The Future of Manufacturing Operations Management

What are the key challenges and how technology can help

pwc

Introduction

Tomorrow's production environment challenges manufacturing companies to deal with increasing complexity. Smaller lot sizes, shorter lead times, and product customization paired with cost pressure and unstable demand due to global crises challenge operations.

To cope with these challenges, the technology market provides software solutions to collect data and translate it into actionable insights. These solutions act as enablers for manufacturing companies to accelerate this development. One question remains, how do you get full value out of the technology?

Our recent research shows that manufacturing companies face challenges with transparency on performance, process control, and track and trace possibilities. Research also shows that manufacturing companies' IT landscapes are not fit-for-purpose or ready to face tomorrow's challenges.

This document aims to create a better understanding of the usage and future of MES/MOM solutions, especially in a time of frequent changes in manufacturing operations software and IT landscapes. To create this understanding, we contacted manufacturing companies to get firsthand knowledge about the challenges, usage, pitfalls, and benefits of an MES/MOM solution.

We also consulted leading MES and IIoT platform vendors to get their view on the future development of these technologies and how these technologies play together in manufacturing operations management. In this document we will focus on MES/MOM solutions and their role in manufacturing operations in order to get a better grip on production performance and control.

Please reach out to us for a discussion about the results of our study and the future of manufacturing operations management.

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Executive Summary

It is inevitable that tomorrow's production environment will become more complex to operate. On the other hand, we see a great set of emerging technologies to offer a helping hand to overcome future challenges. Our study indicates that 44% of companies reported challenges with transparency on performance, and 37% indicated a lack of process control in production. The reason for that could be that the present manufacturing operations IT landscapes are not fit-for-purpose based on our findings and experience. Multiple systems used for managing manufacturing operations lead to a low data utilisation and minimal insights gained from shop-floor data.

In the future we see that the manufacturing operations management will break data silos and integrate best of breed technologies to create full transparency across functions and plants. This will be supported by MES and IIoT platform technologies that complement each other, enabling integration of functions as well as external partners.

The benefits of using MES are better production transparency, effective scheduling as well as better process control. 58% of the companies we spoke with, and are using an MES, observed an increase in their OEE, and 42% observed improvements in quality and better process control. MES enables vertical integration, from shop floor to top floor, and drives harmonisation of manufacturing operations. Only 36% of the companies reported utilising MES, while others deal with a fragmented manufacturing IT landscape with legacy systems leading to limited transparency and poor control. It seems like companies are hesitating to implement an MES or don't see the clear benefit of it yet.

42% of the respondents reported complexity and 37% increased customisation effort as challenges during MES implementation. The MES implementation journey should address a set of rudimentary questions upfront to make it successful, such as

- How will the future impact my operations and what are my most critical operational pain points to be addressed by the solution?
- How would MES add value and how would it fit into the IT landscape together with other technologies?
- How much would the overall investment be?
- Which technology vendor would be the most suitable to meet my expectations?
- How do I manage the change and is my organisation fit for the subsequent operational changes?

Having answers to the vital questions above will support the decision-making process and create a sharp picture of how to best utilise and integrate the different technologies. It also became clear that today's and future challenges for manufacturing operations are far too versatile to be addressed by one system only. It will require a step by step approach, starting with the elementary capabilities to steer and schedule production in an effective way. This will provide a solid foundation to further expand to IIoT based solutions, enabling predictive and cognitive services. Therefore, implementation of a "state-of-the-art" MES, seamlessly integrated into your enterprise architecture, is the inevitable first step to take advantage of today's and future manufacturing operations challenges.

> The functionality of the available tools (MES, IoT, etc.) and needs of businesses are constantly evolving, so the right tool today may be the wrong tool tomorrow. For example, the importance of remote work and resilient supply chains skyrocketed in importance during the pandemic. One manufacturer we heard from doubled their output and won business from competitors during the pandemic thanks to the supply-chain agility and remote work capabilities enabled by their cloud-based MES system.
>
> **Matthew Wopata**, Principal Analyst at IoT Analytics

1 Challenges

Tomorrow's production environment becomes more complex, while the technology market provides a helping hand. 44% of the companies reported challenges with transparency on performance, and 37% indicated a lack of process control in production

Manufacturing companies face increasing pressure to stay competitive in a time of changing customer behaviours and growing competition. On the other side, new technologies provide more and more opportunities to improve production performance and deal with changing customer expectations and competition.

We currently observe a few key aspects impacting manufacturing operations. Greater product customisation leads to increased product variants and smaller lot sizes. Smaller lot sizes and shorter lead times require accurate and reliable production planning and detailed scheduling as well as safety stock planning. This also helps to ensure short lead times in order to satisfy customer expectations.

At the same time, sustainability aspects and greater product safety requirements demand better capabilities to ensure end-to-end traceability throughout the supply chain. All this combined with constant cost pressure and shaky demand due to global crises.

On the other hand, technology companies offer a wider range of solutions to collect data from different parts of the supply chain, contextualize and translate it into new insights. Technology solutions provide manufacturing companies off-the-shelf Manufacturing Execution Systems (MES) to bring the manufacturing operations management to the next level, e.g. by optimising efficiency on the shop floor, while IIoT platforms enhance data collection and analytics capabilities with several applications for production performance improvement, e.g. predictive maintenance and OEE improvement.

44% of the respondents highlight transparency on performance as the biggest challenge in manufacturing operations

What are some of the key challenges manufacturing companies face when trying to deal with market trends? Our survey indicates that 44% of the respondents highlight **transparency on performance** as the biggest challenge followed by **process control** at 37%. As a third challenge, **track & trace of production process and quality management** has been identified by 34% of the companies asked. A significant amount of the respondents also highlighted challenges regarding **lack of resource transparency and manual detailed scheduling**. In order to tackle these challenges, the key is to have reliable, near real-time data to get a better grip on production. Figure 1 shows all challenges selected by the respondents.

