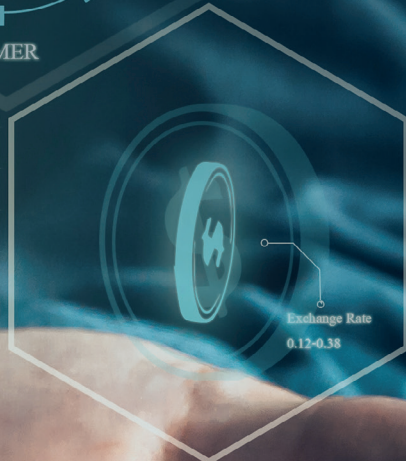


IIoT Has a 'Thing' for MES

Why IIoT Platforms Won't Replace MES for Industry 4.0

White Paper



EXECUTIVE SUMMARY

The industrial internet of things (IloT) is ushering in a new era and we believe it will only succeed as a marriage with MES. Some say IloT will spell the end of MES – that it will no longer be needed. We understand why that seems attractive, but we don't agree.

For one thing, many of the functions that MES performs today cannot be replaced by these new IoT platforms, even with analytics and apps. In addition, IoT and big data systems can produce unprecedented improvements in many areas but need MES to leverage their true potential and benefits.

Some companies and "experts" have been insistently conveying the message that with the advent of IoT, MES is not required anymore. This document explains why this is erroneous. It also explains why so many solution providers and even some manufacturers would like MES to die off.

As has been the case for many years, the death of MES is greatly exaggerated. MES is actually critical in these IloT environments. There is a natural fit where MES provides orchestration to ensure that the IloT local edge intelligence optimizes rather than sub-optimizes business performance.

MES provides a dozen capabilities that are essential to the success of IloT projects. We'll describe those briefly, along with the characteristics of the New MES designed to support this environment. Leveraging IloT makes MES more important than ever. In fact, we see that IloT has a thing for MES.

MES Dozen Drivers for IloT



ORCHESTRATION:
Optimize plant & operations outcomes



RESPONSIVENESS:
Trigger change on anomalies



MODELING:
Optimize plant and business results



CONTEXT:
Tease meaning for data in, beyond the device or plant



ORGANIZATION:
Map and store info on operations and assets



ENFORCEMENT:
Reliably ensure correct execution in plants



CONNECTION:
Act as plant liaison to smart supply chain



STANDARDIZATION:
Store and roll out workflows or processes



VISIBILITY:
Show production status in real-time across all assets



SMART SURROGATE:
Act as proxy when there's no case for sensors



COLLABORATION:
Provide common current data for all ops groups



STREAMLINED INNOVATION:
Enable rapid ramp-up and improvement

The IIoT World

Today's technology holds out hope that manufacturers can orchestrate the complex world of production and supply chain with more speed and reliability than ever before. Perhaps the biggest new technology to drive that is the Internet of Things (IoT).

The specific version is Industrial Internet of Things (IIoT). IIoT uses "machine learning and big data technology, harnessing the sensor data, machine-to-machine (M2M) communication and automation technologies that have existed in industrial settings for years," according to TechTarget.

Leveraging existing technologies is one of the core strengths of IIoT. Those who feel IIoT is not new have a point; most manufacturers have been using M2M, sensors and automation for years. To have full transformative effect, IIoT builds on not only the automation but also the information systems already in place to drive new insights by applying sensors and analytics and connecting the smart devices.

IIoT can make machines, materials and products "smart" and connected. These are a foundation for Industry 4.0, Smart Manufacturing and Digitalization.

IIoT for equipment can have a quick return and long-term benefits. Relatively unsophisticated equipment may not warrant adding traditional sensors and standard interfaces, but the external IIoT approach may be easy to justify. For sophisticated equipment that does have sensors and standard interfaces, IIoT offers a fast and affordable way to test additional process measurements. Depending on the results of the test, either the sensor may be removed, or become a permanent fixture.

Incorporating IIoT into products before they are built can shift production to a distributed and autonomous mode. The IIoT can store production orders and specifications on the device, or product being built. This enables the shop floor marketplace, described in the paper *Manufacturing Software for Industry 4.0: Embracing Change and Decentralization for Success*. In addition to directing the product through the plant, it will also work through the supply chain and into use at the customer for post-sale services.

