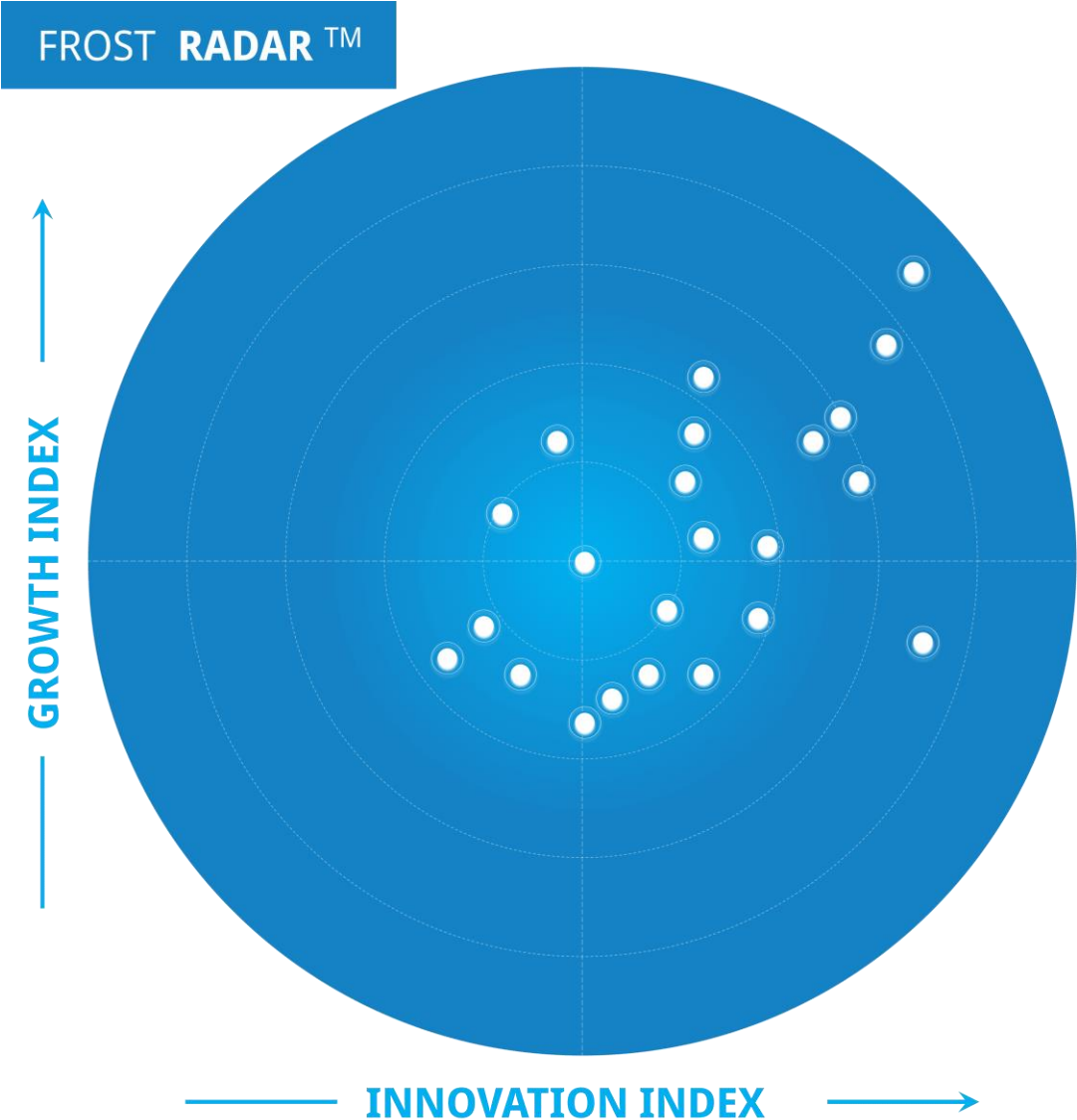


Frost Radar™

Manufacturing Execution Systems, 2024

A Benchmarking System to Spark Companies to Action - Innovation that Fuels New Deal Flow and Growth Pipelines

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Research Summary

The Frost Radar™ on manufacturing execution systems (MESs) offers a competitive benchmark analysis derived from Frost & Sullivan's Global MES Growth Opportunities study published in February 2024, specifically ranking the top 14 companies in the MES industry on their growth potential and ability to innovate and disrupt.

