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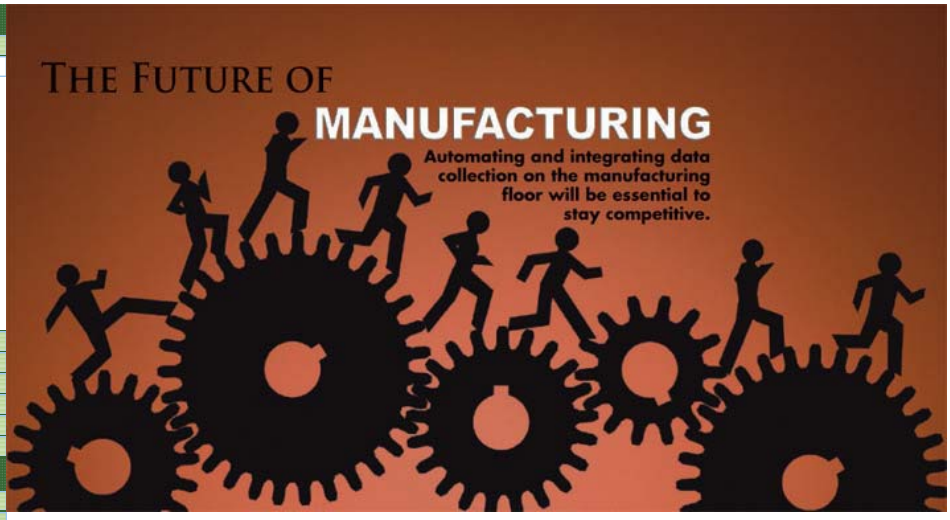

by Joseph A. De Feo and Matt Barney, Ph. D.

Manufacturing has contributed so comprehensively to our quality of life that it's almost impossible to pinpoint where the great leaps forward have occurred. Semiconductor manufacturing, for example, has followed Moore's Law, doubling performance and halving costs every 18 months, and the trend is expected to continue. Biotechnology processes can now manipulate probabilistic yeast and other microorganisms to produce useful pharmaceuticals and vaccines. Nanotechnology promises to revolutionize the way that all goods are made in perhaps as few as 20 to 30 years.

As it has in the past, manufacturing in the future will require companies to produce consistently excellent outcomes for customers and society. Regardless of where they're located, manufacturers will have to manage uncertainty with sophistication. Methods to manage production, quality, cost, cycle time, and safety have been critical in past decades, and they'll continue to be so in the future. Manufacturing will be driven by the marketplace in ways that will test organizations' abilities to produce at high volumes while keeping costs down and supply chains lean.

What are the next great leaps for manufacturing? Here are some scenarios to watch:

• *Volatility in the marketplace, caused by changes in customer demands, will test manufacturers' abilities to respond*. Companies will have to change work practices and keep pace with technology so that they can react quickly enough to remain profitable. Volatility will place continued cost pressure on operations to combat dwindling margins. As a result, successful organizations will have to grow revenue and shrink costs faster than their competitors.

• *Mass-producing "customized" products will become the norm as more consumers demand products that they feel meet their own needs and cultures*. Competition is driving prices down, and consumers, using the internet, have the means to locate the lowest prices. To compete, manufacturers must stay ahead of consumers' needs by increasing product innovation and speeding up time-to-market.

• *The key to survival will be quick response to customers' needs*. Competition has always influenced how a manufacturer operates. Manufacturers that are quick to adapt will grow. Those that are slow will struggle and fail faster than ever before.

• *Product development will have to respond to customer demands for "my product now."* World-class competitors will speed up design cycles and production processes to get new products to market faster.

• *Outsourcing unprofitable products will increase as manufacturers realize the importance of managing unprofitable product lines*. Increasingly, manufacturers will outsource complete products and systems to smaller, more nimble manufacturers.

Responding to challenges

Manufacturing organizations are engineered systems that exist to achieve goals. Manufacturing will continue to transform its inputs into outputs that customers value. Understanding this value-creation flow has prompted automation and sophisticated information systems such as "business process management" workflow software. Major bottlenecks in manufacturing always constrain value creation for customers, regardless if the manufacturing goals address volume, speed, quality, or costs. Often the most serious bottleneck is a change in the customer requirements or disruptive technologies that radically change how the production function creates value.

However, value creation involves a series of bundled assets that perform in reasonably predictable ways across a factory's processes. This fact, particularly as defect prevention takes a more prominent role than it did in the past, will require manufacturers to develop more sophisticated means to manage variability. Sciences such as organizational psychology and

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enterprise risk management can offer critical lessons for manufacturers. Factory complexity can be overwhelming even today. In the future, as the use of automation increases, manufacturers will have to address ever-more complex variables. Leading manufacturers will need a coherent model to help them continually adapt to the marketplace and leverage their existing investments.