Common challenges in manufacturing operations management

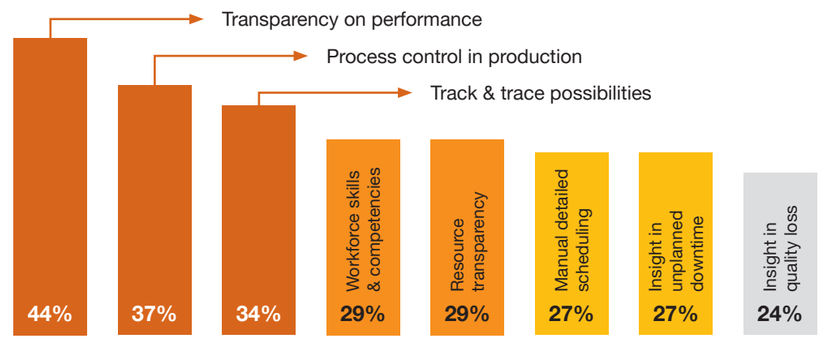

Figure 1. Common challenges encountered in manufacturing operations management

Question: Which challenges are you currently facing in manufacturing operations management?

Current manufacturing operations IT landscapes are not fit-for-purpose. Multiple systems are used for managing manufacturing operations, leading to a low data utilisation and minimal insights.

The root cause of these challenges is often multifold. Firstly, disconnection of processes and systems in the manufacturing operations layer, and secondly, a disconnection across the different functions. The disconnection is often caused by a complex and fragmented IT system landscape, and the way information is exchanged between the different layers. This means data sits in deep silos and can't be fully leveraged, which leads to a low data utilisation.

In order to better understand the statement of the fragmented system landscape and the reasons behind the challenges that companies face in manufacturing operations, we wanted to find out which systems are used to support manufacturing operations. Figure 2 shows the systems used to manage manufacturing operations. Our survey indicates that 56% of the respondents use different ERP modules to manage operations. 49% and 38% of respondents also mentioned that they use MS Office and Email to manage their manufacturing operations. Pen and paper are still used by 33%. These findings explain why companies struggle with transparency and control in production processes.

Systems used to manage manufacturing operations

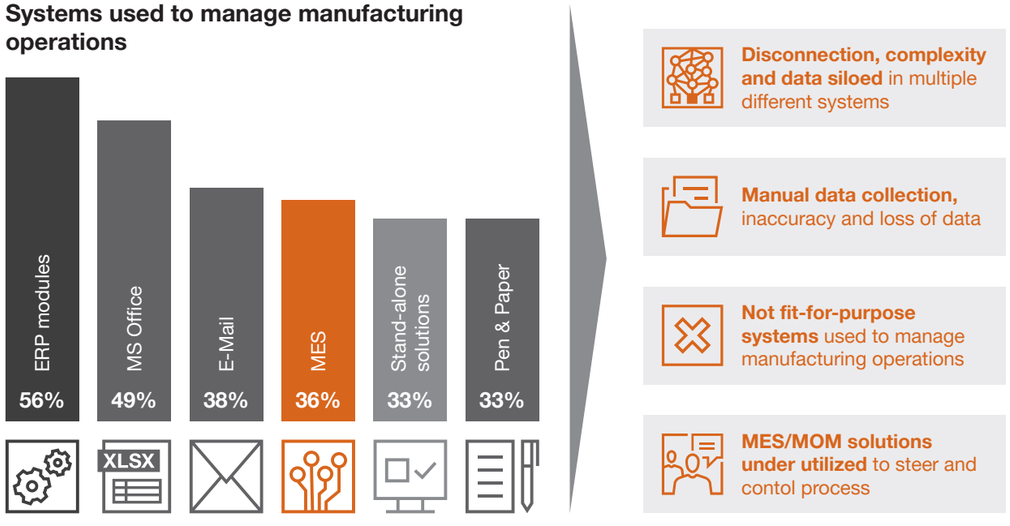

Figure 2. Systems used to manage manufacturing operations

Question: Which systems are you using to manage manufacturing operations?

Manufacturing companies' system landscapes are fragmented, limiting their ability to improve production performance

Many manufacturing companies struggle to orchestrate the manufacturing IT landscape to build better transparency into production performance and better leverage the information on the shop floor. Often, companies are dealing with continuously growing and scattered internal IT system landscapes (home-grown applications and 3rd party solutions), at and across different plants. Besides that, there is often decentralised master data management and an IT architecture that is characterised by an absence of boundaries in the functionalities of each system. An absence of clear boundaries between the business layer and the manufacturing layer, and within the manufacturing layer itself, can foster overlap of activities, gaps and counterproductive data transfers.

50% of the companies indicate that data collected is not being used, and 34% would like to have more data points to improve analysis

The fragmented IT landscape leads to disconnection between manual and standalone solutions, which causes complexity and data silos. Manual data collection processes increase inaccuracy and loss of valuable data. Our survey results showed that manufacturing companies are not able to leverage the full potential of the data collected. In order to get valuable insights, data points must be connected, and the right tools applied to be able to better steer, control and optimise manufacturing operations. Also, systems for operations management should be designed for the right purpose having the right capabilities, in order to successfully manage manufacturing operations. As figure 2 of our study indicates, MES solutions are under-utilised assets in manufacturing operations management, as only 36% of the respondents claimed to use MES solutions.

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Future

Future manufacturing operations management will break data silos and integrate best of breed technologies to create full transparency across functions and plants.

