Digital Manufacturing

"Enabling Lean for More Flexible Manufacturing"

August 2011

A CIMdata Report

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Lean initiatives and flexible manufacturing strategies are required to be competitive in today’s crowded and rapidly changing consumer-driven market. To support the need to be flexible and lean, companies of all sizes are realizing that digital manufacturing solutions can be used to define, simulate, validate, and improve manufacturing processes without the cost and time often associated with physical trial and error. Flexible manufacturing concepts enable companies to design a cell, production line, and even an entire factory, to produce a variety of products by reconfiguring existing equipment. Lean is a system or methodology developed in Japan that seeks to reduce waste in manufacturing processes. Just as product engineering uses CAE technology to simulate product performance in many scenarios or use cases, digital manufacturing enabling technologies can be used to design and simulate the production facility—including its layout, tools, equipment, fixtures, and processes—with lean concepts fully integrated. This paper discusses these issues and illustrates through two case studies how manufacturing companies can benefit from various digital manufacturing enabling solutions today.

1. Introduction

“Lean” is a major initiative in companies from small to large and across virtually all industrial sectors. It is focused on improving business performance through the elimination of waste. While lean is technology-agnostic, technology can enable dramatic improvements in both product and process that help to deliver products that delight the customer and significantly improve the bottom line. Digital manufacturing enabling solutions have matured from their automotive industry roots to where they are a key strategy element for manufacturing organizations across most industries.

This paper will explore some of the theoretical background of lean systems and flexible manufacturing concepts. In addition, this paper shows how digital manufacturing solutions can be leveraged to enhance and enable an organization’s manufacturing goals and objectives.

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1.1 Manufacturing Technologies…a Continuous Evolution

As companies have gone global, competitive pressures have increased dramatically. This pressure is what has forced them to continuously improve—delivering new, innovative, and higher quality products desired by customers faster, while maintaining and improving the bottom line. To

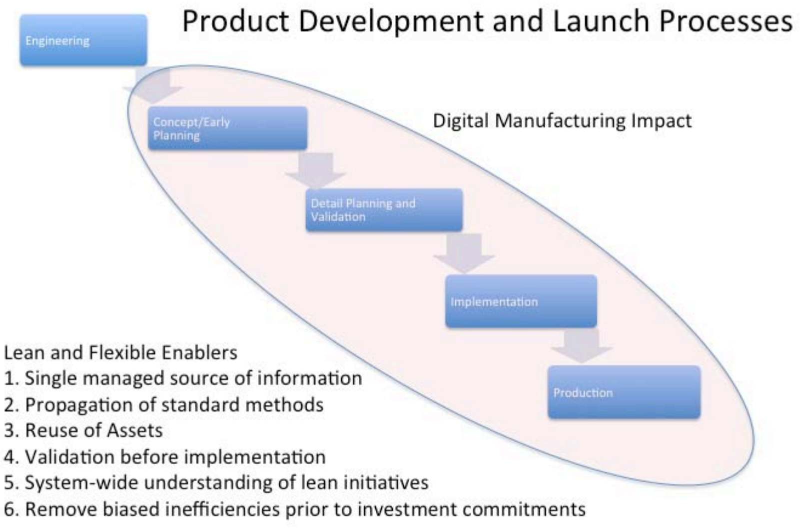

Figure 1—High-Level Benefits of Using Digital Manufacturing Technology

achieve these goals many businesses have focused on a quality-based continuous improvement process known as “lean manufacturing,” or simply, “lean.” Lean came into focus as industries started to recognize the success of Toyota in the 1980s.

In parallel with the quality revolution, product development technologies began their initial evolutionary steps with the introduction of early 2D computer-aided design (CAD) systems in the 1960s, through 3D wireframe and surface modeling in the 1980s, to solid modeling in the 1990s. Product data management (PDM) and product lifecycle management (PLM) first became common in the mid- to late-1990s and continue to evolve, enhance, and expand their capabilities today. Enterprise resource planning (ERP) evolved from material requirements planning (MRP) in the 1960s and manufacturing resource planning (MRPII) in the early 1980s, and continues to evolve today, extending deep into global supply chains. CAD and computer-aided engineering (CAE) and various simulation and analysis (S&A) tools have been used since the 1960s to design products and simulate product and process performance. What began as simple drafting and stress analysis to determine if a component would permanently deform from a load has evolved into complex software that applies many algorithms and mathematical strategies to simulate complex physics related to a product’s use and function in the real world.

