b) Payapps, (c) PIX and (d) Datum360. These large companies have become serial acquirers with a robust M&A playbook and constant pipeline. This level of M&A is an attractive backdrop for disruptive startups to be recognized and investors to eventually be monetized at accretive values.

At AVP, we are exploring the next generation of companies that are reshaping the manufacturing software landscape. This paper will delve into three main topics:

1. Why We Are Interested
2. Manufacturing 101
3. Areas of Opportunity

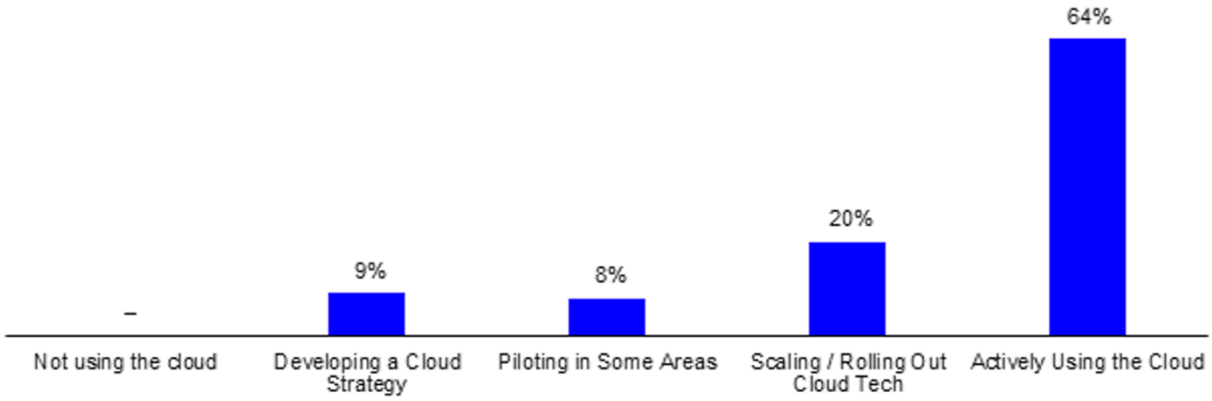
# I. Why We Are Interested

Manufacturing technology presents an attractive investment vertical given the sizable market, opportunity for disruption, recent tailwinds and potential for strong returns.

## A. Digital Transformation of Manufacturing:

Historically, the manufacturing industry has been an "old-school" pen and paper or basic Excel operation, and just recently companies have started to adopt advanced technologies such as AI, Industrial Internet of Things (IIoT), cloud computing and big data analytics. Manufacturing is one of the most data intensive industries with ~1.9 petabytes of data generated every year, which enables technologies like AI to have a substantial impact.[1] Many manufacturers are switching from outdated, on-premise solutions to scalable cloud-based solutions to drive better connectivity and capabilities, as seen when GE publicly announced its push to the cloud in 2014.[2] Manufacturing has historically been slow to adopt technology, but these recent digital transformations are allowing startups to take advantage of an industry with a real need for disruption.

Cloud Adoption Within Discrete Manufacturing




*Source: McKinsey[3]*

## B. Talent Shortage:

Retaining top talent for manufacturers has been an increasing concern, and job openings in the industry are around all-time highs of ~800,000 in the USA.[4] A National Association of Manufacturers Outlook Survey conducted in early 2024 highlighted that more than 71% of manufacturers have difficulty attracting and retaining employees.[5] This trend will be compounded by the aging of the workforce and retirement of the older generation, as nearly 25% of the sector's workforce is 55 or older. It is estimated that there may be 2.1 million unfilled manufacturing jobs in North America by 2030 based on a study by Deloitte and the Manufacturing Institute.[6,7] There has also been labor pushback, as evidenced by the recent docker workers strike, and these workers are demanding better wages and limiting automation to maintain job security. As aging employees retire and find other industries, manufacturing companies risk that these employees take their specialized craft knowledge with them. Thus, there is need for modern solutions to increase efficiencies to minimize the talent gap, as well as create technical processes to retain trade specific knowledge within the organization.