Interviews with leading technology executives highlight some of the key trends regarding future manufacturing operations management. **Microsoft's technology executive focusing on manufacturing operations** strongly believes that a platform driven approach will become more common in manufacturing operations. The key idea is to break data silos and enable end-to-end digital continuity not only across manufacturing operations, but also across other functions and manufacturing plants. Through the platform approach, companies can create a single source of truth for information, connecting data from different touch points and contextualize those data points to understand correlation throughout the processes. IIoT platforms will play a key role enabling the breaking of data silos and providing scalable data platforms to turn data into new insights through analytics, modeling and simulation.

> IIoT platforms will be a key enabler to move from connected to predictive to cognitive.
>
> **Neal Meldrum**, Business Strategy Leader for Manufacturing, Microsoft

This means that manufacturing operations management will step to the next maturity level by moving from connected to predictive to cognitive, or in other words, from connecting machinery or other shop floor assets with IT. This is done by predicting events by analysing historical data to continuously learn from data collected on the shop floor.

Manufacturing operations generate more data than ever and will generate a lot more in the future. In order to turn the vast amount of data into meaningful insights, a set of AI embedded applications will be needed.

> 80% of manufacturing data created in the last 2 years has not been used to its full potential, due to data silos between different sites, plants, and even between work cells.
>
> **Neal Meldrum**, Business Strategy Leader for Manufacturing, Microsoft

Leading technology executives point out the importance of broader ecosystems by ensuring the necessary development pace. Partnerships are being established to build connected operations solutions. No one can do everything themselves. An African proverb says, "If you want to go fast, go alone, but if you want to go far go together". Technology companies want to clearly go far and fast.

This development is possible only by specialising and by building digital partnerships with leading technology players in the market. One partner might be focused on providing infrastructure and a marketplace for applications, whereas others focus on application development, digital twins and AI. Discussion with Microsoft Technology executives highlights that manufacturing operations will also start leveraging more AI and voice, speech, sound and image recognition to steer the process.

MES and IIoT platform technologies will complement each other enabling integration of functions and as well as external partners.

Manufacturing Execution Systems have been in manufacturing operations already for decades, going from visibility to more complex process modeling and control. The first wave of MES implementations focused mainly on MES modeling, tracking and tracing, as well as dispatching for a real-time view into the manufacturing process. During the second wave, mid-size to smaller companies wanted to better understand OEE. The third wave focuses even more on quality process modeling, sampling process and execution as well as statistical process control.

> MES will be the base for IIoT solutions as they supply the main part of digital twin information. MES solutions will run on IIoT IT Infrastructures in the future.
>
> **Peter Bollinger**, CEO of iTAC software AG

MES technology vendor executives also highlight that we will see more hybrid deployments where edge computing and cloud solutions play together combining the best of both worlds.

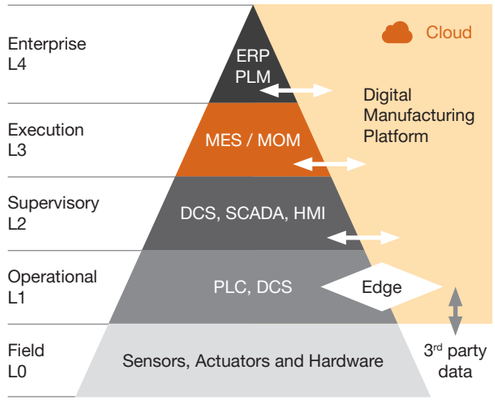
> We want to build a community with open source and enhance manufacturing operations management.
>
> **Neal Meldrum**, Business Strategy Leader for Manufacturing, Microsoft

Making a big step forward into the here and now, we see increasing seamless data exchange and interaction with the rise of IIoT platforms and other manufacturing applications. MES/MOM solutions will move towards a platform approach focusing on functionality as a service and micro services leveraging IIoT IT infrastructure and applications.

> Technologies like low-code platforms help partners and business experts of manufacturing organisations to build purpose-built apps by themselves along with MES/MOM functionalities.
>
> **UV Subba Rao**, Director Innovation to Market, Siemens Digital Industries Software

> Future of MES/MOM is modularity with deployment flexibility, enabling manufacturers choosing critical functions of MES/MOM – either on-cloud, on-edge or on-premise alongside legacy systems for agile digital transformation.
>
> **Dr. Raffaello Lepratti**, Global VP Business Development & Marketing, Siemens Digital Industries Software

Figure 3 illustrates how the interplay of future manufacturing operations management IT landscapes could look. In future manufacturing operations management IT landscapes, MES/MOM will interact closely with IIoT platforms enabling integration of multiple functions within a company, from manufacturing planning to quality, logistics, procurement, and engineering, building a digital continuity across the operations. This means that the future manufacturing operations management IT landscape will be more vertically and horizontally connected combining data from different sources to accelerate the data utilisation and provide completely new insights across the value chain to better control, steer and optimise manufacturing operations.

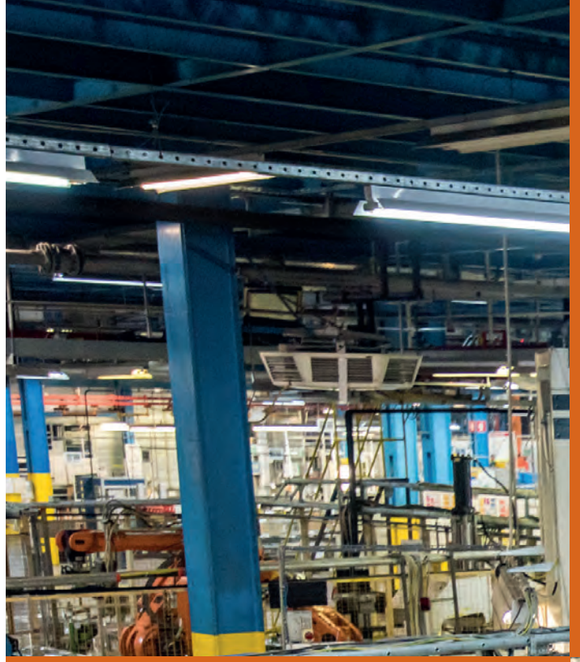


ERP is suite of integrated applications to use, collect, store, manage, and interpret data from different business functions. It provides essential information such as demand, goods received, financials, procurement data, HR for production.

