

**Tech-Clarity**

*making the value of technology clear*

# **Tech-Clarity Insight: Integrating PLM and MES**

*Realizing the Digital Factory*



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## Executive Overview

Manufacturers frequently struggle with the roles that their enterprise systems should play in developing and producing profitable products. Tech-Clarity research on this topic, including *The Evolving Roles of ERP and PLM*, provides insight into how these systems play complementary roles in the manufacturing industry. The past research, however, did not address the role of Manufacturing Execution Systems (MES). The roles of “innovation” and “execution” as defined in the research are not complete without considering MES. MES plays a distinct and important role in producing profitable products. The time has come to revisit the roles of enterprise systems in manufacturing. This paper reviews the MES and PLM experiences of three leading manufacturers in order to help others define the roles for their own systems.

ERP, Product Lifecycle Management (PLM), and MES all offer distinct value. That value is amplified when the solutions have well-defined roles and are integrated from both data and process perspectives. Specifically, the integration of MES with PLM offers improved efficiency, reduction of errors, increased agility, faster time to market, and enhanced product traceability. As a manufacturing executive from a major aerospace company explains, integration “*removes manual processes, helps automate, and reduces the human error factor.*” This offers significant time savings from manufacturing engineering efficiency, rapid commissioning, improved quality, and reduced scrap and rework.

Combining MES and PLM offers the ability to close the loop between engineering and manufacturing. This involves designing products to meet requirements, optimizing product designs based on early manufacturing input, designing manufacturing processes to ensure product quality, and then validating that you build what is designed. “*Where does PLM end? Where does MES begin?*,” asks Mr. Bagher Feiz-Marzoughi, Head of IT for Siemens Electronics Works Amberg. “*We are now talking about product and production lifecycle as a whole.*” Integration of MES and PLM can provide a synchronized manufacturing backbone, integrating the product and production lifecycle.

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### ***Leading manufacturers are leveraging MES and PLM to make progress towards the digital factory vision.***

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Manufacturers open strategic benefits by bringing the virtual manufacturing environment closer to the physical plants. As Siemens’ Feiz explains, “*We would like to be able to move production between our thirty plants – that is one of our long term goals.*” Designing manufacturing processes digitally and automating manufacturing commissioning makes this more of a reality. Leading manufacturers are leveraging MES and PLM to make progress towards the vision of the digital factory, an integrated approach to design, validate, and deploy manufacturing processes as a holistic process.

## Why Now?

PLM-MES integration is more important now than ever due to increased competition, globalization, and product complexity. Manufacturers today must optimize costs and continuously improve productivity to compete in a global market. At the same time, they need to be agile to respond quickly to customer demands and take advantage of market opportunities as they arise. “*Our vision is to make time to market shorter,*” says Siemens’ Mr. Feiz, “*We talk about ‘halving’ time to market.*” That is no small goal. Time to market includes time to design, but also includes time to commission the plant and ramp to full production. This makes improving manufacturing engineering efficiency critical to improve time to market and customer delivery, particularly for complex manufacturing. Likewise, improving operator efficiency by providing standardized work instructions allows operators to ramp up more quickly, allowing companies to get products to market faster. Companies can also reduce training time on new products or production lines in order to get production lines ramped to full capacity as soon as possible.

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These efficiency improvements reduce cost. “*We have to do more with less,*” points out Angie Dinsmore, who is responsible for PLM Strategy at ATK Space Systems. “*We can’t only compete technically; we must also compete on schedule and cost.*” One path to reduced cost is reducing manufacturing errors and the associated scrap and rework. Waste like this can be minimized across the product lifecycle. “*There is waste found in information search,*” the aerospace representative points out. “*There is also waste when a change doesn’t make it in or when we make things that are non-conforming.*” Harmonizing the PLM and MES environment helps reduce these costly mistakes. “*Data gets in once, so there is less chance for errors,*” ATK’s Dinsmore say.

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***Improving the integration between design and production improves product quality.***

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Improving the integration between design and production improves product quality as well. “*We need requirements traceability all the way through production,*” explains Ms. Dinsmore of ATK. “*We need to bring up a piece and know why we are building it the way we are, and why we are inspecting it the way we are.*” Increased product complexity and multiple product variants make the job of quality production and validation harder, making synchronization between MES and PLM more important.