Usually, the promises for improved business outcomes can justify these IIoT investments easily. However, gaining the benefits is not necessarily easy. The orchestration challenges shift in this world of distributed intelligence and decision-making.

This is so new many practitioners and experts are debating and learning about how to manage operations in this IIoT environment. A common argument we've heard is that MES will vanish and simply become a set of apps running on an IoT platform. We do not agree and find that the original reasons why MES has become an integrated suite of applications are even stronger now.

What IoT Platforms Do

At a high level, an Internet of Things (IoT) platform is the middleware of the new way of working. Most IoT platforms include a communication network and software for monitoring, troubleshooting and administrating the connected devices and managing the network and data management. Some IoT platforms have software for translating or analyzing the data and support for app development.

DO IIOT PLATFORMS AND APPS MEAN MANUFACTURERS NO LONGER NEED MES?

WE DON'T BELIEVE SO; IN FACT, THE NEW MES PLAYS A CRITICAL ROLE IN IIOT SUCCESS.

In short, the IoT platform is the plumbing between the data collected from "things" or devices at the edge and the user-facing applications, as Figure 1 shows. This does not mean all IIoT platforms are basic.

Some of the most sophisticated IIoT platforms do have capabilities for data collection and aggregation, visualization of data, alerts and notifications, integration to enterprise systems, forms, dashboards, collaboration and data analytics. These capabilities sound very similar to what MES does and some would argue that adding apps for specific types of MES functionality will allow the IIoT platform to provide all of the capabilities MES does.

However, IIoT platforms act as a master layer from the bottom-up, meaning from the equipment interfaces and IIoT to the layers above. MES is just

another source of information that the IIoT platform collects along the cycle of bringing the detailed data to the cloud.

Alone, IIoT does not offer many new possibilities to manufacturers. That's because:

1. It cannot pull in all the context;
2. It is not designed for orchestration across one or more facilities;
3. The IIoT devices have sensors with some processing and communication capabilities, but are not responsive.

To summarize, the problem with this IIoT platform centric approach is that it is not equipped to drive toward the business objective. The objective is responsiveness - for the equipment or product to change its behavior to optimize business outcomes. This is what MES does.

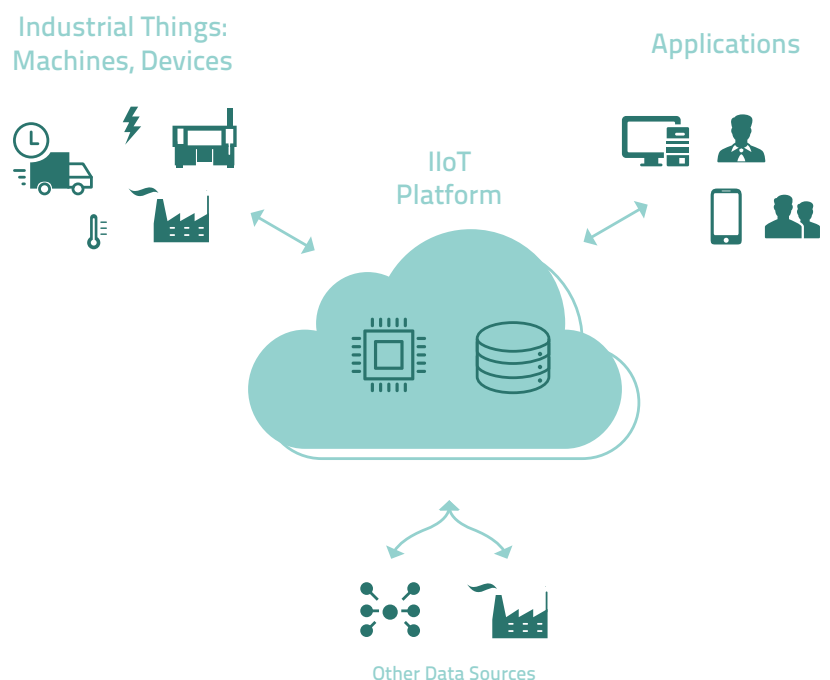


Figure 1

An IIoT platform connects smart devices through a cloud-based network to applications, users and other data sources. It is intelligent middleware. MES is one of the applications that an IIoT platform pulls from and feeds.

In this way, IIoT boosts rather than destroys the need for MES. Our view comes from both long experience and deep analysis of the new reality.