1.2 Digital Manufacturing…the Missing Link

While product-engineering groups have been leveraging computer-aided (i.e., digital) technologies for many years, their manufacturing-engineering colleagues have, for the most part, only been using digital manufacturing simulation and other related tools for a rather short period of time—and when used, they have been relegated to a small niche where failure in manufacturing production was not an option. On the other hand, manufacturing organizations have been using ERP to manage customer orders and billing, raw material ordering, and the process of converting raw materials into finished goods for many years. Typically, ERP is text-based and works based on bills of material “thrown over the wall” from engineering. Digital manufacturing software is an umbrella for a group of applications that analyze tolerances, generate tool paths for machining processes, graphically program robots, and define and simulate material handling and flow through work cells and factories. Pioneers in this space include Tecnomatix and DELMIA, now parts of Siemens PLM Software and Dassault Systèmes respectively. The latest implementations of digital manufacturing tools enable closed loop simulation and change impact analysis from product concept through production.

In general, CIMdata defines digital manufacturing as systems that support the definition of processes used to produce a product, including supporting simulation and analysis of those processes, and the manufacturing environments used to produce the product, including production equipment and lines.

2. Defining Flexible Manufacturing

Flexible manufacturing is a strategy for designing production facilities that can adapt to variations in product, manufacturing process, and production volume. It can be thought of as an extension of lean manufacturing, as lean is ultimately focused on delivering—in the most cost effective manner possible—the desired product from the customer’s viewpoint. The reality is that significant resources need to be marshaled to produce even simple components in volume, let alone complex assemblies. Modern products are designed in families to support market segments sliced and diced in many different ways, for example by color, by size, by features and options. To support this, products are often designed to be modular and to reuse existing modules as much as possible. Marketing makes a best guess on product mix, but until sales data arrives, there is uncertainty. So the best companies design their manufacturing processes to be robust enough to handle the uncertainty or risk.

Historically, dedicated production lines with minimal flexibility have been used to produce high volume products. The typical example of this was the classic Detroit automotive assembly line. Dedicated machines and assembly equipment were custom designed to support the production of a particular vehicle. This also paralleled the design process, where a new vehicle was designed from scratch every five to seven years. In Japan, leveraging lean philosophies, new vehicles had a three- to five-year lifecycle. This was accomplished by reusing many components and processes, and only changing what added value to the customer. Honda is famous for being able to build almost any car in almost any of their plants around the world, easily and relatively inexpensively. This enabled shifting production anywhere in the world—bringing production of the right products to where the customers were located. Additionally, if the volume of a car exceeded the capacity of a local factory, it could be produced in another factory with excess capacity and then exported.

The other place where Japanese auto manufacturers have traditionally excelled is in volume ramp-up. Because so much of a design is reused, much of the production equipment is reused. Again, Honda is famous for running two generations on the same production line, validating the new generation while closing out production of the current generation. This technique allows minimal downtime in expensive production facilities, and full production at launch.

Up to the mid-90s, U.S. automotive manufacturing plants were shut down for weeks or months on a model changeover, and the ramp to production volume was spread over many months. Fortunately, the U.S. manufacturers learned much from the competition, and many of the U.S. brands are now produced in flexible factories that rank among the world's best.

The key components of a modern flexible factory are computer numerical control (CNC) machine tools, programmable robots, programmable logic controllers (PLC), and modular material handling equipment. The machine tools, robots, and PLCs are generally commercial off-the-shelf (COTS) technologies controlled by software, and therefore quite flexible. You can almost think of them as Legos®, as they are the building blocks of the modern flexible factory. Updating software allows completely different motions to be defined within a motion envelope, and therefore different products can be manufactured using the same equipment, just programmed a little differently. Changing modular tooling, like cutters, measurement probes, and grippers, extends the variability of a product even further.

2.1 What is Lean?

Lean, also known as "lean manufacturing" or "lean production," is focused on the elimination of waste. The elimination of waste improves quality while reducing cost and shortening production time. While doing more with less has always been a focus of companies, modern lean theory is primarily based on the Toyota Production System developed by Toyota to improve the quality of its

Applied Manufacturing Technologies

Applied Manufacturing Technologies (AMT), located in Orion, Michigan, was founded twenty-two years ago to provide engineering services that help manufacturers, systems integrators, line builders, and robot OEMs deploy robotic-based automation solutions. Their focus is to provide engineering support when companies or systems integrators want to improve the performance of manufacturing processes by using engineering methodologies, and not trial and error.