Beyond efficiency and cost, there are additional strategic reasons to improve how Engineering and Manufacturing work together. For example, many companies are trying to implement a “design anywhere - build anywhere” strategy where production is

transportable between facilities. “*We expect to collaborate more, be more global, and move work more agilely across the globe,*” says the aerospace participant. An integrated, automated MES-PLM environment can help. Integration also supports strategies such as concurrent engineering and provides supporting collaboration tools. “*Design engineers design a part and throw it over wall to Manufacturing and then over to Quality; but they can’t build it,*” Ms. Dinsmore of ATK remarks. “*Concurrent engineering can help resolve this.*”

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***Companies are looking to streamline and integrate their product and production processes and systems.***

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For these reasons, companies are looking to streamline and integrate their product and production processes and systems. Some may see this as a necessity to reduce cost in a challenging economy, others to improve quality, while others may seek faster time to market. Some may require integration to support process control and visibility in a regulated supply chain. The challenges differ by company. “*Our first and primary issue is that business is growing,*” says the aerospace executive. “*We have doubled in size over the last ten years, and we expect to do same in next ten. Our process and system landscape was not conducive to that scalability.*” While not all companies are facing the need to scale due to growth, there are many reasons that integrating MES and PLM are becoming more important, and just as many sources of value to manufacturers.

## **Product Innovation and Execution Roles**

Previous Tech-Clarity reports on ERP and PLM define the roles of each and recognize the need for both solutions. There are many companies that operate with just these two solutions; however they are missing a significant opportunity. While ERP manages the commercial business of manufacturing, it lacks the granularity and detail that MES provides. While ERP typically includes routings which define operations performed at workcenters, they are typically defined at the level required to plan resources and account for work performed. MES, on the other hand, is designed for detailed process instructions and manufacturing information including parameters and machine code for automated equipment.

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***PLM acts as the master of all of our product and process definition data.***  
*Executive, Leading Aerospace Manufacturer*

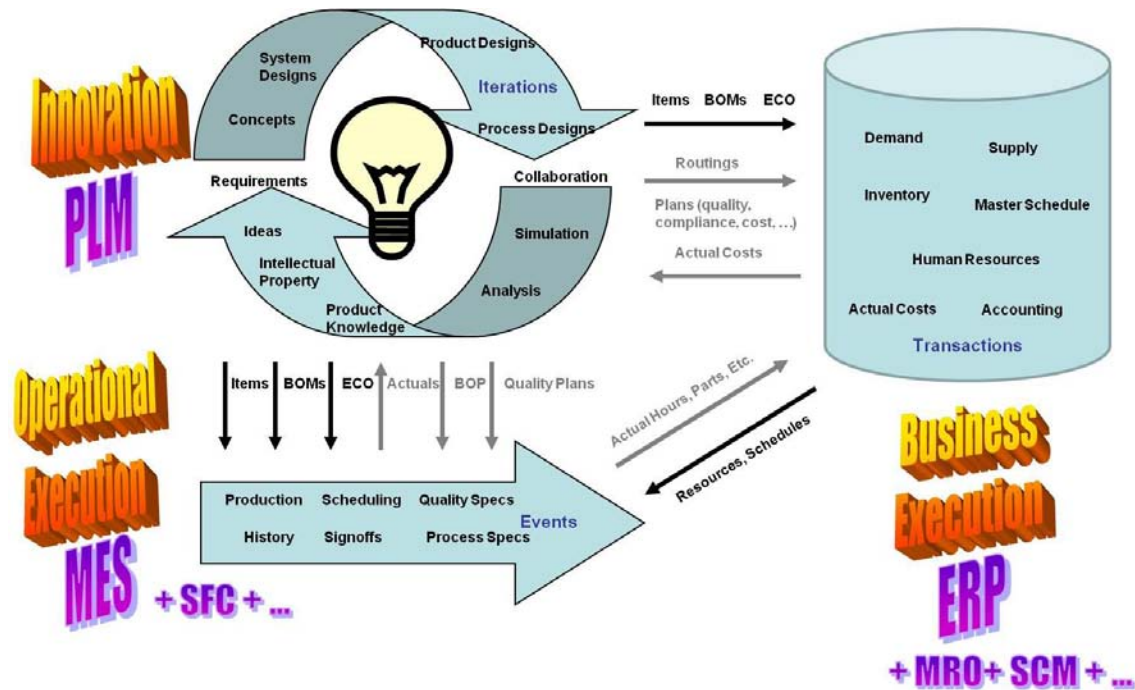
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Where does this manufacturing data come from? Today’s leading PLM systems have the ability to define and manage the process by which the products should be built. As the aerospace executive explains “*PLM acts as the master of all of our product and process definition data.*” PLM now contains the complete product description, serving as the “single source of truth” for product data. The expansion of PLM to include