MOM/ MES is the operational manufacturing solution of the factory. It integrates the top floor with the shop floor, schedules, executes and steers operations across production, inventory, quality and maintenance.

Digital Manufacturing Platform/IIoT Platform facilitates advanced analytics and integrates multiple functions/ solutions across the plants and value chain.

Figure 3. The future of manufacturing operations management



MES/MOM functions are crucial for completing the digital thread, by closed-loop data flows between design, planning and operations and weaving the change management efficiencies to bring product & process innovations to life – faster, better & cheaper.

Dr. Raffaello Lepratti, Global VP Business Development & Marketing, Siemens Digital Industries Software

IIoT is not to replace operational systems in brownfield, but interface with existing operational systems.

Neal Meldrum, Business Strategy Leader for Manufacturing, Microsoft

Looking ahead, MES and IIoT platforms will be more dependent on each other and combine the best of both solutions. IIoT platforms will be key enablers for manufacturing companies together with MES. IIoT platforms provide enhanced capabilities for data collection and contextualisation, advanced analytics, and simulation and modeling. A IIoT platform for virtualisation and simulation, combined with advanced analytics, will bring higher levels of transparency and insights into manufacturing operations. MES and IIoT platforms will form something that can be called an integrated solution for manufacturing operations management.

Companies want to further improve scheduling capabilities through AI based applications enabling simulation towards different targets and learning capabilities.

CEO of MPDV

MES and IIoT platforms will depend on each other and joint solutions for the shop floor will drive further improvements beyond Industry 4.0 features.

Peter Bollinger, CEO of iTAC software AG

Companies are going in the direction of MOM and full integration because they want to enable digital continuity. This means end-to-end visibility and transparency, a full view on processes from engineering to manufacturing operations. This creates one single source of truth as everything is connected.

Arnaud PORTET, DELMIA Senior Sales Director Eurocentral, Dassault Systèmes

Overall manufacturing functions on the shop floor do not change with technology, instead how the functions are used and deployed varies. With IIoT, Cloud and other advanced technologies, MES/MOM functions will be decoupled for highest deployment flexibility (e.g. on-premise, cloud, edge or any combination).

UV Subba Rao, Director Innovation to Market, Siemens Digital Industries Software

3 Benefits

Leading companies use MES for better production transparency, effective scheduling as well as process control. 58% of the respondents using MES observed an increase in their OEE, and 42% observed improvements in quality and better process control.

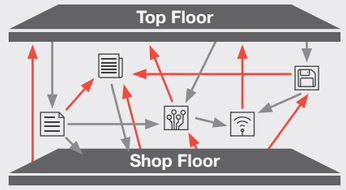
Many manufacturing companies struggle with the fragmented IT landscape as illustrated in figure 4. The MES-centered IT infrastructure orchestrates the manufacturing layer by integrating core manufacturing management capabilities, and by connecting the shop floor to top floor. Organisations who set up their manufacturing operations IT landscape in the right way will gain significant benefits out of it:

- **New insights** through better utilisation of data manufacturing operations can further optimize and automate processes to increase efficiency, as well as drive product innovation
- **Time-to-Value** will get shorter through new tools and scalable platforms. Functionality-based solutions and platforms will enable companies to implement things in smaller pieces following value-driven use cases
- **Data driven processes** will enable better control and provide new insights from manufacturing operations. This means faster decision making and collaboration across the manufacturing process and functions and plants

As with previous generations of manufacturing IT, an MES is vital to control, steer and monitor daily manufacturing operations. To accomplish the next level in manufacturing performance, you need to connect machines and other assets to communicate across the vertical information system structure from shop floor to top floor.

> Production requires more specific information on the shop floor, more accurate scheduling and resource management.
>
> CEO of MPDV

Coming from fragmented IT landscape...



- **Fragmented IT solution landscape** for Operations Management
- **Standalone solutions and decentralized** Master Data Management
- **Communication fragmented and through different channels**
- **Lack of real-time data** availability for production, inventory, quality and maintenance management

...to a well organized MES-centered IT infrastructure

- **Optimized real-time** Operations Management
- **E2E integration across all IT systems** and core processes to increase automation and process control
- **Visibility and traceability** across processes from raw material to end product
- **Integrated end-to-end planning** (not siloed) of all operations' steps to increase OEE

Figure 4. From mess to MES

MES adds value by improving the capabilities to control, steer and improve production performance

Figure 5 shows the improvements through MES implementation and the importance of an MES driving operational excellence. 58% of respondents observed improvements in their OEE, and 42% and 33% respectively observed increased real-time visibility, quality and fact-based decision making.

58% of the respondents indicated improved OEE through MES implementation

Other observed improvements are manufacturing cost reductions and improved throughput times. These are often driven by a centralised collection, processing and monitoring of shop floor data, in order to have a better overview regarding production parameters and to ensure better and even automated decision-making processes in certain areas. Technology executives of leading MES providers confirm the importance of MES in real-time production process control.