The global MES industry stood at \$13.66 billion in 2023. Frost & Sullivan expects it to reach \$25.43 billion by 2030, achieving a compound annual growth rate (CAGR) of 9.3% from 2023 to 2030. Labor shortages, supply chain optimization, technological improvements to MES products, increasing sustainability concerns, and the pandemic-related decline in manufacturing are driving manufacturers to adopt MESs at higher rates. This industry is fragmented, and vendors vary in their growth strategies, from pursuing more mergers and acquisitions (M&As) to developing products internally with industry-specific focus to adopting a general-purpose MES approach. Some commonalities between the companies featured in this Radar are their approach to offering hybrid deployments, their plans to develop containerized software architectures, and their strategy of expanding MES into a manufacturing operations management (MOM) solution.

Frost & Sullivan analyzes numerous companies in an industry. Those selected for further analysis based on their leadership or other distinctions are benchmarked across 10 Growth and Innovation criteria to reveal their position on the Frost Radar™. The publication presents competitive profiles of each company on the Frost Radar™ considering their strengths and the opportunities that best fit those strengths.

Strategic Imperative

Vendors have been evolving their manufacturing execution systems (MESs) in recent years to increase the scope of functionalities. Increasingly, companies design these systems to include functions that belong to the broader category of manufacturing operations management (MOM). As such, it is common to find sources that use the terms MES and MOM interchangeably, as an MES is the most important component of MOM. However, this may lead to some confusion when comparing products in the market.

To avoid confusion, Frost & Sullivan defines MES as a system that performs the traditional MES functions (data collection and storage, tracking and tracing, production management, integrated reporting, work order management, downtime and overall equipment effectiveness [OEE] tracking, and in-process quality monitoring) and at least one additional capability (quality management, business intelligence [BI]/analytics, bill of materials [BOM]/recipe management, advanced production planning and scheduling, and resource management).

Disruptive technologies are transforming MESs by changing the underlying software architecture from the traditional monolithic approach to microservices powered by docker containers. Vendors are making this effort to increase the modularity and composability of their products. As a result, an MES becomes more flexible and implementation become simpler and quicker.

Higher modularity also leads vendors to offer MES on a Software-as-a-Service (SaaS) model, which opens up adoption potential for a new population of manufacturers. Another aspect of technological transformation in the MES sector is the systems' integration with other technologies, such as edge computing devices, low-code (LC) and no-code (NC) developing environments, augmented reality (AR) and virtual reality (VR) apps, and artificial intelligence (AI) solutions. LC and NC platforms enable a more flexible data architecture, which eliminates the need for customers to predefine every possible data table before implementation. Rather, users can create and deploy data tables at any time with ease.

Competitive intensity is high in the MES industry, as technological innovations have boosted the growth of smaller companies in niche sectors. Incumbents have been engaging in M&As with more intensity in recent years, reflecting the industry's accelerated consolidation.

Transformative megatrends are shaping the future of manufacturing. Extreme product customization and a tightening supply chain are forcing manufacturing companies to seek solutions that provide agility and efficiency to their operations.

Furthermore, manufacturing organizations' increasing focus on sustainability is driving their net zero initiatives and evolution toward autonomous operations.

Finally, innovative business models are changing how MES vendors approach their customers. Manufacturers are faced with a changing landscape in industrial software. As software products evolve, the lines between them blur as a variety of systems can accomplish the same tasks (e.g., MES with quality management systems [QMSs] or IIoT platforms). This evolution creates even greater confusion among manufacturers when deciding what they should do to improve their operations, which is one of the main reasons why successful companies in the MES industry today are adopting a consulting-like approach to their sales strategy. They seek to become strategic partners that offer solutions to their clients' problems rather than vendors that simply sell stand-alone products.