MES acts top-down, and is more strategic. It comes from the shop-floor

processes that determine whether a company makes a profit or not. From that vantage, MES orchestrates the lower level equipment and devices in alignment with these value-adding processes. Since the ultimate goal of Industry 4.0 is to guarantee productivity

increases, this must occur through processes. For example, manufacturers achieve consistent quality of products through quality of processes and quick introduction of new products through efficient processes across departments.

The Critical Role(s) of MES for IIoT

As intelligence becomes distributed across the IIoT and its connected devices and equipment, orchestration is required not just to ensure the data gets to the right place, but to make sense of it. MES ensures that IIoT data is in a context that allows people to make sound operational and business decisions.

Often, these decisions need to be made quickly – but there is a danger of making them exclusively at the edge. Because of the tight interdependence of all activities across a plant or all the plants in a company or supply chain, there’s a high risk of optimizing one process or area of the operation in a way that sub-optimizes the overall business outcomes. This is where MES plays a role. It’s where MES has always played a role, in fact. The difference is that now, the environment is changing.

Manufacturing Execution Systems (MES), as shown in Figure 2, is the set of applications that runs plant and multiplant operations from a consistent set of data, much as ERP runs the offices. It serves operators, engineers, supervisors, schedulers, quality and maintenance personnel directly. It also delivers plant information in ways that other people and applications across the enterprise and supply chain can use it.



Figure 2
MES does provide connection to devices and to other applications, but in the middle, it's a rich set of functions to manage and optimize production operations.

MES History

Decades ago, it was important to specify "integrated MES" because previously, separate point applications (or paper or spreadsheet-based systems) provided various functions. For example, data collection, routings, work instructions, quality, scheduling, recipe management, maintenance were all managed in disparate pieces of software. This is still the case in many plants, though most companies know it's not optimal.

Integrated MES became the norm in industries such as semiconductor and electronics largely because it delivers a plantwide view. MES is the

consistent system for both operations and operations support roles such as engineering, quality and maintenance to share status – in context. This view is available in near real-time, fast enough for operations decisions and for plant status to inform enterprise decisions.

Beyond showing status and providing visibility across the plant, the MES has always guided and informed the people working there. It does provide a middleware between the ERP and plant automation, bridging between the very different speed and granularity

of transactions in those systems. Yet it does much more.

Specifically talking about data, the ISA-95 idea that each level going up would fulfill a specific role of data aggregation, calculation or sampling, making sure that only the relevant information will be passed up is now obsolete. This paradigm has been disrupted by big data and machine learning applied on big sets of granular data. These algorithms will get the most value if no information is lost in data aggregation or simplification

A Dozen Things MES Delivers for IIoT

There are things that MES does that an IIoT platform and apps cannot. In addition, there are ways in which MES provides the optimal means to fully leverage the benefits of IIoT. A core function of MES is to manage and control manufacturing processes. It is not by accident that the word process, so critical for manufacturing, is so rarely used in the MES-free theories.

Here are a dozen specific things that MES delivers that are important to IIoT success (listed below and shown in Figure 3).

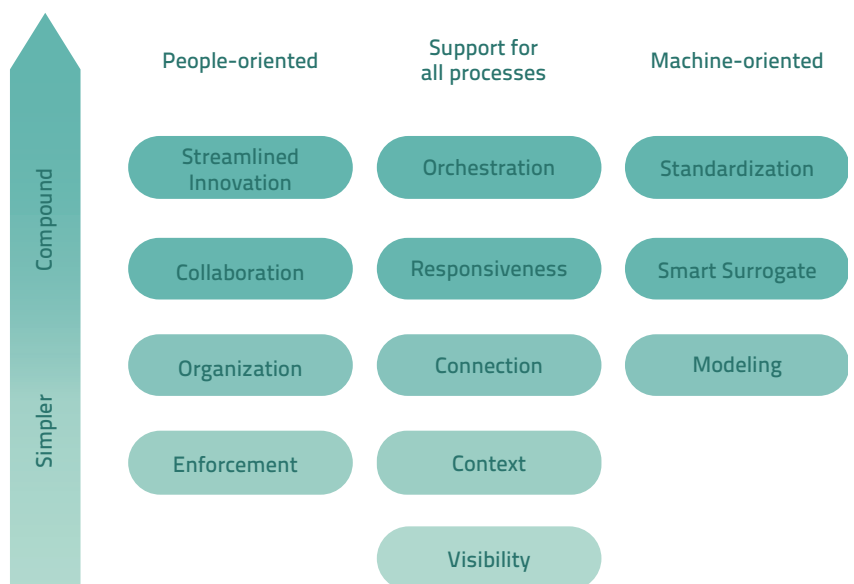


Figure 3
MES must provide advanced capabilities in at least these 12 critical areas for IIoT to succeed.