## C. Cost Pressure and Reshoring:

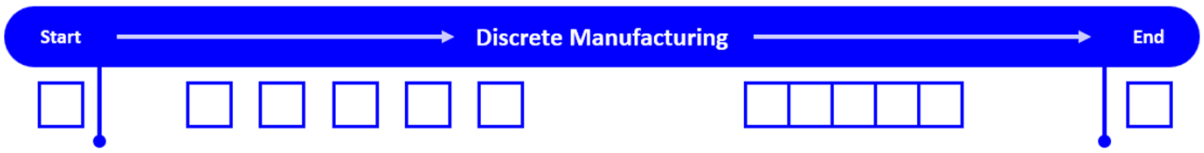
The manufacturing industry has been dealing with rising costs, which have enhanced the need for digital solutions. According to AGC, labor costs increased 4.1% from Q1'23 to Q1'24 in manufacturing, creating operational, financial and strategic opportunities for software businesses.[8] National security interests, trade barriers and supply chain disruptions are also pushing businesses to find alternatives to global supply chains. According to a KPMG report in 2023, 84% of CEOs are nearshoring / onshoring operations or bringing them in-house.[9] The desire for nearshoring or in-house manufacturing solutions require substantial investment and creates potential margin compression. For companies to remain competitive during this transition, they are turning to technology and alternative solutions to help solve cost competitive dynamics.

### D. AI Advancements:

Although AI is top of mind for most individuals and companies, manufacturing specifically exhibits clear advantages and the companies have demonstrated open-mindedness towards AI. According to a survey completed by Deloitte, 93% of companies believe that AI will be a pivotal technology to drive growth and innovation in manufacturing, and 87% of manufacturing companies say they have adopted or plan to adopt AI within two years.[10] In a recently published report by the National Bureau of Economic Research about early adoption of AI in the US, manufacturing has shown the highest adoption out of any industry at ~12%, leaving plenty of room open for opportunity.[11] Overall, GenAI holds the potential to slash manufacturing and supply chain expenses by up to $500bn, transforming every stage from planning and product development to production and maintenance.[12] More than half of manufacturing businesses plan to increase spending on software by 10% or more in 2024 compared to 2023.[13] The willingness to adopt new technologies and the tangible benefits recognized by manufacturing companies creates an environment ripe for innovative startups to bring novel offerings to market.

## II. Manufacturing 101

Within the manufacturing software space, there are many ways to break down the processes and workflows of operations. While the manufacturing lifecycle typically follows the (a) design/engineer, (b) execute and (c) manage/maintain workflow, one can divide the manufacturing type into two sectors: discrete and process. Discrete manufacturing refers to the production of single parts or units that come together to create a final product through a series of specific and differentiated workflows. Discrete manufacturing processes typically require more planning and scheduling, as the process is less standardized and often relies on many different pieces coming together.[14] Process manufacturing, unlike discrete manufacturing, does not have a distinct start or end, rather it is defined by its continuous combination of supplies, ingredients or raw materials, like a recipe. Traditionally, process manufacturing is used for high-volume products that do not require customization (e.g. homogenous goods).[15]