Manufacturing Process Management (MPM) capabilities such as developing the bill of process and creating manufacturing instructions has allowed PLM to author and house detailed manufacturing data. As *Tech-Clarity Insight: Leveraging the Digital Factory* reports, “MPM tools provide facility engineers, industrial engineers, and manufacturing engineers the tools they need to design and implement optimal manufacturing processes.”

***Developing the BOP in PLM provides traceability to the BOM, leveraging PLM’s configuration and effectivity control.***

PLM serves as the platform for manufacturing engineers to develop the Bill of Process (BOP). Developing the BOP in PLM provides traceability to the BOM, leveraging PLM’s configuration and effectivity control. MES then provides the framework required to produce the product on the shop floor and capture the history as the product is built. This history provides the detail required to track components and labor, manage quality, and provide the results ERP needs to manage inventory and financial implications. The role of ERP, then, is managing inventory, orders, human resources, master planning, purchasing, financial control, reporting, and other commercially-oriented transactions. ERP manages supply and demand at the macro level. In the words of the aerospace executive, “ERP is the master of how much we need and when we need it,” based on demand signals the company receives.



**Figure 1: The Roles of ERP, PLM, and MES in Manufacturing**

Integrating the product and process from PLM with the supply and demand planning from ERP into MES, as the aerospace executive explains, “*brings together product data and orders into the shop floor – providing the right product data at the right time and measuring progress of manufacturing until the order is fulfilled.*” In essence, PLM drives and captures product and process innovation, MES manages and tracks the execution to turn those products into reality, and ERP manages the commercial business of manufacturing (Figure 1).

## Integrating the Product and Production Lifecycle

The roles of PLM and MES are distinct and unique, but must be integrated to provide full value. This is also true for product innovation and manufacturing processes. Engineering intent and manufacturing know-how need to be documented and clearly communicated to the shop floor. Operators should not be craftspeople working to a general idea of the product. “*We don’t want operators working by themselves, it’s a safety concern,*” explains ATK’s Dinsmore. “*People want to do things the way they want to, but that can result in blown up buildings or serious injuries. They can’t do their jobs the way they used to, we need tighter control.*” The aerospace manufacturer also stressed the importance of control. “*Operators are forced to follow a process, so they don’t take things out of step,*” explains the aerospace executive.

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***We don’t want operators working by themselves, it’s a safety concern.***  
*Angie Dinsmore, PLM Strategy, ATK Spaces Systems*

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Ensuring that engineering intent is translated to the shop floor doesn’t mean that manufacturing expertise is unimportant. In fact, manufacturing knowledge is a critical asset and represents important company intellectual property. Best practices in production should not only help a single operator or team, but communicated back to engineers who can use this knowledge in their designs and plans so that it benefits many more operators. “*We have lots of tribal knowledge,*” ATK’s Dinsmore says. “*We need to capture that information and share it.*” Manufacturing input and best practices should be incorporated into the product model to improve repeatability, drive out variability, and capture manufacturing knowledge for future products. “*We want to share the best way to perform an operation so we do it the same way globally and repeat it as a standard,*” describes the executive from the aerospace company. “*That should take out innate variation and lead to improved quality.*”

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## Automating the Integrated Product and Production Lifecycle

To support the integrated product and production lifecycle, manufacturers must develop an infrastructure that harmonizes the rich information between engineering and manufacturing. *“What we need is a data backbone for all processes and functionality for product and production,”* explains Mr. Feiz of Siemens. *“We need methods, applications, and data integrated to realize the whole process in the product and production lifecycle.”* In this integrated backbone, PLM plays the role of defining the plan for the product to be produced. MES is the execution engine that puts the plan and BOP into action and tracks the results.