MES acts as an enabler to harness the full potential of Lean practices

What are the observed improvements thanks to the MES implementation?

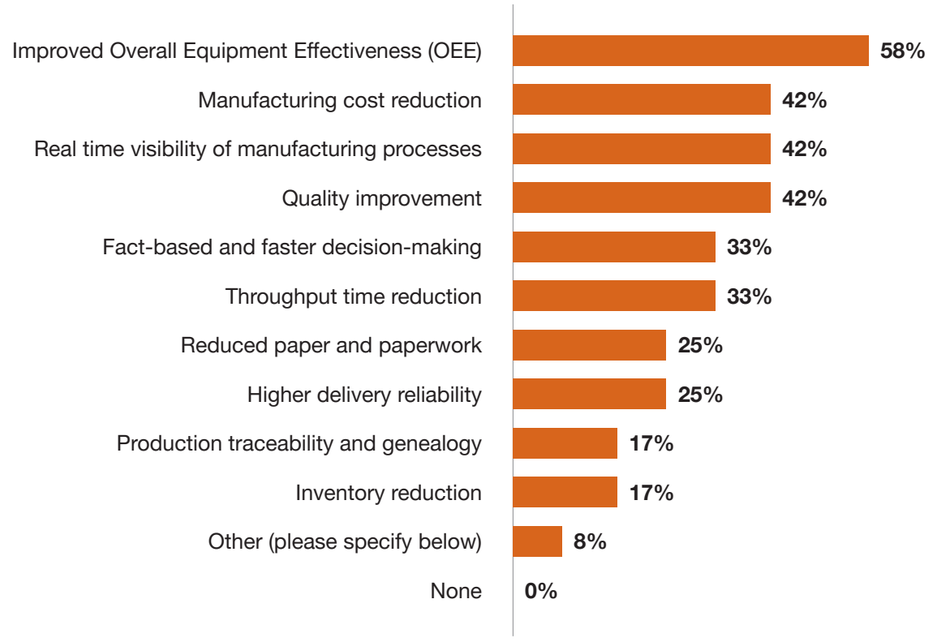


Figure 5. MES helps to increase the performance in day to day operations

Question: What are the observed improvements thanks to the MES implementation?

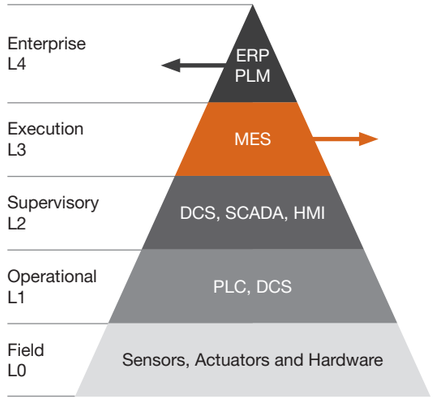
MES enables vertical integration and drives the harmonisation of manufacturing operations.

Only 36% of the companies utilise MES, while others deal with a fragmented manufacturing IT landscape with legacy systems, leading to limited transparency and poor control.

As figure 6 shows, MES/MOM is the orchestration layer and supports vertical integration between ERP and shop floor control systems. Better and faster decision-making processes require real time information from the shop floor. Therefore, integration with an ERP system is key.

ERP

- Integrated end-to end business process management, from procurement to invoicing, complemented by human capital and FI&CO
- Single source of truth regarding master data, e.g. materials, routings, bill of materials etc.
- Providing input data for shop floor execution, e.g. order data incl. inspection lots
- Processing result of data collections done in MES for subsequent processes in ERP or other integrated systems
- Warehouse- and transportation management
- Collaborative functions for seamless data exchange with vendors and customers
- Interfaces with MES, PLM, WMS and others



MES / MOM

- Vertical data integration from shop floor to top floor
- Production execution incl. process automation or even process orchestration
- Performance analysis to support better decision making process
- Detailed planning and scheduling based on real-time capacity data and OEE
- Traceability of production orders and WIP
- Integrated quality management and nonconformance handling within production line
- Predictive maintenance and quality management supported by AI
- Data collection from workers or machines

Figure 6. MES/MOM as a key element within the automation pyramid

As a result of our study of several clients using MES, we identified some of the most commonly used MES functionalities, as figure 7 shows. At the top are data collection during the production process, both manually and automated. Traceability of production orders and WIP are key functionalities from what we were told. In-line quality management is frequently used too, as well as maintenance management, to ensure zero breakdowns. Beside real-time capacity and OEE data, the insights gained from production performance tracking and analysis are used to perform detailed production scheduling.

Which of the following MES functionalities are being used?