Growth Environment

In 2023, the global MES industry totaled about \$13.66 billion. Frost & Sullivan expects it to reach \$25.43 billion by 2030, achieving a CAGR of 9.3% from 2023 to 2030. This sector is entering a new growth phase, driven by factors mentioned in the Strategic Imperatives section and accelerated by the effects of the COVID-19 pandemic. Manufacturers are investing in technology in response to the global decline in production caused by pandemic-related policies.

North America (NA) is the largest market, closely followed by Europe. This is because of the region's large manufacturing installed base and a high degree of technological development. Asia-Pacific is the fastest-growing market due to the rapid technological transformation of many industries and the emergence of newer ones, such as electric vehicles (EVs) and battery manufacturing.

Some common features among the top MES products include hybrid deployment options; SaaS offerings; microservices-based software architectures; and a rich variety of complementary products, such as supervisory control and data acquisition (SCADA), human-machine interfaces (HMIs), automation hardware, distributed control systems (DCS), and warehouse management systems (WMS).

Technological advancements have empowered smaller vendors to become competitive in niche sectors, with some being highly disruptive and competing directly with incumbents in many industry verticals.

Frost & Sullivan expects slow industry consolidation during the next 5 years. This will occur by means of M&As and by companies going out of business when failing to keep up with the technological transformation.

Pricing models are also evolving. While most manufacturers that own an MES still use a perpetual license, all vendors are looking to switch to a subscription-based model to secure annual recurring revenues. They may base these subscriptions on factors such as concurrent users per functionality or application, number of connected machines, or number of plants.

Finally, a trend that is heavily influencing growth in the MES industry is the aging workforce and a growing labor shortage. Manufacturers are finding it increasingly difficult to hire qualified young workers. In part, this is caused by the lack of appeal that manufacturing-related labor has among younger generations of workers. One way that manufacturers can navigate this issue is by improving the technological environment of production processes to make them more appealing to younger people, for example, by adopting connected worker solutions to deliver standard operating procedures or KPIs through smart glasses or other connected devices.

Among the most important pillars that support these kinds of working environments is an MES and its data management capabilities.

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Source: Frost & Sullivan

Competitive Environment

The MES industry is highly fragmented, populated by more than 50 software vendors and more than 50 value-added resellers and system integrators (SIs). The top 7 vendors in this space have less than 45% of the total share. However, Frost & Sullivan expects to see accelerated industry consolidation as incumbents and bigger companies will leverage M&As while smaller competitors will be forced to continue innovating to stay afloat.

The MES industry has existed for more than 20 years. It began as a series of in-house developed applications among several manufacturing companies, and then some of them started commercializing their MES products following the standard functionalities as defined by the Manufacturing Enterprise Solutions Association (MESA). Among these first vendors were some of the most important industrial automation companies in the world, such as Siemens and Emerson. Over time, the industry expanded, and the idea of having an industry-specific MES allowed growth for several niche players. Many of them were acquired by the bigger companies and integrated into existing MES portfolios to cater to a wider range of end-user industries.

During the last 10 years, the idea of having an MES that can serve process and discrete industries alike has become popular. Among the factors that drove this idea are that every industry has a component of both process and discrete manufacturing as well as the development of containerized software architectures for applications, which increases composability. An MES with greater composability has higher configurability and can adapt more easily to different production processes. However, only a few vendors are able to cater to process and discrete industries alike with a single system, such as Tulip Interfaces, Symphony AI Industrial, and GE Digital (now GE Vernova). All vendors that cater to both types of industries with a single system have developed highly composable software architectures.

Composability is becoming a frequently used term to describe MES and modern industrial software. It is also used with other terms, such as containerization and modularity, which may create some confusion. Modularity is the concept of dividing a system into smaller, self-contained parts or modules. Containerization is an application of modularity to software architecture. Containers package an application along with its dependencies (e.g., libraries and configurations) into a single unit, and each container is isolated, consistent, and portable. Composability builds upon the concept of modularity and describes a system that can combine or assemble different modules into a larger system. Composable systems leverage cloud infrastructures to provide scalability and rely on application programming interfaces (APIs) for seamlessly integrating with other systems.

