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**Lean Manufacturing/
Six Sigma**

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Lean Manufacturing/ Six Sigma

By Mark Marselli
Editor-in-chief

Few company officials would admit that they run anything less than an efficient operation, but for many reasons, especially the human element, more businesses are turning to Lean Manufacturing and Six Sigma to perform better.

The motivation is simple: if your competitors can cut costs or make a product better and/or quicker, your business is not going to last. That challenge has increasingly led companies to solutions such as Lean Manufacturing and Six Sigma. The two programs are not interchangeable although some elements do overlap. But what is striking about them is what they can do, as outlined in this article: bring results. Better yet, they can do so without a transfusion of capital dollars or euros.

This feature presents commentary from two specialists in a Q&A format about these programs as well as comments from two companies that have employed the methodology.

Lean Manufacturing and Six Sigma

The following information is provided by STAT-A-MATRIX/The SAM Group, a worldwide training and consulting firm whose focus is on quality and business process improvement.

Lean manufacturing is based on the Toyota Production System; the term “lean” has been used to characterize the Toyota paradigm. “Lean” describes a method of doing more with fewer people, equipment, space, etc., while continually seeking to eliminate waste (MUDA). Some critical components of a lean system include: just-in-time production based on customer demand, JIDOKA (quality principle of building quality into the process), and top down-bottom up management through

teamwork. The goal is achievement of a perfectly leveled production system based on customer demand (TAKT time), and total elimination of all waste through continual improvement (KAIZEN).

Companies that do not practice lean manufacturing may understand what it is, but may denounce lean as not applicable to their environment. For example, they may think that small lot production would not be practical based on their current forecasting methods, equipment requirements and method of large batch production.

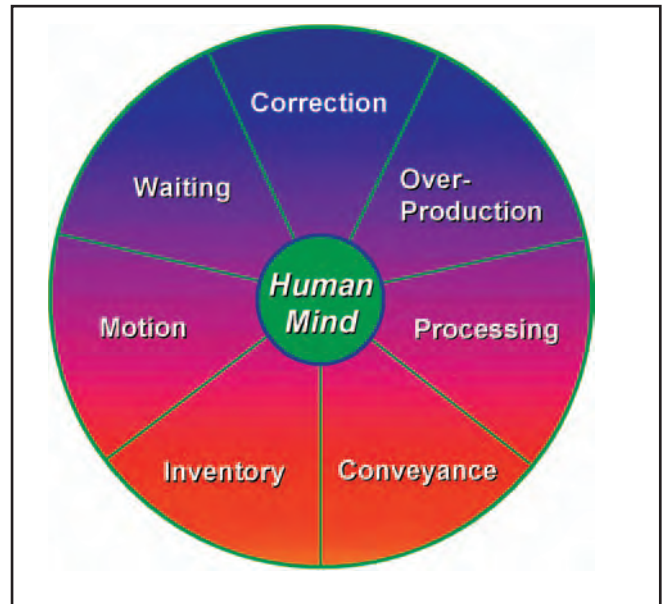
The lean system is based on common sense but involves a structured process frequently described as “value stream management.” Value stream management refers to the application of lean principles to the flow of activities and work that produces value for a customer. The value stream is the network of processes and operations through which material and information flows from initial state to completed product.

Six Sigma is not so much a new concept as it is a repackaging of time-tested concepts and tools—some dating back to 1931. It is an outgrowth of the statistical approach to quality, of methods such as Statistical Quality Assurance and Statistical Process Control, followed later by Total Quality Management (TQM).

Sigma, in statistics, is a measure of standard deviation. Typically, products were specified to meet a particular set of

criteria, plus or minus an allowable tolerance. Products within three-sigma deviation were considered acceptable, which means they would be about 99.7% defect-free. The idea of Six Sigma is to stretch the concept of quality to 99.9999% defect-free—in short, to approach the mythical target of “zero defects” while still retaining a finite credible goal.

To reinforce the concept, Six Sigma added a new measure: DPMO (defects per million opportunities). At three sigma, one would still have a few thousand defects per million opportunities; at six sigma, the number is reduced to 3.6 DPMO.