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*Mr. Bagher Feiz-Marzoughi, Head of IT, Siemens Electronics Works Amberg*

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With minimal automation the product design itself can be shared with the plant floor. *“We now show operators a 3D model they can manipulate and move around instead of a 2D drawing,”* says Dinsmore of ATK. But the product design is not enough. Production – particularly automated production – requires a significant amount of detail, such as machine programming, operator instructions, and task sequencing. This is where integration between PLM and MES plays a crucial role. *“The MES layer needs a lot of attributes and information for the machines,”* explains Mr. Feiz of Siemens. *“The workplan, including the routing and bill of process, is the binding issue between PLM and MES.”* Integration does not end with MES. MES validates processes and passes the required information to the equipment and controls on the shop floor. Integrating plant automation to MES and PLM reduces time, cost, and errors in commissioning the plant and provides an integrated environment to tie production reality to engineering plans.

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***Integrating plant automation to MES and PLM reduces time, cost, and errors.***

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Engineers develop product designs and then continue to add additional information throughout the design process. Product designs can be fleshed out with information, extending the bill of material (BOM) to a BOP. *“The BOM, BOP, and bill of work area (BOW) are the three pieces of the process plan that represent the completion of authoring,”* describes the aerospace executive. *“That is what will be passed down to MES.”* The BOP can be made very rich and include parameters required to produce the product. These process plans can be authored in PLM and used in MES. Then, the workcell gets only the information that is needed for the task. *“The real benefit is to provide up to date work instructions to the operator at the point of use, when they need them,”* adds the aerospace executive. *“That takes away a lot of waste.”*

## Closing the Loop between Designs and Products

MES not only helps operators build a high quality product, it also captures valuable data about manufacturing. MES documents the production process including operations, operators, equipment, specifications, and times. This event-based information is highly valuable. *“Our priority is to get work instructions to the right place and then capture good data when people execute,”* states the executive from the leading aerospace company. MES documents that proper processes were followed and helps close the gap between engineering and the reality on the shop floor. *“The tact time for a cell might be three weeks, but the operator is expected to sign off after each operation,”* Ms. Dinsmore of ATK explains. Capturing information close to execution provides better data. *“Otherwise it is always a catch up to see if all operations were completed instead of knowing that everything has been done in process, in order,”* explains the aerospace executive.

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***MES documents that proper processes were followed and helps close the gap between engineering and the reality on the shop floor.***

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Capturing execution data in MES and integrating it with PLM provides holistic traceability, which has strategic advantages. The data becomes even more valuable when correlated with production performance and product quality. For example, detailed manufacturing history helps companies identify the root cause of errors so they can be corrected in related products, and can help limit the scope of recalls. *“MES can help you go back in time and look at history,”* explains Dinsmore of ATK. *“It is a traceability issue; you know how you built it.”* This includes information including who produced the product, when, with what, and any exceptions that occurred.

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***Integration between MES and PLM provides a platform to document and share the as-built configuration.***

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Shop floor history is also important to assure customers and regulators that what is produced matches approved designs. Data from MES includes the “as-built” view of the product. Integration between MES and PLM provides a platform to document and share the as-built configuration, including specific lots and serial numbers where appropriate. This as-built view is a required deliverable in some industries and a valuable source of information in all. *“All as-built data and reconciliation will be in PLM so we can compare to the as-designed,”* Dinsmore of ATK explains. *“If there is an error or discrepancy we can solve it real time, and it will help us identify other items that should be checked.”* As-built information in PLM then becomes a strategic asset that can be leveraged for downstream process such as Maintenance, Repair, and Overhaul (MRO) as discussed in *Tech-Clarity Insight: Enabling the Aerospace Product Service Lifecycle*.

Another benefit of capturing accurate as-built configurations is the ability to conduct comparisons between the as-designed and as-planned models to identify and capture deviations, document them, and to set up for continuous improvement. *“We will identify nonconformance in MES where the data is structured,”* explains the aerospace executive. *“MES will enable proper root cause analysis supported by real operational and output data, arming our (six sigma) black belts to make improvements and ultimately improve quality. It is absolutely vital information,”* he concludes. Integrating PLM to MES helps trace requirements from concept all the way through control plans and activity on the shop floor. It also demonstrates the attainment of customer requirements. This helps drive quality into design and production processes. As the aerospace executive concludes, *“Quality is innately in the PLM and MES space.”*

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Executive, Leading Aerospace Manufacturer***