Frost & Sullivan predicts that industry-specific knowledge will remain a top concern for manufacturers in the next 5 years. This is why vendors, mostly incumbents, are seeking growth by means of M&A as doing so enables them to quickly gain market share and expertise in previously unattended industry verticals.

One of the main restraints for MES growth is the general lack of customer awareness about the technology's benefits. Traditionally, MES implementation has taken 12 to 18 months (and sometimes even longer), and manufacturers have struggled to see real value at first. While this lack of awareness remains, vendors are tackling the issue by making their implementations faster, simpler, and less expensive to quickly show value to their customers. These results, among others, are achieved through strategic partnerships with SIs and consulting firms to make the products more composable, and by leveraging the capabilities of NC and LC environments for customization.

The MES competitive landscape is composed of the traditional industrial automation vendors (Siemens, Rockwell Automation, Emerson, ABB, Honeywell, Dassault Systems, and GE Vernova), pure-play MES vendors (Critical Manufacturing, Aegis Industrial Software, and iTac Software), industrial software vendors (AVEVA, Tulip Interfaces, and Symphony AI Industrial), and a hyperscaler (SAP).

The industrial automation vendors leverage their broad solution portfolios (hardware and software), industry expertise, and brand recognition to promote their MESs. Most of them have expanded their customer reach into different industry verticals by means of both acquisitions and internal development. ABB and GE Vernova stand out for organically developing MES solutions that cater to a wide range of industry verticals, without engaging in M&As. Of note, these vendors have different priorities when looking at the industrial automation market from the ISA-95 automation pyramid's perspective. For example, ABB, Emerson, and Honeywell focus strongly on the second level of the pyramid (where systems such as DCS, SCADA, and HMI sit), and that translates to relatively slower development of their MES solutions. In contrast, GE Vernova, Siemens, Rockwell Automation, and Dassault Systems focus more firmly on the third level of the pyramid (where MES resides). Finally, Siemens stands out as the top innovator in this Radar for being able to keep its MES's technological backbone updated throughout its existence, by rapidly integrating acquired systems and standardizing user interfaces (UIs), and for providing its customers with one of the most impressive environments for innovation.

The pure-play MES vendors have complete MES and MOM solutions tailored for specific industries. These companies have developed MES solutions with state-of-the-art software. Aegis Industrial Software stands out for offering one of the most highly rated MES products among customers in the electronics industry. Critical Manufacturing achieved the highest growth score on this Radar for its tremendous growth performance in the past 3 years and poses as one of the strongest contenders for becoming an industry leader. Finally, iTac Software stands out for offering a complete and reliable MES for the automotive industry, as well as for being the biggest vendor in Germany.

The industrial software vendors have also developed MES solutions with state-of-the-art software. They too offer complementary software solutions such as connected worker, data ops, and industrial AI. AVEVA and Tulip have demonstrated strong growth performances in the past 3 years. Tulip achieved a high innovation score for developing one of the most composable MES solutions available. Finally, Symphony AI Industrial has also developed a highly composable product, but it is still very new with a limited industry presence.

The only hyperscaler that has developed an MES robust enough to get featured in this Radar is SAP. The company leverages its strong data management capabilities and cloud infrastructure to appeal to MES customers. SAP's expertise in the financial and supply management areas enables it to offer an MES that better serves those needs, which represents a distinct value proposition.

While compiling this Radar, Frost & Sullivan found that many organizations provided valuable qualitative and quantitative data and insights, and others either did not respond, declined to take part, or refused to provide any information to support their growth strategy, revenues, or innovation strategy in the global industry. As a result, this Radar reflects the best estimations of revenue and revenue growth metrics for those companies that do not publicly disclose their overall financial status or the financial performance of their MES.

After a comprehensive analysis of their performance focused on this Radar's 10 analytical criteria, Frost & Sullivan independently plotted 14 of the most significant companies in 2024. The position of each company on the Radar is a result of the relative scores obtained on each criterion for growth and innovation.