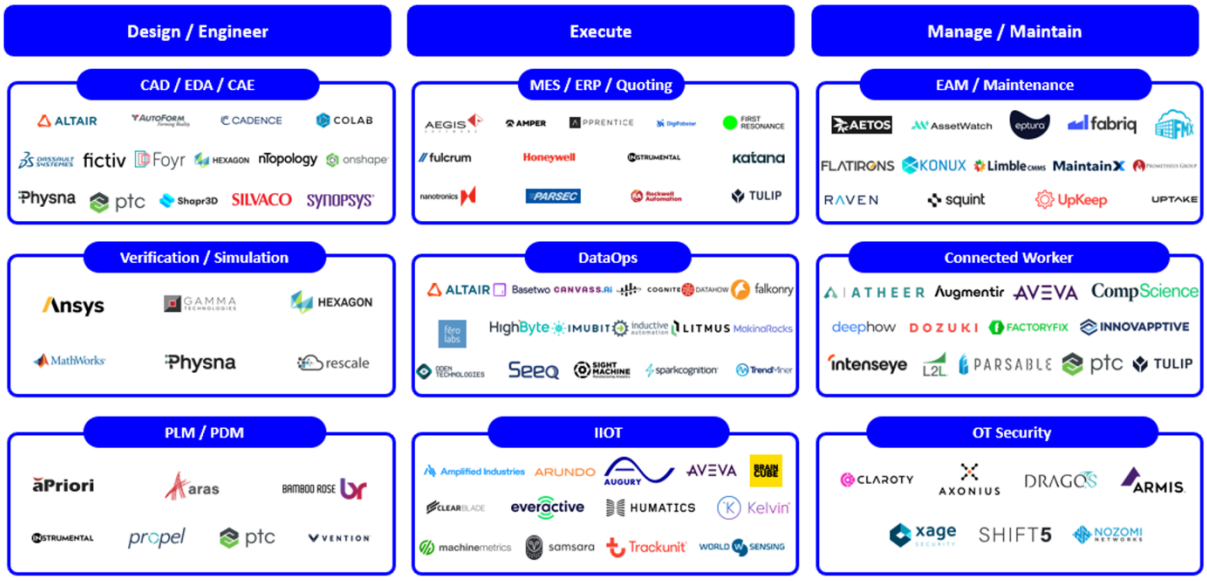



**Discrete manufacturing** refers to the production of individual parts or units that come together to create a final good through a series of specific and separate workflows. Typical industries include automotive, aerospace, consumer goods and electronics.


**Process manufacturing** does not have a distinct start or end, rather it is defined by its continuous combination of materials. Typical industries that use process manufacturing include chemical, food and beverage, pharmaceutical, oil and gas refining, cosmetics and textile dyeing.

Despite the different processes, both discrete and process manufacturing typically follow the same workflow of (a) design/engineer, (b) execute, and (c) manage/maintain throughout the lifecycle and incorporate PLM, DataOps, connected workers/smart manufacturing, IIoT and OT security. We have laid out a software landscape that incorporates the different aspects of the manufacturing process from concept design all the way to asset disposal.

Manufacturing Software Landscape




*Note: Market map is not comprehensive and only includes select representative companies per subsector.*

## A. Design / Engineering

The design / engineer sector involves creating and documenting the process and product design using computer-aided design software, engineering analysis tools and other design tools. It includes conceptual design, detailed engineering, simulation and product lifecycle management.

**Computer-aided Design (CAD) / Electronic Design Automation (EDA) / Computer-aided Engineering (CAE):** Using modern technology, computers are able to simulate, analyze and automate the design and prototype of different products.

**Verification / Simulation:** Predicts and simulates the whole product process. This can accelerate time to market, reduce costs, ensure efficient implementation and test processes to find any vulnerabilities or improvements in advance.

**Product Lifecycle Management (PLM) / Product Development Management (PDM):** PLM solutions represent the entire lifecycle and go beyond design and engineering, whereas PDMs are the subsector that focuses specifically on product development.

Key pain points this sector faces:

- **Outdated processes:** Design processes have previously relied on manual documentation and communication methods, leading to potential errors, delays and difficulties in maintaining traceability.
- **Knowledge gaps:** Gaps in information caused by the recent turnover of workers can lead to inefficiencies and longer ramp time of employees.
- **Rising costs:** With meaningful delays in the supply chain and materials costing more, there is less room for errors. Companies must prioritize mitigating any mishaps on their end to avoid unnecessary purchases in an inflationary environment.

## B. Execute

Within the execute sector, technology businesses enable manufacturers to track, monitor and collect data about their inventory and production processes. In addition to MES and ERP systems, integration with DataOps and IIoT solutions have become increasingly popular as the rise and reliance on data has skyrocketed.

**Manufacturing Execution System (MES) / Enterprise Resource Planning (ERP):** Solutions and systems that oversee, track, schedule and document each stage of the production process.

**DataOps:** Integrates data from various sensors and system architectures and merges them into a platform that provides tools, processes and structures to support a data-focused enterprise.

**Industrial Internet of Things (IIoT):** Collection of sensors, instruments and devices that are connected through the internet to industrial applications (i.e. monitors on machinery).

Key pain points this sector faces:

- **Massive Amounts of Data:** Manufacturing plants have several different sensors, processes and systems going at once, which creates enormous quantities of data. Companies need to aggregate the data efficiently and contextualize how the various sources are interconnected to have visibility into their production processes.

- **Unplanned Downtime:** Companies are scaling back budgets and need to execute (troubleshoot product quality problems, remove roadblocks, avoid unnecessary shutdowns of production lines) as soon as possible to avoid unnecessary costs and have budgets for unintended circumstances. Unplanned downtime costs industrial manufacturers $50bn annually[15].

## C. Manage / Maintain

Once the plant is up and running, it is important to manage and maintain the assets effectively, carefully and securely through predictive maintenance and OT security. ~96% of business leaders have indicated that they need invest to in OT cybersecurity and recent cyberattacks have made it even more necessary.[16] This sector involves managing and maintaining the company's physical assets throughout their lifecycle, including capital planning, procurement, installation, performance, maintenance, compliance, risk management, security and asset disposal.