Three areas look promising for helping manufacturers. The first is enterprise standardization, the second is the "cue-see" model, and the third is the ability to become leaner and greener.

Standardizing everything

Standardization will embrace common operational sequences, part-dimensional strategies, and guidelines for equipment and tooling. For example, according to a September 2007 article in *Manufacturing Engineering* ("Chrysler Implements: Flexible Manufacturing," by Bruce Morey) the Chrysler Group has retooled its assembly plant in Sterling Heights, Michigan, to build multiple models on one production line. Challenged by an increasingly niche-oriented automotive market, Chrysler must increase the number of models it offers while decreasing its capital investment. The company plans to offer 50-percent more models in 2009 compared to 2004, according to John Felice, Chrysler's vice president of manufacturing, technology, and global enterprise. More important, the automaker recognizes that a market with unpredictable demands requires a rapid manufacturing response.

"Chrysler believes that the key to flexibility lies in standardization," writes Morey. "Intended as a model for all future plant upgrades, the flexible manufacturing system (FMS) relies in part on a standardized bill of processes (BoP) and a standard body-shop design that depends on modern robotics. Since the rollout of Chrysler Group's FMS in 2000, the model has served as a template for its plant modernization. The Sterling Heights, Sterling Stamping, and the Belvidere, Illinois, assembly plants have pioneered this strategy.

"The FMS BoP provides a common manufacturing system for all Chrysler plants that's intended to drive manufacturing quality and efficient product design."

It also will help integrate the product design and production systems. The FMS BoP must be flexible, robust, and aligned. Without the right technology, it won't be possible to adjust to fast-changing markets and "nanosecond customers," a term that the Juran Institute has coined to define the type of customers most consumers have become. These are consumers who want it now, want it simple, want it functional, and want it for less--always.

The cue-see model

Another area of promise is a simple, highly flexible, and powerful approach to characterizing the tolerances of every process at every level.

The cue-see model refers to managers' ability to "see" the "cues" of value creation and focus factory attention on bottlenecks. It focuses on the four variables of quality, cost, quantity, and cycle (QCQC). Cue-see provides leaders with a holistic, multidisciplinary framework for creating process capability. The model identifies the classes of variables required to set goals along with their marketplace-required tolerances, and it incorporates software to track and pinpoint improvement projects. The model is useful for establishing factory goals and communicating to everyone where bottlenecks to further value creation lie.

These are the four QCQC factors:

• *Quality: the degree to which the product delights the customer*. The core processes that produce the products, and the support processes required to execute the core processes, are the specific areas that must be addressed so that customers are ultimately delighted.

• *Cost: the total cost to the customer and the factory* . Cost is critical and must be managed so that the desired profit margin targets can be achieved. Similarly, price points must be attractive enough that sufficient customers will purchase the product in a volume that will meet the business plan.

• *Quantity: the total number of units that must be produced to satisfy customer and marketplace demand*. A wonderful, Six Sigma-quality product at the right price that doesn't supply the full demand of a customer or marketplace fails to deliver full value. Highly adaptable manufacturing is especially valuable in its ability to expand and shrink as the market demand fluctuates.

• *Cycle time: products and services produced in the factory only have value in context--i.e., in a time frame that's useful to the customer*. The perfect product at the perfect price that's too early or too late can have less, or even no, utility.

Beginning with the end in mind, customer delight (quality), price points (cost), and volumes (quantity) alongside the time frame needed to delight the customer (cycle time) frame the critical-to-quality (CTQ) flowdown of all other factory requirements in all processes. As a form of *hoshin kanri*, cue-see uses CTQ flow-down throughout the factory--including process specifications for every machine, engineer, and software program, in both core and support processes. These assets produce multiple interactions that consistently delight customers.

Nevertheless, cue-see can do these things only if managed dynamically, thereby adapting to the marketplace. Advanced software that includes modern business process management and uses methods such as pi calculus can ensure -production-line optimization across all processes. Most important to the entire factory is the cue-see model's ability, in conjunction with automated factory-level dashboards, to see the flow of value, and the respective bottlenecks, at the places where they really count. A factory is like a garden hose with a billion kinks in it, and the challenge for leaders, including quality leaders, is to find and relieve the tightest kink to produce the most flow of value. By embedding the cue-see model into factory production software, the factory leader can include specific targets and tolerances for every process and, ultimately, measure using normal process capability indexes. In this way, all the factory's process performance goals are based on customer delight and shareholder goals, ensuring that the entire factory's talent can understand where improvement efforts will have the best payoff.