The Seven Steps of Kaizen (the elimination of waste through continuous improvement). The major focus is elimination of overburden, unevenness and waste. This and other images in this feature provided courtesy of Stat-A-Matrix.

Think of airline safety. Would one accept a few thousand accidents per million takeoffs and landings? (Actually, airline safety operates at an even higher level than six sigma; baggage handling does not.) Even at 99.9% quality (equivalent to a sigma level greater than 4), there would be:

- At least 20,000 wrong drug prescriptions per year.
- Unsafe drinking water almost 1 hour each month.
- No telephone service or television transmission for nearly 10 minutes each week.
- More than 9,000 wrong felony convictions per year.

Lean Manufacturing and Six Sigma: observations

Below is the first of two separate Q&A interviews on Lean Manufacturing/Six Sigma. This one is with Doug Anton, AEM Consulting Group, Inc., who has been training companies in it since the 1980s.

WJI: What is the origin of Lean Manufacturing?

Anton: The contemporary pioneer of the lean manufacturing, Taichi Ohno, first experimented with just-in-time production concepts in the 1940s. The Japanese, however, were not the original inventors of lean. In his book, *Toyota Production System*, Taichi Ohno talks about how in 1945, the war was at an end and the president of Toyota Motor Company said that Japan needed to catch up with America in three years. At the time, Toyota Motor Company had poor cash flow, a limited market share and not a great brand image. To accomplish this immense goal, Taichi Ohno turned to American sources for inspiration. One of them was Henry Ford's book, *"Today and Tomorrow."* It was out of print in this country for years, yet it was a bestseller in Japan. In his day, Henry Ford could build cars more effectively, cheaper and faster than anybody. He was a master of eliminating waste in his factories. The heart of the lean manufacturing approach is the continual elimination of waste.

Ohno also studied contemporary American companies and consumer habits. He found inspiration for his kanban, or "pull system," from the way American shoppers "pulled" products from supermarket shelves, in a take-only-what's-needed, when-it's-needed approach. Ohno spent decades developing and perfecting lean techniques, which are perfectly applicable to any company or process.

WJI: How and when did you first get involved with Lean Manufacturing? How hard was it to sell the concept to potential customers?

Anton: In the 1980s, I was working at GardenAmerica, a Black and Decker company. GardenAmerica, a manufacturer of lawn sprinkler equipment, found that its biggest selling valve was a three-quarter inch anti-siphon valve, a com-

Color this program a Six Sigma success

Luke Maucione, general manager of manufacturing at the Guilford, Connecticut, USA, plant of the Algonquin Industries, is a believer in Six Sigma.

Maucione, a Six Sigma-trained blackbelt who came five years ago to Algonquin, a division of Rea Magnet Wire, said he did not come with lofty expectations one might expect at a GE or ABB. Instead, his goal was to apply the tools of Six Sigma to help the company improve its manufacturing of nonferrous wires.

Six Sigma, in a way, can be counter-intuitive, Maucione explained. If a problem exists, employees may have a "gut feeling" as to what the cause is and focus on that.

That situation happened not too long ago with a wire discoloration problem that would not go away, he recalled. Employees, both hourly and management, had different ideas as to what the source of the problem was, "but it took Six Sigma to solve it," he said. By using Six Sigma data methods, experiments were designed that pinpointed the problem, which ironically turned out to be

a combination of the factors that had been suggested, he said. The individual suggestions were on the right track, but none by itself recognized that the problem stemmed from the combination of the contributing factors, he explained.

"In a way, using Six Sigma is reinventing the wheel, with the benefit being that you can make the wheel again without relying on luck," Maucione stated. For instance, the experiments required the deliberate creation of scrap to find out how to control the process, he said. The challenge for getting employees to think outside traditional ways requires changing the workplace culture, getting employees to turn to data to seek solutions, he said. However, the more

employees see that Six Sigma tools work, the further the process will evolve, he predicted, adding that there have been further success stories to date, most at basically no cost to the company.