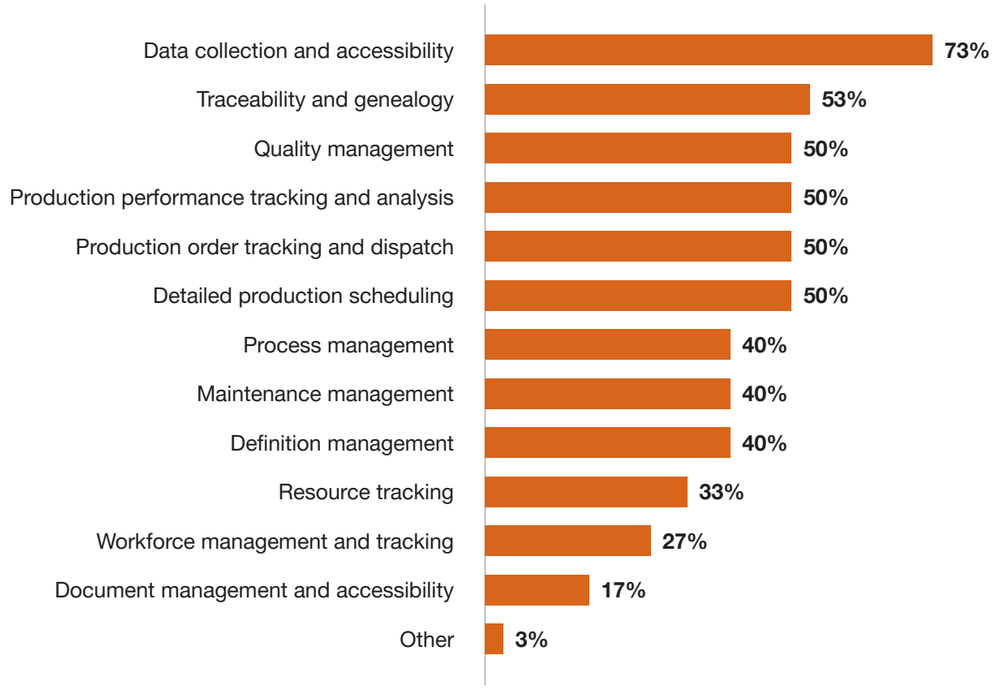


Figure 7. Most commonly used functionalities of an MES based on the study

Question: Which of the following MES functionalities do you use?

However, as our study indicated, manufacturing companies often rely on their existing ERP systems for manufacturing operations management, often due to a lack of awareness of the capabilities and advantages of an MES. We often get asked questions like, “Do I need an MES, why can’t I manage my manufacturing operations through the ERP solution?” There are key differences regarding design and capabilities between these two systems.

An ERP system is meant for planning and managing end-to-end business processes within and beyond the organisation and to provide input data for an MES. MES focuses on manufacturing operations management and shop floor execution, including worker guidance, machine steering, process automation, traceability of goods and quality and maintenance management, nowadays even supported by AI capabilities to optimise production. With increasing product mix and customisation, MES can support greater flexibility and quick reaction times according to customer demand.

Whereas some ERP solutions nowadays come with certain manufacturing features like detailed scheduling and resource capability management, ERP systems initially were not designed to cope with the complexity of the manufacturing operations layer. In order to bridge that gap, it requires a tight system integration between ERP, MES, product lifecycle management (PLM), and other software solutions.

MES has capabilities to cope with the rapid speed and the huge amounts of data generated on the shop floor. We talk here about milliseconds rather than minutes, like in the ERP layer. In order to process these data masses in an efficient way, MES offers capabilities such as pre-processing of shop floor data, in order to send condensed data to the ERP layer.

> One key requirement for a modern MES solution is that the system is able to collect all data from the shop floor and respond to control function requests from the machines in near real-time.
>
> **Peter Bollinger**, CEO of iTAC software AG

4

Journey

42% of the respondents reported increased complexity and 37% increased customisation effort as challenges in MES implementation.

According to our study, there are a few reasons why companies hesitate to implement an MES, these reasons are illustrated in the fígure 8. Although many of the benefits and improvements of MES are distinct for manufacturing operations, implementation decisions are not that obvious. According to our study, there are a few reasons why companies hesitate to implement an MES. The most common reason seems to be the lack of understanding if an MES is compliant with the existing IT landscape. This is aligned with our experience showing that many manufacturing clients struggle to position MES in the right way, while on the other hand they have limited understanding of the connectivity on the shop floor. Another client's concern is that an MES implementation is too costly and risky. Some companies also see that they are either too small for MES or there is no MES solution that fits the company's complex processes.

What are your reasons for not implementing an MES?

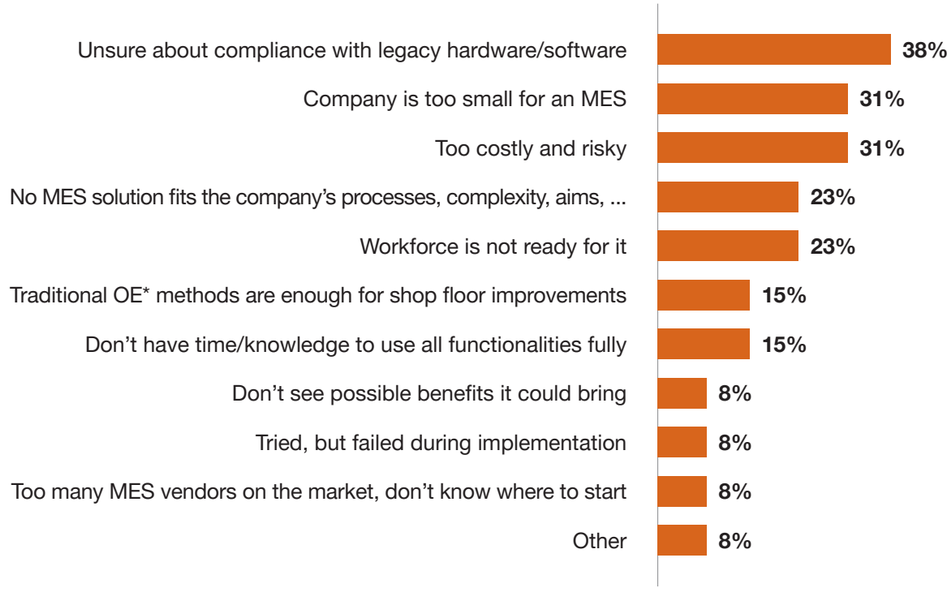


Figure 8. Reasons for not implementing MES

Question: What are your reasons for not implementing an MES?

(*OE: Operational Excellence)

Our study indicates that some of the concerns raised by the companies without MES are true. It seems that the complexity and usage of MES together with increased customisation efforts, as well as time and capacity to implement, are the top three challenges. Every MES implementation demands careful pre-work regarding processes, scope, interfaces and detailed requirements, supported by the considerable involvement of key experts to manage the complexity.