Projects can range from improving a small single manufacturing cell to designing, engineering, programming, and commissioning a large flexible automation system. While AMT leverages advanced manufacturing simulation technology, one of the big enablers of flexible automation is that robots and automation technology have become more standardized at a lower cost, enabling them be used in more places. As the technology is integrated into larger more complex systems, programming the systems becomes extremely complex as well. Advanced software is required to ensure that they will operate as designed. Michael Jacobs, CEO of ATM, has stated, "First and foremost, our employees are knowledgeable process engineers. While simulation tools are extremely valuable, it is critical that they know how to apply them to achieve results in the real world."

AMT has been using robot simulation software since the company's inception. In the early days, single robots were programmed offline, but significant work still needed to be done to validate the robot programs and simulate the process. Today, software tools like the Tecnomatix suite from Siemens PLM Software are being used for the entire process: discrete events, robot simulation, and programming, as well as for product and tooling simulation. According to AMT, these modern tools make it much easier to build complex models that simulate entire processes.

According to AMT's Automotive General Manager, Andy Jones, "Customer demand for flexible manufacturing has dramatically increased factory complexity and thus the requirement of simulation tools. Manual teaching and robot path planning (i.e., manually positioning the physical robot and capturing program as you go) won't cut it today considering the time required and the importance of knowing the system throughput before the programming and commissioning process begins. Companies have significant capital invested to support flexible manufacturing, so, the costs of downtime or failure associated with poor process planning, have driven manufacturers to use simulation rather than trial and error."

Flexible manufacturing can be very different across industries. At AMT, a typical automotive project supports high volume and is able to be reconfigured to support three to five different parts. In the medical device industry, AMT has developed production lines to support products that are manufactured with unique features for each patient. In these cases, flexible manufacturing may need to support ten thousand variants, and is really an application of mass customization. The digital manufacturing capabilities of Tecnomatix have enabled AMT to demonstrate production operations to their customers and progressively validate the physical equipment prior to it being employed; reducing risk and ensuring a smooth startup.

automobiles. Modern lean theory has two primary schools of thought—tools, and flow focus. Today's digital manufacturing enabling solutions support both theories. Components of lean include:

- *Value stream mapping*—the process of defining how material and information flow within a process. The end result is a flow chart showing steps of the process, and identifies value add and non-value add steps, queues, and work-in-process (WIP) in a visual representation. Value stream maps are used early in a "kaizen" or "continuous improvement" event to understand a process and aid in its redesign.
- *One piece flow (small lots)*—the holy grail of lean production. Top benefits include minimization of space and cost associated with WIP, and improved quality, because defects are caught sooner and before significant WIP builds up.
- *Mistake-proofing—Poka-yoke* is the Japanese term for mistake-proofing. It is a common tool in lean production. A poka-yoke is any method that helps an operator in a factory avoid making a mistake. Common examples include go/no-go gauges to ensure that raw material is the right size for a machining process, or making components that only fit one way so there is no opportunity to assemble a component backwards or upside-down.
- *Pull systems (Kanban)*—this comes from the flow school of thought in lean and the Toyota Production System. Supply and production are based on customer demand. In many ways it can be thought of as the opposite of an inventory system and functions as a real-time scheduling system. The concept is that when production is smooth there is less opportunity for waste. Pull starts from the customer. To satisfy the customer, the customer "pulls" product from the manufacturer. Within the manufacturer, the order pulls from production; within production, components are pulled from production lines or suppliers, on and on.
- *Improvement events (Kaizen)*—the core of lean systems. It is a method of identifying and eliminating waste by observing production, measuring, and testing. Regular, small incremental improvements yield large results over time. Kaizen strengthens teamwork, participation, and consensus.