1. CONTEXT:

IloT sensor data and machine learning algorithms may be adequate to detect anomalies and even predict some failures. However, without more context those analytics can reach only a fraction of their potential. MES can add data about the specific product, equipment and recipe, plus data from previous steps and equipment maintenance history. One telling example is that vision systems with machine learning cannot tell sheepdogs from mops, or kittens from ice cream! (Figure 4)

2. CONNECTION:

In addition to being the set of applications that run the plant, MES is designed to integrate with other applications. It delivers context at the right level naturally, since it manages production processes end-to-end. In this way, MES can act as plant liaison to the smart supply chain. For example, MES can show procurement and supplier quality teams material receipt time, incoming quality test results,

process or quality anomalies and final test parameters. It can also deliver information to engineers, showing product and process as-designed vs. actual parameters tied to throughput, yield and environmental metrics.

3. SMART SURROGATE:

Part of what's exciting about IoT is that it adds intelligence to the devices. However, in many cases, there's no business case for adding sensors to products and equipment. In those cases, MES can act as proxy for those devices. The MES knows what processing the product needs and can communicate the next step needed on behalf of the product. It can also broadcast availability on behalf of the equipment to ensure that products get through the production process efficiently.

4. RESPONSIVENESS:

As mentioned above, IloT typically is not responsive. So MES can trigger changes in routing, equipment behavior, or operator instructions when anomalies

occur. This is where the value of IloT with MES appears in better production outcomes.

5. ORGANIZATION:

MES maps and stores information on operations, both processes and assets. The IloT can operate a facility autonomously only when all of that information is known. Without a system in which to organize and leverage that data, IloT-based operations would be nearly impossible to understand. For example, just sensor data and an IoT platform cannot determine the equipment state. Without that view, the plant cannot see overall equipment effectiveness (OEE). OEE is a signal for where to focus both immediate changes in automation settings as well as long-term continuous improvement efforts.



6. STANDARDIZATION:

MES stores and allows easy and consistent roll out of workflows or processes. Whether in a single plant or many, this engineering time saver will be increasingly essential.

Once the local machine learning kicks in, putting it into the context of what works for the plant, supply chain and business will allow companies to confidently leverage best practices even in the dynamic IIoT environment.

7. COLLABORATION:

Having a common information system across plant operations (in one or multiple facilities) delivers consistent current data, allowing all operations groups to work together and use each other's data with minimal friction. This is a major benefit of MES compared to function-specific apps.

8. MODELING:

Many companies implementing MES find benefits before the software is in full use. That's because MES is based on a model of the plant(s), or a digital twin of the process. In the IIoT world, the model is the framework on which all of the dynamic activities between devices can occur. When this model is connected into metrics about supply chain and business results companies can ensure their IIoT efforts optimize both plant and business results.

9. ENFORCEMENT:

Manufacturing Execution Systems manage and enforce every aspect of manufacturing workflows, including equipment, materials, procedures and automatic or manual processes. These processes can be engineering related (equipment, product or process), quality, logistics, etc. MES sets and manages the policies and rules required to make sure that all entities, human or non-human,

operate as they're supposed to, and that production value is maintained or increased.

10. VISIBILITY:

Modern MES shows production status in real-time across all assets. Mapping the in-context data onto the plant model enables instant visibility. In the IIoT-enabled world, rather than knowing where a product is based on start time and pre-set routing, the plant floor marketplace will enable optimal paths given the current state of each product and piece of equipment. Nothing is pre-set. So, gaining real-time visibility across the entire facility – or set of facilities – will be more important than ever.

11. STREAMLINED INNOVATION:

One of the major benefits of Industry 4.0 and IIoT-enabled production is making personalized or one-off product quickly and cost-effectively. The only way to do that is to have MES showing all of the context to enable rapid ramp-up and improvement in products and processes.