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## Summary

Integrating MES and PLM provides strategic value, including improved efficiency, reduction of errors, increased agility, faster time to market, and enhanced product traceability. PLM supports world class product design and manufacturing planning. MES provides the ability to execute against those plans. Integrating the two helps close the loop and help achieve the vision for the “digital factory.” Technology innovations in PLM are driving the ability to make this vision a reality. The aerospace company interviewed for this paper, in fact, is on their second generation. *“The process of planning manufacturing processes, executing them, and capturing operational data is well understood and well embedded,”* he explained, *“But we had quite aging tools so we are refreshing them.”*

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***MPM provides the ability to define and manage a full BOP  
in the context of the product data in PLM.***

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Although this aerospace company is on their second generation, other companies have been slower to adopt an integrated model. Industry standards exist and provide a framework, but few have executed on them in full. Continued growth of the PLM and MES solution suites makes this more realistic than ever. For example, leading PLM solution suites have expanded to include manufacturing process planning capabilities, providing the ability to define and manage a full BOP in the context of the product data in PLM. This approach helps enable the integrated PLM-MES solution to becoming the backbone for all industrial manufacturing data. *“Manufacturing needs data, and this data*

*is created by colleagues in R&D,” says Mr. Feiz of Siemens. “Manufacturing can use this and add their attributes and store them in our data backbone, making it the whole backbone for the product and the factory.” How important is the integration? “Without the integration, data would still need to be passed from PLM to MES,” explains the aerospace executive. “Would we employ an army of people to do it? And put quality at risk to boot? The interface is absolutely critical,” he concludes.*

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***Without the integration, data would still need to be passed from PLM to MES...***

***The interface is absolutely critical.***

*Executive, Leading Aerospace Manufacturer*

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The digital factory helps companies realize the design anywhere – build anywhere strategy. “*Our mission is to implement standard processes and implement the digital factory,”* explains Siemens’ Mr. Feiz. “*With transparency of data and function we could more easily change processes such as moving a production line because we have full transparency of our bill of resources and could simulate everything.*” Integrating PLM and MES is not for everyone, but the leaders are investing in the future. “*People have been talking about this for so long,*” observes the aerospace executive, “*Now, we are actually seeing organizations do it for real.*” The value is available, the tools are ready, and the early leaders are showing the way. “*Our goal is to eliminate the borders between organizations and software,*” Mr. Feiz of Siemens says. “*The digital factory is no longer a vision – it is a reality.*”

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***The digital factory is no longer a vision – it is a reality.***

*Mr. Bagher Feiz-Marzoughi, Head of IT, Siemens Electronics Works Amberg*

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## Recommendations

Based on industry experience and research for this report, Tech-Clarity offers the following recommendations:

- Leverage PLM in order to define and develop innovative products and production processes
- Utilize MES in order to communicate work instructions to the shop floor, control production, and provide product traceability
- Define complementary roles for PLM, MES, and ERP that leverage the respective strengths of each
- Integrate product and production lifecycles to improve time to market and product quality
- Develop an integrated manufacturing information backbone to achieve greater value from MES and PLM
- Close the loop between engineering and manufacturing by capturing and sharing accurate as-built product configurations
- Consider the opportunity to simplify the manufacturing systems environment through pre-integrated PLM-MES offerings
- Take advantage of the ability to turn the digital factory backbone into reality

## About the Author

Jim Brown is the President of Tech-Clarity, an independent research and consulting firm that specializes in analyzing the true business value of software technology and services. Jim has over 20 years of experience in software for the manufacturing industries, with a broad background including roles in industry, management consulting, the software industry, and research. His experience spans enterprise applications including PLM, ERP, quality management, service, manufacturing, and others. Jim is passionate about improving product innovation, product development, and engineering performance through the use of software technology and social computing techniques.

Jim is an experienced researcher, author, and public speaker and enjoys the opportunity to speak at conferences or anywhere that he can engage with people that are passionate about improving business performance through software technology.

Jim can be reached at [jim.brown@tech-clarity.com](mailto:jim.brown@tech-clarity.com), or you can find him on Twitter at [@jim\\_techclarity](https://twitter.com/@jim_techclarity) or read his blog at [www.tech-clarity.com/clarifyonplm](http://www.tech-clarity.com/clarifyonplm).