> Companies don't fully understand the complexity of an MES implementation. It is as complex as an ERP implementation.
>
> **Arnaud PORTET**, DELMIA Senior Sales Director Eurocentral, Dassault Systèmes

> For a successful MES implementation, the chosen MES solution must have the capability to be adapted to the customer's production process.
>
> **Peter Bollinger**, CEO of iTAC software AG

Vendors of MES software are aware of the challenges their customers are facing. During our interviews with different MES vendors we identified the key pitfalls presented in figure 9.

Manufacturing companies encounter the following challenges in MES implementation		MES technology companies highlight the following pitfalls in MES projects
42%	Usage/complexity of MES	• Organization, processes or/and ERP System not prepared for an MES Solution – poor understanding of processes • Architectural backbone insufficient
37%	Increased customization effort	• Focusing on features and functions instead of how much value it will bring to the company • Underestimating the overall investment
21%	Time and capacity to implement	• Management pushes the implementation without commitment • No dedicated MES team and resources and proper stakeholder engagement
	Lack of commitment from the management	
	Last minute scope expansion	• Not fully understanding of the complexity of implementation • Time required for the change and value realization

Figure 9. Challenges faced during the MES implementation

Question: What are the challenges you have faced during MES implementation?

Successful MES transformation reduces complexity, is based on **well-defined requirements** and relies on a **fit-for-purpose vendor**. MES implementation is a change of ways of working to meet future requirements.

To prevent our clients from getting stuck in these pitfalls, we have developed a proven framework for a successful MES project, based on our field experience.

Figure 10 introduces the key success factors for the approach for MES projects to help companies in overcoming the observed challenges.

1. **How future will impact your operations?**	• Consider future changes that will impact your manufacturing operations and required capabilities Understand the current operations maturity
2. **How will MES add value and fit into the IT landscape?**	• Understand the value of MES • Decide on which capabilities will be hosted where (ERP, MES, IIoT platform) • Reduce complexity and define clear system boundaries
3. **How much is the overall investment for MES?**	• Develop bottom-up business case with clear quantified benefits • Understand the cost drivers, involve vendor • Create good understanding of the total cost of ownership
4. **Which technology vendors are most suitable?**	• Compare different vendors against your value-driven requirements • Use commonly defined selection criteria • Emphasize industry experience & future roadmap
5. **How will we manage the project and the change?**	• Allocate full-time project manager and cross-functional team • Ensure buy-in right from the start • A well-trained project team with common understanding of the target state

Figure 10. Approach for a successful MES project

1. How will the business strategy and future trends impact our manufacturing operations in the future and where do we stand today?

As the companies' business strategies are constantly impacted by market trends and changes in customer behavior, and consequently so are companies' manufacturing operations. The key thing here is to understand how these changes will impact manufacturing operations, and what are the required capabilities in the future in order to be successful. As an example, shortening lead times or smaller batch sizes demand better capabilities for more accurate and real-time end-to-end planning.

A well-structured MES maturity assessment helps to identify the main improvement opportunities across the production network and already provides a good understanding of the most significant (10-12) use cases for an MES.

> You need to understand your processes, and set up the right processes before installing an MES. Know your value stream first.
>
> CEO of MPDV

2. How will MES support our manufacturing operations and how does it fit into the IT landscape of the future?

The next step is to define high level requirements as well as the high-level IT architecture. This is the stage where companies should spend significant time building those strategic cornerstones and a common understanding on which capabilities should be hosted in which system. The figure 11 illustrates high level key dimensions which indicate the value of MES transformation. This framework can be used to get an understanding of the key needs and complexity across different plants and divisions.

At this stage it is essential to understand what these business-critical interfaces are, and which systems the new MES would be integrated with. This already forms a solid basis for the future discussion about how the IT landscape will look. The key is to reduce complexity and define clear boundaries for different systems.

Every industry, company or shop floor has its own characteristics and a different degree of complexity which needs to be managed. The expected benefits and costs depend on multiple dimensions. Careful assessment of key drivers for the MES provides improved understanding on the need for an MES implementation.

These eight dimensions together indicate if an MES could help to better manage daily operations in your production network. Speaking about a production network, it is important to assess these 8 dimensions for each plant within the network individually, considering the dimensions as a guidance. It's also necessary for the question of whether one MES solution would be realistic or whether different MES solutions should be considered.

> Most of the companies focus on features and functions they want, not about how much value the MES will bring to the company.
>
> **Arnaud PORTET**, DELMIA Senior Sales Director Eurocentral, Dassault Systèmes