**Enterprise Asset Management (EAM) / Maintenance:** Management and maintenance of physical assets throughout their entire lifecycle.

**Connected Worker:** Connective technologies that integrate the worker into their environment, which helps enhance and coordinate different engineering roles across the plant.

**Operational Technology (OT) Security:** Protects the physical, critical infrastructure to ensure safety, availability and reliability of machinery and equipment.

Key pain points that this sector faces:

- **Security risk:** Given hardware nodes are often unprotected, asset data has become a target for cybercriminals. Attacks on OT systems are vastly different than IT systems and businesses need to be properly equipped to handle several types of risks. Almost 70% of industrial firms had an OT cyber-attack last year and the looming cybersecurity threat is crucial to address.[17]
- **Remote and hybrid work:** Like many other industries, COVID-19 triggered a digital transformation that made working from home more accessible and necessary. Given the physical nature of manufacturing work, it is becoming critical to have platforms that are purpose-built to access from anywhere to stay connected, even when the workers are physically absent.
- **Labor shortage:** There is currently a shortage of skilled labor workers who have been around long enough to understand the product and ensure that they are being managed throughout their entire lifecycle. This is particularly impacting the disposal and end of lifecycle process, as fewer workers have seen the entire process through.

# III. Areas of Opportunity

## A. Digital twins

A digital twin is a 3D digital model that represents a real-world product, system or process. The key components of digital twins include the physical entities being modeled, the data link connecting the physical and virtual worlds and the digital representation which can imitate how different scenarios will play out. In a manufacturing context, digital twins enable manufacturers to create direct replicas of plants, processes or products for decision-making, applicable from initial investment and designing to production. Overall, digital twins enable manufacturers to test and perform modifications in a virtual space, making it quicker, easier and safer than in the real world.[18] A recent McKinsey survey revealed that 86% of senior executives in industrial companies recognize the applicability of digital twins to their production operations, with 44% having already implemented them.[19]

Legacy companies like AVEVA and Siemens have robust solutions for digital twins, but newer entrants are coming into the space that are focused on quick time to value, enhanced analytics, integrations and easier to use solutions.

Basetwo AI is an industrial DataOps company focused on optimization that serves as an AI copilot for manufacturing processes, offering AI-generated recommendations for critical equipment and processes. Their platform ingests data from various sources and provides recommendations for optimizing them, such as reducing cycle time, cost savings and improving environmental efficiency.

As manufacturers increasingly adopt digital twins, they gain a deeper understanding of their operations, enabling them to make informed adjustments at a reduced cost, ultimately driving expertise and competitiveness in the industry.

## B. Maintenance

Maintenance is a critical function for manufacturers, and when it is not prioritized, the consequences can be severe. Proper maintenance not only prevents costly downtime but also extends equipment lifespan, ensures product quality, enhances safety, maintains compliance and drives cost savings. A McKinsey study found that predictive maintenance typically reduces machine downtime by 30% to 50% and increases machine life by 20% to 40%.[20] Keeping maintenance top of mind is paramount to ensuring smooth operations and reducing overall costs. Given the substantial investment in capital equipment, manufacturers who can operate their equipment longer generally have better financial results.

To support this, various computerized maintenance management systems (CMMS) like Maximo (owned by IBM) have been developed to help manufacturers effectively manage maintenance tasks and processes. Newer startups are taking a more innovative approach to CMMS, providing easier to use features and better workflows and data.

Aetos, for example, is leading the development of the next generation of CMMS, which they call a visual maintenance management system (VMMS). This solution provides a 3D capture of a facility, enabling virtual asset management, maintenance and asset-specific training – bringing greater visibility and control to maintenance teams.

With the support of IoT and modern maintenance software, manufacturers can more effectively manage and maintain their assets, leading to improved effectiveness and reliability throughout the production lifecycle.

## C. OT Security

OT Security, also known as industrial control system (ICS) security, protects industrial hardware and software and keeps all assets secure. Cyberattacks on both physical and virtual environments have increased significantly as attacking methods become more sophisticated. According to the Fortinet 2024 State of Operational Technology and Cybersecurity Report, cyberattacks on OT systems have surged by 73%.[21] ~73% of OT devices are unmanaged, exposing important data and assets to cybercriminals.[22] The number of IOT devices are increasing rapidly, causing more unprotected hardware nodes, and it is especially important to keep the data safe.