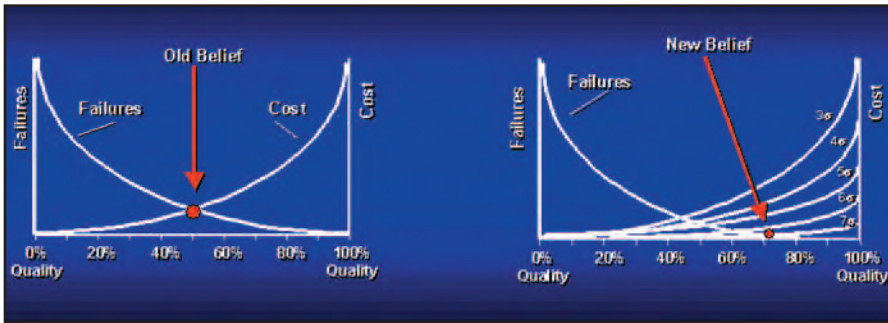
Using Six Sigma tools with lean manufacturing methods creates a powerful toolset for solving problems. For instance, one project teamed both machine operators and engineers in an effort to reduce insulated magnet wire set-up time, Maucione said. "The results reduced set-up time by a third initially and are estimated to cut the set-up time in half upon full implementation." Another project, packaging of stem wire, reduced material han-



Luke Maucione, general manager of manufacturing, Algonquin Industries Division.

dling and resources needed to package stem wire for shipment. "The results allowed us to refocus the equivalent of one full time employee's hours to do direct labor instead of indirect labor tasks within the plant," he noted. A future project, he said, is to optimize up-time of rolling mills and reduce waste in the operation of rolling mills for the electromechanical product line.

"Six Sigma has great tools, and while we don't use the full arsenal, we use the good tools, the ones that make returns for us," Maucione said. The goal, he concluded, is to build upon that beginning, going after the most worthwhile projects now and growing as a company to be ready to take the process to a higher level.



The traditional cost of quality vs. the Six Sigma cost of quality. The old belief was that at a certain point, the cost of further improvement would be prohibitive. Six Sigma seeks to make further goal achievements possible.

mon item likely to be found in most people's backyards. In fact, we made over a million of these valves a year. Before we started our lean manufacturing approach, our production line covered two stories, required 50 or 60 people and had stuff stacked to the ceiling. It took hours to get a completed valve through that line from start to finish. When we restructured and went to a kanban pull line, it took minutes to go from raw material to finished valve, in a box, and off to the warehouse, in a much smaller use of manpower and space. For GardenAmerica, this meant huge savings: the company went from having \$2 million of WIP inventory to \$250,000. That kind of cost efficiency enables companies to stay competitive in the marketplace. So does lean's efficient utilization of space, which typically means double-digit reductions in floor space and storage space.

Previous to this success, I remember all the planners were really hung up on this thing they called "shop floor control." We want to know where everything is through every stage, they'd say. We came along with our JIT project, our cycle times went from hours to minutes, and suddenly it didn't make any difference anymore.

WJI: How has Lean Manufacturing changed over the years?

Anton: Lean Manufacturing started to be applied in the US in the early 1980s. At that time, at GardenAmerica, my focus was on utilizing automation to modernize the company. Automation is a good strategy but lean is a more appropriate overall approach. I learned the basics from people who had worked at Hewlett Packard when it was called JIT, the infamous "Just In Time," or as

many companies applied it as, "you carry my inventory for me and send it just as I need it." Lean continues to morph today into an endless list of new and better techniques. I'm very fond of going to the "horse's mouth" for getting the most accurate story.

Taichi Ohno, who developed it at Toyota, along with Shigeo Shingo and a few others at Toyota Motor Co., are really the ones who figured this all out, and it took them decades to put all the pieces together. What we really see since I first got involved in it in the mid-nineteen eighties, is again, it's been reshaped: it's a new book, it's another view on it, so I think it's morphed away a little bit from what it was first intended to be. Certainly Toyota is one of the best manufacturing companies in the world with the most successful JIT production system there is.

WJI: Do people who do not use Lean Manufacturing have a false sense of what it is?

Anton: It's amazing how few companies are willing to take the leap into lean. Since leaving Black and Decker, I've been consulting for 11 years, and after working with 50 or more small to mid-sized companies in Nevada, California and Arizona, I would say that lean is an under utilized strategy.