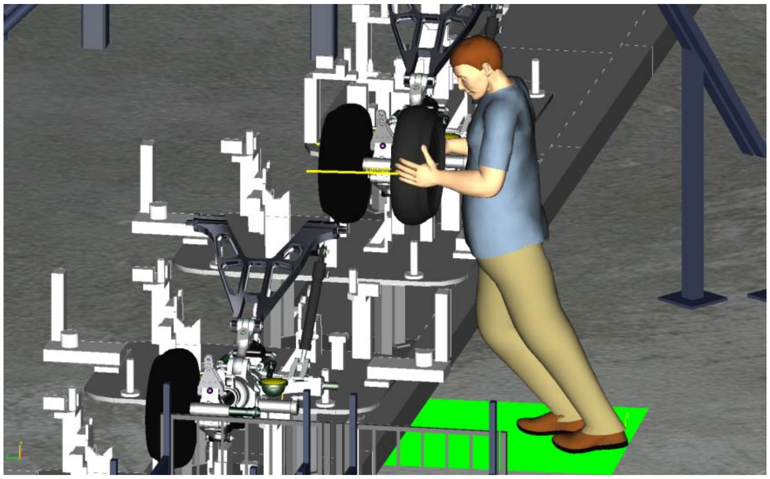

Figure 2—Work Cell Showing Digital Manikin for Manual Operations

3. Using Digital Manufacturing Software as an Enabler

Lean manufacturing, as developed in Japan, is a pragmatic empirical method for eliminating waste to improve business performance. It has been practiced for many years with paper and pencil. Digital manufacturing technologies enable lean practitioners to accomplish bigger improvements faster by leveraging product and process information stored in product- and process-related systems. It also allows companies to reuse and reconfigure equipment in a virtual environment and thereby minimize risk and cost when changing factory configurations.

3.1 Digital Manufacturing Technology

Digital manufacturing technology is a broad category, in many ways much broader than the CAD technology marketplace. In the CAD world the output is basically a 3D geometric model, 2D drawing, and possibly some non-graphic or textural attributes that describe non-geometric properties like color, weight, and part number. Digital manufacturing technology needs to simulate a much broader variety, as it is the link from the virtual world where products and their associated manufacturing processes are defined, to the physical world where products are physically produced. Components can be produced using many different technologies including subtractive machining processes like milling and turning; formed by stamping and forging; molded via compression, injection, or transfer process; built up using additive techniques like composite layups; and even by rapid prototyping. Individual components can be made from a combination of the above techniques (e.g., a cast metal component can be machined and inserted into a plastic molding process), as a result even trying to simulate a component production can be extremely complicated.

Today’s digital manufacturing solutions typically support:

- Data synchronization from design through manufacturing in an enterprise information management environment, including linkage and data integration among CAD, CAM, tool design, ERP, MES, and other software applications.
- A systematic, structured, visual, and analytical approach to part and assembly computer-aided process planning to obtain an optimal process solution. Establishing and cataloging manufacturing constraints, costs, throughputs, and best practices is also performed.
- Detailed line, cell, station, and task design for part manufacturing and assembly process management, including plant design and creation of mechanical assembly-line layouts.
- Discrete event simulation of manufacturing operations and material flows to visualize, validate, and optimize processes, including production line balancing, measurement, and verification of line performance. Simulation and assessment of worker movement, ergonomics, safety, and performance is provided to assure compliance with government and industry standards.
- Maintaining and managing information on manufacturing resources, including software to support commonization and re-use of parts, assemblies, equipment, and processes. The software also provides manufacturing documentation, shop floor instruction, improved visualization, effective communication, and collaboration among workers.
- Programming of robots, welding, painting, coordinate measuring machines, and other factory equipment, as well as creation, testing, optimizing, and managing printed circuit boards and product assemblies. Quality planning, product inspection, control of dimensional variation, and continual assessment of production quality is also provided.

To effectively define, simulate, and optimize manufacturing processes, a range of manufacturing-oriented software tools need to be organized and integrated. PDM applications that provide extensive data and business process management capabilities provide this backbone. The key technology components are described in the following sections.

3.2 Main Digital Manufacturing Components

3.2.1 Computer-Aided Manufacturing

Computer-aided manufacturing (CAM) software actually predates CAD software. The original software was a programming language used to describe the location of a cutter in a machining center. Today, there are two basic categories of CAM solutions—standalone and bundled. Standalone CAM solutions have integrated geometry creation and editing capabilities, and most importantly the ability to create, import, and/or translate geometry that allows them to generate tool paths and other manufacturing information based on geometry from one or more CAD systems. Individuals in small companies or small, independent workgroups in larger organizations typically used standalone solutions. Bundled CAM software directly leverages geometry created by CAD software, and tool paths are associated to the CAD geometry, meaning that a change to CAD geometry will automatically trigger the CAM software that a tool path needs to be updated. In the high-end market (e.g., NX, CATIA, and Pro/ENGINEER), CAM software comes bundled from the same solution supplier as the CAD software; in the mid-range market (e.g., SolidWorks, Solid Edge, and Inventor) bundled CAM software is not common, but third-party software developers are able to leverage the appropriate partner program and APIs to successfully provide integrated CAM capabilities.