These techniques will also automatically cause financial valuations, using real-options methods, to prioritize those actions that will have the best payoffs, given uncertain costs and benefits. Traditional factory financial valuation using net present value will be insufficient in the future, because it can't handle uncertain future values and costs appropriately; however, real options can. In short, the cue-see model helps managers find and resolve the tightest kinks in the factory's flow.

As projects are dynamically identified, valued, and chartered, leaders will be able to use the software's automated data-

collection systems to identify the most consistent bottlenecks, and employees will know that correcting them will provide the highest value. Similarly, business process management software, with participative design and management by process owners, will automatically ensure *poka-yoke* defect prevention and process compliance as processes are reoptimized and fully deployed across the factory.

An important improvement for factories of the future, support services will no longer be questioned for value creation. Cue-see specifies performance requirements for human resources, information systems, finance, and legal, as driven by the requirements of the factory's customers and shareholders. Together with automation software, cue-see will particularly help in areas that are underinvested and shortchanged (e.g., communication and human resources) because it will force established transfer functions for all departments in core and support processes.

Becoming leaner and greener

"Most manufacturers believe that they're operating at 90-percent of efficiency levels, according to traditional methods of measurement using operator collected data," says Hellen Budaya-Pileska at *automationmedia.com* ("Overall Equipment Effectiveness: Key to Manufacturing Quality," by Thomas R. Cutler). "However, when changing to a world-class metric of productivity, such as overall equipment effectiveness (OEE), manufacturers discover that they're operating at much lower efficiency. Exposing the manufacturing teams to the three components of OEE ¾ quality, performance, and availability ¾ they learn to focus on the most critical issues that produce real benefits for the company."

An effective lean pro- gram must be connected to real-time changes in customer demand. New technology is currently available to do this, and it's gaining in popularity.

For an even leaner profile, Toronto-based Sockeye Supply Chain has created a dynamic supply-chain management tool to address a number of enterprise resource planning shortcomings found in other supply-chain management solutions. This application allows for the comanagement of inventory levels by a supplier and the manufacturer to dynamically address any inventory level discrepancies in real time. Sockeye works in multitier, multisystem, multi-enterprise and multilanguage corporate scenarios with a highly flexible architecture, making it a powerful solution for the most complex supply-chain needs. Its inbound collaboration feature set focuses on providing the visibility and decision support to manage the replenishment of parts inventory from suppliers to manufacturers. It uses multiple replenishment methods based on the supplier/buyer relationship.

Lean produces an operational and cultural environment that's highly conducive to waste minimization and pollution prevention. Significant environmental benefits typically ride the coattails of lean initiatives. The powerful economic and competitive drivers behind lean promote a willingness to undertake substantial operational and cultural changes, many of which have important environmental performance implications. Lean typically results in less material use and scrap, reduced water and energy use, and a decrease in the amount of chemicals used.

Lean can also be leveraged to produce even more environmental improvement. Although lean currently produces environmental benefits by using fewer resources to produce a unit of product and establishes a systemic, continual improvement-based waste-elimination culture, lean methods don't explicitly incorporate environmental performance considerations, and thus overlook some environmental improvement opportunities. Lean provides an excellent platform for broadening companies' definition of waste to address environmental risk and product life-cycle considerations, as some lean practitioners have demonstrated.

Some regulatory friction can be encountered when applying lean to environmentally sensitive manufacturing processes such as painting and coating. The right-sized, flexible, and mobile operating approach used in lean manufacturing can be quite challenging in these situations. Some lean practitioners believe that it can even constrain environmental performance improvements or increase the risk of noncompliance.

Environmental agencies have a window of opportunity (i.e., while companies are embarking on lean initiatives and investments) ¾to collaborate with lean promoters to further improve the environmental benefits associated with lean. A growing network of organizations promote lean and, along with organizations promoting environmental improvement and pollution prevention, strive to eliminate waste from business. The Environmental Protection Agency's Green Suppliers Network (*www.greensuppliers.gov*) has been instrumental in promoting this.

It's exciting to look ahead at all the progress that will be made in manufacturing in the future. In particular, automating and integrating data collection to ensure that the entire factory is optimizing value for customers and shareholders will be far more seamless and simplified, and the process will be substantially more powerful. Enterprise standardization, the cue-see model, and becoming leaner and greener are three approaches that will help translate organizational sciences into a pragmatic toolkit for factory managers to take their operations into the future.

About the authors

Joseph A. De Feo, is president of the Juran Institute and co-author of the popular resource Six Sigma Breakthrough and Beyond *(McGraw-Hill Professional, 2003). His most recent co-authored publication is* Quality Planning and Analysis for Enterprise Quality *(McGraw-Hill Science/Engineering/Math, 2005).*

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