Critical Manufacturing

Innovation

- Critical Manufacturing's MES is a modern, industry-tailored solution that is highly rated among its users. The MES stands out for its strong data management capabilities, namely handling IoT and transactional data within the same data model. This simplifies development, maintenance, and integration efforts, as well as enables more secure scaling.
- The MES is fully containerized, UIs are simple and intuitive to use, and screens are customizable in an NC environment.
- Critical Manufacturing is one of the few MES vendors that certifies its SI partners, which is part of its strategy of offering high-quality customer service.
- The company focuses its R&D efforts on keeping its technology stack up to date, enhancing the customer experience through simpler and faster implementations, and improving existing functionalities. For example, in October 2022, Critical announced a strategic partnership with DataWorks to simplify compliance and minimize resource requirements associated with validations in the life sciences industry.

Growth

- Critical Manufacturing has tailored its MES to discrete manufacturing, covering industries such as semiconductor, electronics, medical devices, and industrial equipment.
- Established in 2009, the founders' background in the semiconductor and electronics industries has been a key enabler of growth.
- Growth rates for Critical Manufacturing have been the highest out of all other competitors on this report, at 50% year-over-year (YoY) in 2023. A significant increase in internal headcount was part of this growth.
- In 2018, ASMPT acquired Critical Manufacturing, which has given the latter confidence to continue developing its solutions. The company's strong network of certified SI partners supports it across Europe, North America, and APAC.
- Critical Manufacturing's vision consists of delivering Industry 4.0 to every manufacturer. As such, it also offers and develops complementary solutions to MES, such as AR apps and digital twin tools.

Frost Perspective

- Critical Manufacturing is one of the most well-balanced companies in the MES sector, with a state-of-the-art technology stack, a wide range of targeted industry verticals, and a strong SI network that supports its presence in 3 main global regions—all of which has resulted in the highest growth for any MES vendor in 2023.
- Frost & Sullivan sees Critical Manufacturing as a strong contender for market dominance in the future. However, growth rates this high are hard to maintain. Critical Manufacturing should focus on sustaining high standards for its certification program and on carefully balancing its headcount by establishing limits on hiring for permanent positions and taking a conservative approach to demand forecasting.

Strategic Insights

1. The top MES vendors are increasing the composability of their products. This approach expands the potential number of manufacturers that their solutions can reach by freeing customers to adopt only the modules they currently need and later easily scaling up. Composability also increases the potential application of an MES to more industry verticals because with a higher configurability it can more easily adapt to different manufacturing processes. Finally, vendors are changing how they commercialize their MESs. Rather than selling stand-alone products and expecting the manufacturer to adapt to the product, MES vendors are taking selling solutions and adapting to each customer's needs. Composability is an important factor in enabling this new approach because it increases the configurability and scalability of the system, allowing vendors to adapt the final solution, including only the modules or functionalities that the customer requires.
2. Although most MES deployments are still fully on-premises, hybrid MES deployments are becoming more popular, as they can leverage the cloud's overall lower total cost of ownership and increased scalability in addition to the high reliability and responsiveness of on-premises deployment. Frost & Sullivan expects that hybrid deployments for MES will become the most-used option in the next 5 years.
3. Integrating AI into MES is a common theme of every vendor's roadmap. Given the accelerated development of AI capabilities and manufacturers' increasing awareness of the technology's benefits, it is imperative that MES vendors stay up to date on the latest AI-driven functionalities for MES, such as predictive analytics, copilots, and autonomous operations. However, there is a risk of becoming overly reliant on an AI vendor or of staying behind the latest innovations by developing everything in-house.
4. MES vendors should both leverage the high speeds of development achieved through a partnership with an AI vendor and build internal AI development capabilities.
5. As the industrial landscape slowly becomes more software-defined, pure-play MES vendors and industrial software vendors should make their MES better prepared for integration with other systems to adapt to the manufacturer's digital strategy. In contrast, industrial automation vendors will most likely opt for integrating their MES into a broader proprietary software ecosystem (which may include systems ranging from DCS and SCADA to PLM and MES), effectively becoming strategic partners with their customers. These vendors should consider the possibility of an accelerated evolution of manufacturing toward becoming software-defined, which may eliminate the competitive advantage gained from locking in customers with hardware and software. In this case, industrial automation vendors should also focus on making their MES solutions open for integrations.

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