3.2.2 Process Definition, Simulation, and Optimization

“Process definition, simulation, and optimization,” from a digital manufacturing perspective, is generally referred to as manufacturing process management (MPM). In general, MPM is a collection of technologies and methods used to define how best to manufacture a given product. MPM is a holistic approach to defining optimized manufacturing processes by using a set of integrated tools often governed by a central information repository (e.g., a PDM system). A best-in-class MPM approach supports the exploration of alternative production line approaches—making assembly lines more efficient with the target of reduced lead time to product launch, shorter production times, and reduced work-in-process (WIP) inventories, as well as allowing rapid response to product or process changes—all key aspects of a lean and flexible manufacturing philosophy.

While aspects of continuous process manufacturing (e.g., petrochemical processes) can be defined, simulated, and optimized, this white paper focuses on the discrete aspects of MPM. In a discrete environment the simulation aspect of MPM is typically thought of as a material balance:

Material In – WIP = Material Out

Simulated processes can consist of automated processes, manual processes, or a mix of the two. The simulation capabilities allow manufacturing engineers to virtually operate the manufacturing processes and the associated equipment hundreds, if not thousands of different ways to find the optimal process given the resources available.

3.2.3 Robot Programming

Robots in an industrial environment primarily consist of "pick-and-place" technology—a mechanical assembly or structure that performs a certain range of motion, and a control system that manages that motion. Pick-and-place can range from basic 2D, e.g., kicking parts off a conveyor belt, through five or more axes and double-digit degree of freedoms to pick up a part like a shaft, and insert it into an oblique angle bore on casting. Grippers are one of the key technologies on robots used in industrial settings. Grippers vary in technology and are key to adapting a COTS pick-and-place system to pick up something as fragile as an egg or a bolt and insert it into an assembly at the correct torque.

The key to modern robots is the software control system. The software is based on real-time operating systems and support feedback from sensors. This feedback allows precise dynamic positioning of the mechanical assembly, while accounting for friction, inertia, and system latencies. More sophisticated robots can accept input from position sensors, touch sensors, digital vision systems, or other sensing technologies that provide process feedback. The most sophisticated controllers can work in an autonomous fashion making decisions based on a broad range of process conditions or variables.

3.2.4 Measurement Integration

Integration of production measurements is key to making digital manufacturing work. The primary use is for production quality control to ensure that the product is accurately manufactured. Automation technology is used to drive measurement equipment like coordinate measuring machines (CMM), and the results are used to accept or reject the product. Perhaps even more importantly, is the capture of measurement data for process feedback in manufacturing and product design. Product engineers can design lower-cost, easier-to-manufacture product when they understand the actual manufacturing process capabilities.

3.2.5 Programmable Logic Controllers

One of the most exciting areas of digital manufacturing is the linking of the virtual world to the physical world. When Siemens AG purchased UGS several years ago; one of the visions was to link "Top Floor to Shop Floor." The UGS suite of software contained CAD, CAM, PDM, and MPM