Given the interconnectivity of IT and OT security, several large cybersecurity and networking platforms have expanded their OT offerings or made acquisitions in the sector. Leaders include Palo Alto Networks, Cisco and Fortinet, while Microsoft acquired CyberX in 2020 to accelerate their OT strategy. Specialized startups in the space are focused specifically on OT security and are typically driven by more domain expertise.

Since the 2010s, there have been software businesses that focus specifically on OT security and have gained significant market share. In August, Armis announced that they surpassed $200m ARR and are continuing to grow rapidly. They integrate AI into their cyber exposure management platform, which helps them secure critical environments.

The convergence of both physical and virtual assets puts manufacturers at higher risk of attack. It is crucial for businesses to have comprehensive OT security to ensure reliability and protection for their critical infrastructure.

## D. IIoT

IIoT is the collection of sensors, instruments and devices that are connected through the internet to industrial applications (i.e. monitors on machinery). IIoT bridges physical production with Industry 4.0 technologies, which enables manufacturers to better maintain their equipment, garner insights and analytics and enhance operational efficiency. Rather than utilize a person to walk the floors of a plant and check if there is oil leaking from a machine or strange sounds coming from equipment, there are digital sensors that aggregate data through vibration, temperature and magnetic waves to determine if something has gone awry. Further, these sensors can predict future downtime or maintenance issues, and workers are able to address the problem in advance and have more predictable maintenance.

Legacy players have acquired IIoT businesses to help drive innovation and leverage partnerships. Schneider Electric acquired AVEVA in 2023 to provide an IIoT solution and digital twin that will increase productivity and profitability for Schneider customers.

Augury leverages AI and IIoT to provide insights into machine and process health within the manufacturing sector. By integrating IIoT sensors directly into manufacturing equipment, Augury enables real-time data collection, which is then transmitted to the cloud and can be used for maintenance and monitoring.

As the world becomes more connected and data drives decisioning, IIoT solutions will be at the forefront of manufacturers' needs, and technologies will continue to innovate and adapt for the ever-changing demands of their customers.

### E. Computer Vision

Computer vision enables computers to see, observe and understand visual data from the real world and is used across various industries, from manufacturing to retail. It can analyze thousands of products or processes per minute, identifying patterns and defects beyond the capability of human vision.[23] Computer vision can be highly effective in manufacturing environments, by enhancing product quality, increasing operational efficiency and reducing the risk of human error.

Several large computer vision hardware players, including Cognex and Keyence, provide software for computer vision, but the software is not their core expertise. On the other side, there are software players that cater to specific segments or use-cases that can be served through computer vision.

One particularly exciting application is in workplace safety. CompScience, a connected worker company, uses computer vision to analyze video data from manufacturers: identifying risks, improving safety and lowering workers' compensation premiums. This enables manufacturers to monitor operations closely and can lead to a significant reduction in costs and errors.

Leveraging computer vision for increased visibility into manufacturing operations provides valuable insights, enabling manufacturers to enhance safety and improve overall effectiveness.

**Other considerations**

### A. Sales Cycle in Manufacturing

Selling into the manufacturing industry presents unique challenges due to the sheer complexity of large manufacturers. Manufacturing companies frequently require pilot programs before committing to full deployment. Decision-making can vary significantly between different plants within the same organization, further complicating the sales

process. To succeed, startups must identify and engage advocates within these large organizations early on. While the procurement process may be lengthy, the reward is often long-term contracts that can extend for several years. This creates a double-edged sword: replacing incumbents is challenging, but once established, the solutions tend to be sticky, with reduced churn.

### B. Implementation

Implementation within manufacturing organizations is inherently varied, influenced by each customer's existing technology stack and their approach to technology adoption. Due to the complexity of manufacturing environments, companies often rely on system integrators to navigate the intricate web of tools and processes involved. Integration and implementation typically take longer than in other enterprise SaaS environments and demand more hands-on services. However, once a startup successfully integrates its solution, the opportunity for scaling and transitioning to a self-serve model becomes significantly more feasible.

## Parting Thoughts

The manufacturing software landscape is evolving at an unprecedented pace, driven by advancements in software that enable efficiency and scalability. The market is vast, and with the ongoing digital transformation, talent shortages, cost pressures and market readiness, now is an exciting time to be innovating in the space. We recognize the immense potential of differentiated startups in the manufacturing software market, and we are committed to supporting entrepreneurs and companies that are building tools to transform this essential industry. If you are building in the space, please reach out to us at olivia.tanzman@axavp.com or isabel.young@axavp.com.

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