12. ORCHESTRATION:

While an IoT platform can keep data moving between devices, it cannot optimize plant & operations outcomes. The 11 things MES does listed above are part of its ability to orchestrate production operations. Separate apps even connected to a powerful IIoT platform cannot do that. Just as the orchestra has leads for every instrument, they still rely on the conductor to ensure maximum impact of the overall piece of music or concert.

Some of these things any MES would provide; others require the new MES, described in the sidebar box and the paper *The New MES: Backbone of Industry 4.0*.

What is the New MES and how is it different?

- The plant model is flexible, not fixed
- It includes location processing for mobile interfaces and augmented reality
- Advanced analysis in the cloud to feed plant context to other big data systems
- Binding between assets and processes for context resolution
- Dynamic execution of processes and status in shop floor marketplace
- Service-oriented, modular visibility across operations

Why Some Want MES to Vanish (And Why It Still Won't)

LARGE SOLUTION PROVIDERS AND "EXPERTS"

Clearly, MES delivers big benefits to IIoT. So why have some solution providers and industry analysts been insistently conveying the message that with the advent of IIoT together with IoT platforms, machine learning and big data analytics, MES is no longer required?

We can't say for sure, but perhaps it's what they hope will be true. MES has always been difficult for larger enterprise application providers for two main reasons: segment specificity and deployment efforts.

1. Sub-Segments: Large software providers find the manufacturing applications sector is too small to be interesting when it's divided into meaningful groups or industry segments. Discrete, batch and continuous have different needs and specific industries within each of those modes do also.
2. Deployments: Even with segment specific software, every company, plant or production area might need configuration or customization to support best practices. This takes time and expertise to understand requirements, design, implement, test and deploy.

What these big players needed was a disruptive technology that would dissolve the segment differences, allowing the same technical solutions to operate on all segments. Ideally this new technology would also make deployment easy so that the customers or a network of smaller system integrators could do it.

Apparently, they think they found it in IIoT. The message is quite appealing: IoT devices (which will continue to become both more powerful and affordable) are connected to IIoT platforms that manage and control such devices; in turn the collected data points are stored in cloud-based solutions. There intelligent algorithms analyze them and derive diagnostics, predicting the behavior of the underlying processes and prescriptive actions to improve their performance.

It sounds as if in this environment there's no space (or need) for MES systems, whose main function was to collect and store data for decision making or for fulfilling quality requirements.

And there's an additional angle: the data collected is the new gold. The software players who control the data can also offer additional value-added services on their platforms (at a good selling price). Although Customers own the data, they will pay more and more for solutions from providers that are

able to derive intelligence or insights from this data. This is not dependent on the proliferation of IoT. Yet IoT has the potential to take it to a completely new level, given the amount of data collected (or the cost of generating such data, which will reach incredibly low levels).

MANUFACTURERS

Some manufacturers also echo these MES-free strategies. Here, what's at stake is the prospect of less effort and faster return: a quantum leap.

These companies are hoping they can bypass or circumvent all the difficulties that a standard maturity process takes to get a company from the least mature level to the most. The thought here is: "why should we have to go through all the hurdles of implementing processes, get them under control through people, technology and procedures and later improve it and supplement it with additional data? This lengthy process takes time, effort, investment and persistence. Can't we do all this by implementing Industry 4.0 and IIoT technology stack that does all of it at once?"

The problem is that companies cannot skip or shortcut maturity phases. Whatever the technology, no matter how powerful the sensors, analytics and machine learning are, there's no magic wand that will do the work.

So, the Thing Is, IIoT Needs MES

IIoT and big data / artificial intelligence (AI) are two major disruptors of the Industry 4.0 revolution. These technologies have the power to both democratize the use of digital technologies on the production floor and to take real advantage of all the data being collected.

IIoT and machine learning or AI broke two widely accepted assumptions in manufacturing. 1) Only very sophisticated machinery can afford the monitoring of equipment or process variables. 2) Data for decisions must be sufficiently aggregated so that analysis can be done efficiently.

The new challenges include data quantity and the need to orchestrate new solutions within the existing manufacturing processes. These

processes continue to require enforcement, monitoring and improvement, the existence of a holistic solution like MES is even more important than before.

In fact, in many ways, MES will become the real enabler of this digital transformation. IIoT needs MES, and some MES is ready for it.



Critical Manufacturing drives business value through the convergence of intelligence, operations, and automation technologies for Industry 4.0. Critical's approach and leading Industry 4.0-ready modular MES will make Industry 4.0 a reality for its customers.

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