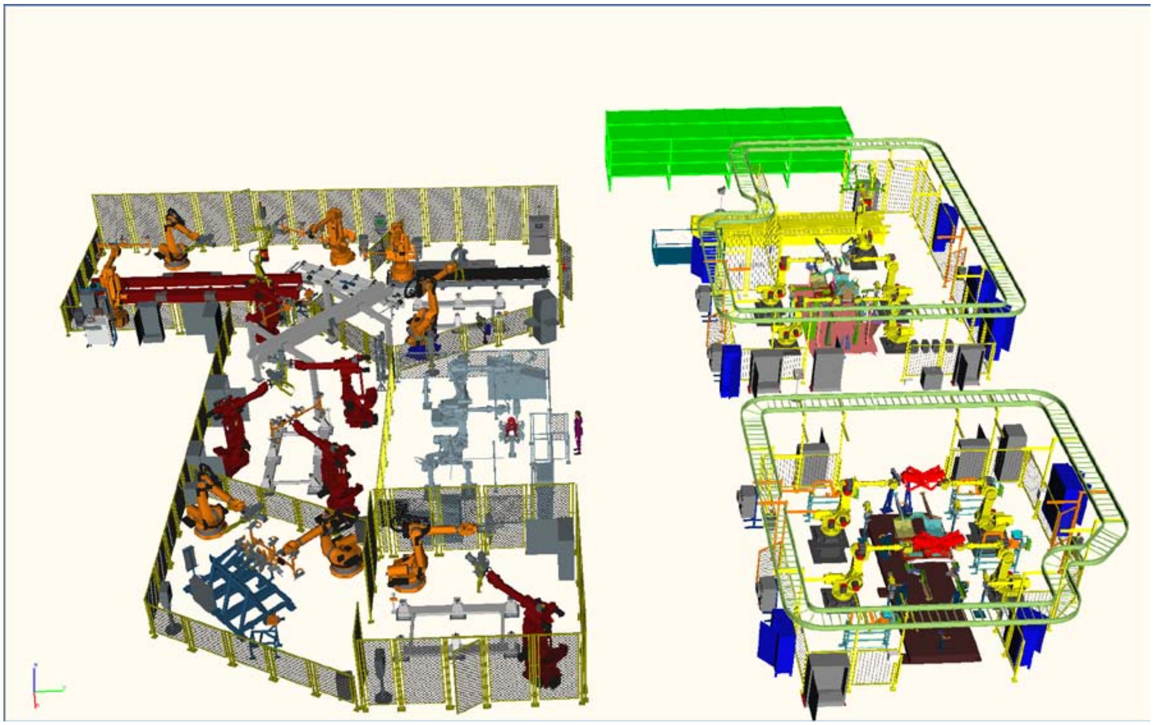

Figure 3—3D Factory Layout Enables Analysis of Change Impact Across Cells

capabilities, and Siemens could see how this could be integrated with their extensive shop floor capabilities to provide closed-loop product and process simulation. The vision is starting to become reality. PLC programs can be developed, validated, and managed within the digital manufacturing environment and downloaded to controllers based on production demand, making for an extremely flexible factory. In addition, production data can be captured from PLCs to track production and equipment statistics for enabling everything from better preventive maintenance programs through improving design processes, as well as updating customer order status.

3.2.6 PLM Enabling Solutions

PLM enabling solutions, with their objective of controlling all information associated with a product, is a key aspect of any digital manufacturing strategy. Enterprise collaborative Product Definition management (cPDm) solutions, like Teamcenter from Siemens PLM Software, are designed to capture, manage, and leverage information across companies and even throughout complex supply chains. Historically, these solutions have focused on product design and the processes to keep that information clear, concise, and valid. Over time these solutions have been extended to capture and integrate the additional information related to tooling, production capabilities and process definitions, quality, and other factors that define the complete product lifecycle. At Siemens PLM Software, the original MPM technology from Tecnomatix has been migrated to utilize Teamcenter as its information repository and backbone. By capturing all digital manufacturing data within the Teamcenter PLM framework, it is now possible to tightly integrate the product definition with production definition and simulation. Furthermore, the two-way integration of shop floor PLCs results in the linking of virtual models to the physical product—an implementation of "virtual commissioning."

Key value points of the data and process management capabilities enabled by Teamcenter and other similar cPDm solutions to digital manufacturing include:

- Single source of truth
- Change- and configuration-management
- Closed-loop feedback

The single source of truth is a PLM concept based on creating a single logical repository for all product-related information. It provides access to product information including requirements, marketing plans, packaging, EBOM, and of course, geometry and drawings. In addition to providing access to product information, PLM also provides a place to store digital manufacturing information and tie it to the product in a holistic bill of information (BOI). Having a complete BOI allows easier searching and change impact analysis—not only can you see what products are affected by a component change, you can also see how the manufacturing process will be impacted.

Change- and configuration-management are core capabilities of almost all comprehensive PLM enabling solutions. They help to ensure that information structures like bills of material—and for manufacturing, bills of process (BOP)—are maintained, and that changes to information are processed consistently, reliably, and quickly. PLM enabling solutions ensure that product information accessed by manufacturing personnel is correct and also provide a common method to control manufacturing information.

Finally, integrating digital manufacturing information with the product information in a PLM environment enables closed-loop feedback to support continuous improvement and lean manufacturing enablement.

