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Three Perspectives Converge on Smart Manufacturing

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By now, everything should be full steam ahead for smart manufacturing with an appealing goal of reaching higher levels of connectivity, orchestration and optimization in the manufacturing value chain—and enjoying a smorgasbord of available and practical information technology building blocks.

But manufacturers continue to be bombarded with an onslaught of technology terms, as well as different ideas on where to begin and how to proceed. This confusion has slowed adoption of new technology. Yet a big opportunity for a huge increase in efficiency awaits.

Much of the confusion can be explained away by examining the different perspectives that must converge to achieve the goal of smart manufacturing, along with the goals of three other related initiatives: the Industrial Internet of Things (IIoT), the Digital Thread, and the Connected Enterprise.

One must also consider the perspectives of sales management, program management, product engineering, production automation, operations management, facilities management and supply chain management. Together, we can organize these perspectives into three dimensions that converge on smart manufacturing: smart factory, digital thread and value chain management.

The smart factory has an automation focus. This dimension combines concepts from the IIoT and the ISA95 model connecting processes and systems flowing from equipment and resources up to higher levels of process control, analytics, and intelligence. The smart factory dimension includes the following functional blocks laid on top of each other:

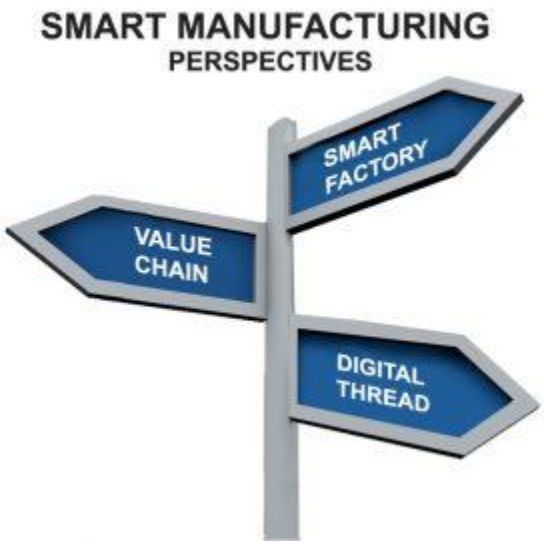
- Smart machines, sensors, tooling and workforce interact with each other via structured communications and integrated systems providing real-time data about their status and the processes they are executing.
- Smart apps, controllers, OT-IT bridges like the manufacturing service bus provide the communication bridge between operations technology (OT) exchanging data directly with machines and tooling, and information technology (IT) systems and

apps where personnel interface to execute supervision, production, inspection, and maintenance tasks at the shop floor.
- Operations management system optimizes the flow of products through production processes and orchestrates the allocation of resources.
- Business intelligence system receives periodic updates of aggregated data for performance analysis and business metrics.

From a smart factory perspective, we are interested in connecting equipment, resources and personnel in order to acquire real-time data through automated methods, analyze it, and leverage that information to (a) provide complete real-time visibility of factory processes, (b) optimize process control and (c) provide insights to where we can further improve performance.

For example, an assembly line with smart manufacturing automated and semi-automated processes may:

- Monitor production flow in real-time to eliminate constraints, dispatch automated material handling, and eliminate wasted idle time.
- Auto-identify parts going down the line to automatically load programs and materials for each different product configuration.
- Automatically aggregate product data, analyze and identify constraints and required adjustments or improvements.
- Manage equipment remotely using sensors to conserve energy, reduce downtime and trigger preventive maintenance.



In the past, organizations depended on custom integration, vendor-proprietary interfaces and separate network protocols for integration and automation at the factory. Moving forward with IIoT, organizations want to embrace open standards and Internet protocols to facilitate an easier swap and mix of multi-vendor equipment and software, which might be on-premise or in the cloud.

The digital thread dimension has an engineering focus embracing concepts from the model-based enterprise. It starts with the engineering design definition of the product and follows the product lifecycle through its sourcing, production and service life ensuring that the digital definition of each product unit is aligned with the physical product. The digital data for each product includes every incorporated revision to the engineering definition and any deviations from the design specifications approved and executed on the product during its lifecycle. The functional blocks in the digital thread dimension include:

- Product design, including definition of 3D models, product configurations and engineering change management practices.
- Processes design for production and verification, including programs and work instructions for automated 3D printing, machining and inspection.
- Production and inspection execution, which includes manual, semi-automated and fully automated tasks, program runs, data collection on actual properties of the product and executed processes, and verification against engineering specifications.
- Product services execution for maintenance of the product during its service life with data collected on product performance, modifications and replacement of components.

Today, there is a lot of manual interpretation, transformation and translation of data between engineering and manufacturing systems. In addition to being inefficient, when each time data is manually converted from one format to another, it introduces a chance for misinterpretation and error.

The digital thread will provide a formal framework for the controlled and automated interplay of authoritative technical and as-built data with the ability to access, integrate, transform and analyze data among disparate systems throughout the product lifecycle. The scope of data includes as-designed requirements, validation and inspection records, as-built records with part genealogy traceability, and as-tested data. The digital thread needs to be able to deliver the digital product data along with the physical product to the end customer.

The value chain management dimension takes a value stream focus and aligns with the goals of lean manufacturing and the connected enterprise initiatives. It focuses on minimizing resources and accessing value at each stakeholder function along the chain, resulting in optimal process integration, decreased inventories, better products, and enhanced customer satisfaction.

Value chain management expands from optimization of the individual plant or production line to the optimization of the entire value chain ecosystem with a renewed focus on including closer customer relations and providing more customer services along with the product. It spans these functional blocks:

- Customer management with online interaction with customers for quicker custom product configurations, order in-process visibility and approvals for changes, deviations or delays.

- Operations management delivering real-time information from production processes to other business management functions and orchestrates activities into the supply chain to make sure that materials, parts, and subassemblies arrive at the right place at the right time.
- Resource management of personnel and equipment required to make the product, provide product services and maintain the equipment up and running with the required capabilities and certifications
- Supplier management with functions from identifying and establishing the supply chain with the right partners to monitoring, synchronizing, and maintaining the required quality levels.

The standardization of IT practices that ERP started decades ago for cash-to-order processes within the organization must be extended across the value chain with an emphasis on open data exchange standards that enable publish/subscribe connections across the internet and cloud services. Configurable, repeatable patterns of orchestrated activities across the value chain will enable highly automated, efficient and agile business processes. Operations management is a common central function in these three perspectives and has the critical role of coordinating the convergence of the digital, physical, and business process dimensions.

While there are some technical and cultural challenges to overcome, it is clear that a network of connected partners, systems and resources will result in the transformation of conventional value chains and the emergence of new manufacturing practices and business models that achieve new levels of orchestration, optimization and customer service.