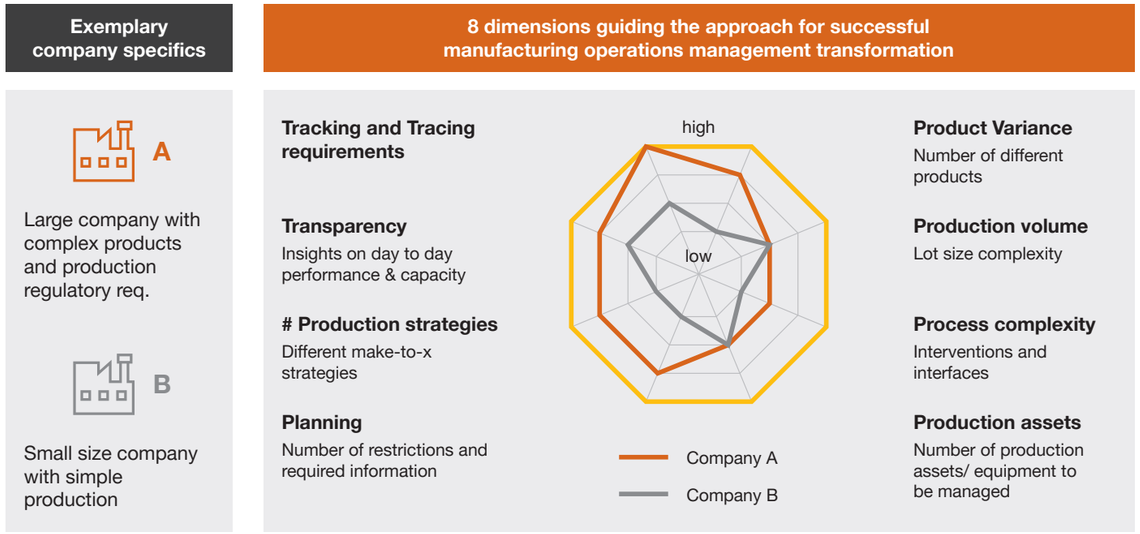


Figure 11. Eight Dimensions of MES potential

3. How much would the overall investment for an MES be?

As our study indicates, companies are afraid of the costs and risks of an MES implementation. A careful review of the improvement opportunities and quantification of the observed benefits helps to provide an understanding of the investment volume and whether it is affordable for a company.

The scoping of capabilities, detailed requirements and identification of interfaces provides a good basis to start assessing the cost of the implementation. For the implementation cost assessment, it is necessary to receive feedback from the potential MES vendors in the form of an RFI/ RFP. There are a few key dimensions which are typically the major cost drivers:

1. Functionalities
2. Level of configuration and customisation of functionalities
3. Number of production assets/volume
4. Number of system and production equipment interfaces
5. Amount of data
6. Tags needed in data historian
7. Number of users

For the cost assessment it is necessary to consider different cost drivers. There are costs to involve internal stakeholders from the business and IT side, initial costs for system setup by an external vendor, license costs as well as ongoing costs for system customisation and service fees.

> The underestimation of budget for the MES project is one of the biggest pitfalls.
>
> Technology Executive of Wonderware

A well-prepared business case helps to evaluate the size of the investment potential and to build further commitment from top management.

4. Which technology vendors would be the most suitable to support you on the MES journey?

In order to select the vendor for the MES, thorough preparation is needed. Detailed requirements based on the defined capabilities of the MES need to be developed, and interfaces to other systems and production assets must be identified. Without these actions the accuracy of the quote from technology vendors risks being poor, which leads to unexpected high costs in the implementation phase.

So how do you find and select the most suitable vendor for your needs? There are many vendors on the market who have strengths in different industries and different areas such as scheduling or maintenance. However, the key is to compare the different vendors against your own requirements, which should be defined against a common standard, such as ISA 95. If you pick a solution which partially fulfills the requirements but has no experience in the required industry, the project cost will very likely increase.

> MES implementation is not just a tool implementation but rather a change of ways of working to meet future requirements for manufacturing operations. The vendor choice defines the collaboration for the next 10 to 20 years.
>
> PwC Expert

In order to select an MES vendor, the key is to have a commonly defined selection criteria to support the decision making process. Your MES vendor should have proven solution capabilities for your industry, a robust roadmap for the future, and a healthy business with the ability to ensure the further development of the system at the pace you need.

5. Who do we need for the project and how should we manage the change?

For companies with multiple production sites in particular, an MES project becomes a challenge to manage. In order to be successful, it is essential to mobilise a cross-functional core team with at least 30% time allocation per expert, supported by a full-time project manager, and strong project steering.

> It is mandatory to have support from top management to the bottom, across all organisation layers.
>
> Technology Executive of Wonderware

The required MES project team must be well-trained on the capabilities of modern MES solutions and share a common understanding on the target state and the current processes. Internal process experts need to be part of the MES team, as it happens that “not all departments have the same understanding of processes used on the shop floor, and the actual processes are sometimes unknown”, according to Peter Bollinger, CEO of iTAC Software AG. Adding to this, the CEO of MPDV noted “companies have to make sure the right processes are in place before installing an MES. The result will only be as good as the processes you put into the solution.”

> People are a central part of change, and need to work together
>
> CEO of MPDV

> MES projects typically for a longer period of time.
>
> Technology Executive of Wonderware

All the key business decision makers should stay close to the project to ensure full alignment and to balance the resource need between the project and everyday operations work. The last thing companies want is business disruption. The most common risks related to implementation of an MES are that companies underestimate how much input is needed from experts and end up having limited resources with limited skills to provide support. Another key thing is to carefully plan the sequence of the implementation starting with proof of concepts to experience potential pitfalls and gaps before roll-out to other production sites.

> Customers should not underestimate how much of their internal resources time will be needed for an MES implementation. The total implementation time for an MES system also depends to a large extent on the availability of resources at the customer’s end.
>
> **Peter Bollinger**, CEO of iTAC software AG

It is wise to start implementation in smaller pieces and avoid a big bang. Also essential to consider is the implementation at production sites. We recommend building an integrated project plan to ensure smooth delivery.

Method

The results and findings of this study are based on insights gained via an online questionnaire, interviews and the knowledge of PwC experts. The online MES questionnaire for manufacturing companies focused on learning about the challenges, usage, pitfalls, and benefits of an MES/MOM solution. It was completed by 50 respondents. The interviews with MES and IIoT platform vendors, as well as an IoT research company, focused on discussing the future direction. It also brought the vendor’s perspective on the role of these different technologies. In addition, we incorporated the expertise and knowledge of PwC experts who work with these technologies and consult clients on manufacturing operations management.

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