3.3 Pulling It All Together

Practical applications of digital manufacturing enabling technologies include factory simulations and in its most advanced form, digital commissioning. The key concept is that it is cheaper, faster, and more accurate to simulate using digital technology than it is to physically prototype or test using trial-and-error methods. Digital manufacturing enabling technologies are the bridge from the virtual to the physical world.

3.3.1 Factory Simulation

While many kaizens (i.e., continuous improvement exercises) have been successfully run on whiteboards and flip charts, and by physically moving work cell equipment during an event, there is a better way to improve a system. By leveraging digital simulations, material flow can be tested in the virtual environment, including with virtual humans doing manual operations. Outputs include animations that can be visually inspected, and calculated data including times, enabling more accurate comparisons. With these capabilities kaizen teams can evaluate more alternatives and do smaller physical tests to validate the simulation, all improving the confidence that the improvement will be successful.

While a kaizen team may be able to optimize a work cell using manual methods, put one, five, or one hundred cells together and no team will be able to optimize a single scenario, let alone incorporate the infinite number of events that happen in a factory every day. Factory simulation software easily scales from the cell level up to an entire production site.

3.3.2 Digital Commissioning

> *"If I had an hour to solve a problem I'd spend fifty-five minutes thinking about the problem and five minutes thinking about solutions. —Albert Einstein*

Einstein's famous quote can be applied to the concept of digital or virtual commissioning of a new production line or facility. Imagine that your CEO has committed to producing a revolutionary new product to solve an unmet market need. The product requirements are defined, but you have to bring a new plant on line in eighteen months, half the time it took the last time. In addition, this product leverages a new proprietary molding technology to make the key component required for its core function. If you miss the market window the company will go bankrupt. Just as product engineering uses CAE technology to simulate product performance in many scenarios or use cases, digital manufacturing enabling technologies can be used to design and simulate the production facility—including its layout, tools, equipment, fixtures, and processes. Because the simulation is math-based (i.e., based on physics and real production data), you can have confidence that the appropriate design tradeoffs are made to minimize waste and optimize flow, and that the target will be met when actual construction of the factory begins. The virtual factory has been digitally commissioned.

4. Summary and Concluding Remarks

According to CIMdata's research and experience, digital manufacturing is developing rapidly in a technological sense, but the market has grown more slowly than expected. According to CIMdata estimates for calendar year 2010, industrial spend associated with digital manufacturing grew to slightly less than a half-billion dollars, and yet

Zollner Electronics AG

Zollner Electronics AG, headquartered in Zandt, Germany, is a family owned company founded in 1975. It began as a manufacturer of inductive components and has grown to become a leading player in the electronic manufacturing services (EMS) industry. As a pure contract manufacturer, Zollner does not develop its own products, but manufactures products for its customers. Supported industries include industrial electronics, automotive, office electronics and data technology, measurement engineering, medical technology, aviation and telecommunications. Manufacturing processes at Zollner include inductive component manufacture, printed circuit board assembly, plastic molding, tool making, cable harness manufacture, metalworking, system integration, and testing. With 2010 sales of approximately 800 million Euros, and locations in Germany, Romania, Hungary, Tunisia, and China, Zollner is able to provide global support to their customers.

Tecnomatix digital manufacturing technology enables Zollner to support both high-volume low-mix (HVLM) and low-volume high-mix (LVHM) processes on a global scale. Product and process information are stored in a central database that can be accessed by any of its factories around the world. According to Roland Heigl, Director of Process Engineering Electronics, this central store of information allows engineers to create proposals faster, parallelize work, and reuse existing proven processes and equipment – but only if the prerequisite to have full control over all processes is fulfilled.

Leveraging Tecnomatix simulations has significantly enhanced the sales process. It is much easier to explain to customers the best practices involved with manufacturing a product using the digital manufacturing technology. The graphic simulations provide visual feedback showing how the product will be manufactured, including manual operations, and help the customer to understand issues including cost and risk. The technology allows the simulations to be created in hours, enabling a fast customer response—and further impressing the customer.

Roland says, "Historically, manufacturing process plans for complex products were developed statically and in isolation. Digital manufacturing has enabled dynamic planning, continuously updated as conditions change, and in the context of the factory. In addition, manufacturing planning is started earlier, and more high-quality feedback can be given to customers on manufacturability."

One of the most recent capabilities deployed at Zollner is to leverage Tecnomatix tools beyond the factory and into logistics management. Roland commented, "The capabilities are used to coordinate material acquisition and receipt at the factory in support of kanban (i.e., pull systems). In addition to just-in-time, the software also supports material sequencing when required."

According to Roland, digital manufacturing technology enabled Zollner to launch 2,500 different products, support 15,000 active products, and process 8,000 customer changes in 2010. He says, "Digital manufacturing software from Tecnomatix is a key technology enabling Zollner to be a global player, and helps to explain why Zollner is the right EMS for their customers."

technology leaders are adopting it across multiple manufacturing industries. The main reason for the adoption of digital manufacturing technology is the same as for the adoption of simulation for product design—it is faster, cheaper, and more accurate to design and simulate in software versus physical trial and error.

Digital manufacturing provides a set of tools that support and complement lean manufacturing concepts and practices. Changes to manual and automated cells and factory material flow can be simulated without having to physically implement them. Digital manufacturing also enables manufacturing flexibility by allowing cells to support more product variations by changing cell control programs or by making minor equipment changes rather than major retooling. While manual methods have been used in kaizens for many years, digital simulations can significantly streamline the process and allow a cell or a full production line to be improved in the context of the entire factory rather than in isolation.

The integration of PLCs allows bidirectional communication with the virtual world. PLCs can be driven directly by the software model so controller feedback, physical latencies, and events are incorporated. This capability is a potential game changer. By allowing the capture of physical plant operations within the virtual environment, a new process can be progressively validated, which is especially important in high-risk situations.

Taken to the extreme, a complete factory can be designed and simulated to optimize operations virtually before the foundation is even poured—from raw material in on one side to the finish groups out on the other. Leading manufacturers and consulting firms like Zollner Electronics and Applied Manufacturing Technologies are leveraging technology from Tecnomatix to do digital commissioning of entire factories. Of course it is not a trivial exercise to model an entire factory, but it is not necessary to model the entire factory to receive benefits. With commitment to the process, cells can be modeled and connected over time, thereby providing value during each step along the way.

While often focusing on eliminating waste on the shop floor, digital manufacturing technology has uses outside the walls of the factory. At Zollner Electronics just-in-time and just-in-sequence manufacturing is coordinated using Tecnomatix software to manage inbound material in support of their kanban process. Zollner Electronics also uses process simulations to improve the sales and customer support processes. Customers find the graphical simulations easier to understand and they can use the information to make better decisions about how their product is manufactured.

Leading manufacturers and consulting firms like Zollner Electronics and Applied Manufacturing Technologies are leveraging technology from Tecnomatix to improve customer communication, optimize production, and even to do digital commissioning of entire factories. All of which enables faster, lower cost, predictable launches that lead to profitable production and customer satisfaction.

5. About CIMdata

CIMdata, a leading independent worldwide firm, provides strategic management consulting to maximize an enterprise’s ability to design and deliver innovative products and services through the application of Product Lifecycle Management (PLM) solutions. Since its founding more than twenty-five years ago, CIMdata has delivered world-class knowledge, expertise, and best-practice methods on PLM solutions. These solutions incorporate both business processes and a wide-ranging set of PLM enabling technologies.

CIMdata works with both industrial organizations and suppliers of technologies and services seeking competitive advantage in the global economy. CIMdata helps industrial organizations establish effective PLM strategies, assists in the identification of requirements and selection of PLM technologies, helps organizations optimize their operational structure and processes to implement solutions, and assists in the deployment of these solutions. For PLM solution suppliers, CIMdata helps define business and market strategies, delivers worldwide market information and analyses, provides education and support for internal sales and marketing teams, as well as overall support at all stages of business and product programs to make them optimally effective in their markets.

In addition to consulting, CIMdata conducts research, provides PLM-focused subscription services, and produces several commercial publications. The company also provides industry education through PLM certification programs, seminars, and conferences worldwide. CIMdata serves clients around the world from offices in North America, Europe, and Asia Pacific.

To learn more about CIMdata’s services, visit our website at www.CIMdata.com or contact CIMdata at: 3909 Research Park Drive, Ann Arbor, MI 48108, USA. Tel: +1 734.668.9922. Fax: +1 734.668.1957; or at Oogststraat 20, 6004 CV Weert, The Netherlands. Tel: +31 (0)495.533.666.