For example, I have a longtime client who has a successful \$25 million job shop. I first helped them with their MRP system, then implementation of ISO, and I have begged and pleaded with them to get active on lean. Why? Because they are a good company that could become better. They have WIP everywhere, long lead times and carry a large finished-goods inventory to satisfy customers. But the comment from the

VP of Manufacturing was, "We don't make Toyotas here." Many companies resist grabbing on to the lean manufacturing strategy. Why? Because aside from the "We don't make Toyotas" mindset, a company that implements lean must make fundamental changes in its approach to manufacturing. The idea of not building inventory makes people nervous. So does set-up reduction, a key feature of lean. In non-lean companies, it takes so much time and effort to set up the machine for each type of widget that the company wants the machine to run as much as possible. Another source of resistance is the expectation in our culture that workers should be busy all the time, while lean's philosophy says, "If you don't need any, you don't make any. Turn the machine off and send the person to go do something else." It's 180 degrees different than the traditional batch or push system; lean is about pull, not push.

WJI: Has Lean Manufacturing become easier to implement over the years? What is the learning curve like?

Anton: The time required to transform traditional companies to lean ones varies tremendously across industries, and even across firms in the same industry. There is no one way for a company to implement lean. Some companies train all their employees in lean principles and then phase in full implementation. Other companies bring in lean experts to get quick results. As a consultant with exposure to different companies with different situations, it has become easier to zero in on where waste is occurring in a company and what steps would most quickly eliminate that waste.

WJI: Can you provide a specific example of how it made a difference in one or two areas?

I consulted for a \$25 million wire and cable company with 170 employees. The lead time from their factory was eight weeks. The president engaged my services because he had the highest number of back-orders in company history while at the same time he had more finished-goods inventory than he'd had in 20 years. He quite simply didn't know what to do. By carefully examining what was going on, we chopped lead time down to five days on all prod-

A combined approach proves a success

At General Cable Corporation, the company has become a firm believer in Lean Manufacturing and Six Sigma. It uses skills from both but has morphed the two into what it calls LeanSigma. As with any program, it takes work, but the payback, the company says, has made the efforts well worthwhile.

Lean Manufacturing focuses on reducing or eliminating waste while

normally haven't had the tools, the approaches and the thought processes, to be able to solve a problem the moment it arises so they do not have to call a supervisor who in turn calls an engineer. It brings tools to speed up the resolution of a problem and reduces downtime."

At some level, 95-98 percent of all General Cable plant personnel now know lean tools, Simmons said. For



At General Cable's plant in Altoona, Pennsylvania, (l-r) associates Gregg Mazak, electro-mechanic, and Jim Porter, production manager, explain to Roger Roundhouse, vice president, automotive, and Larry Fast, senior vice president, operations, the Six Sigma-initiated modifications they made to the Artos machines to reduce scrap in the ignition wire manufacturing process. Photo courtesy of General Cable Corporation.

Six Sigma is a set of tools, using data, to be used for improvement.

Employees are trained to two levels, blackbelts (the experts) and greenbelts. LeanSigma is the combined tool set, explained Tedd Simmons, a Six Sigma blackbelt leader for General Cable. In 2003, General Cable reports that it trained 40 LeanSigma Blackbelts and 120 LeanSigma Greenbelts. To date, the value of the savings from the projects required for certification for each Blackbelt has averaged \$150,000 per year. The advantages, however, go beyond the savings, he said.

"Lean Sigma is a philosophical mindset," Simmons observed. "We have not limited the training to professional staff; we've taken this to the hourly workers. It gives operators who

Six Sigma, all plants have at least one blackbelt and three greenbelts. The blackbelts have the most training, but even the greenbelts learn how to use the tools and understand the charts, he said. The results over the last three years have shown the efforts are a success, he declared. The improvements have come by creating or changing to a better method or system, often involving little or no capital expense, he said.

Cases cited included a blackbelt process on cellular manufacturing to reduce variation of finished copper diameters in work cells in one of General Cable's communications cable plants. Team improvements decreased process variation on pairing machines

(continued)

ucts, sometimes down to one day, and on some days even less than that. Now imagine what that does for servicing the customer.

WJI: When did you get involved with Six Sigma and what exactly is it? Is it totally separate from Lean Manufacturing, or is it taking the program up a notch?

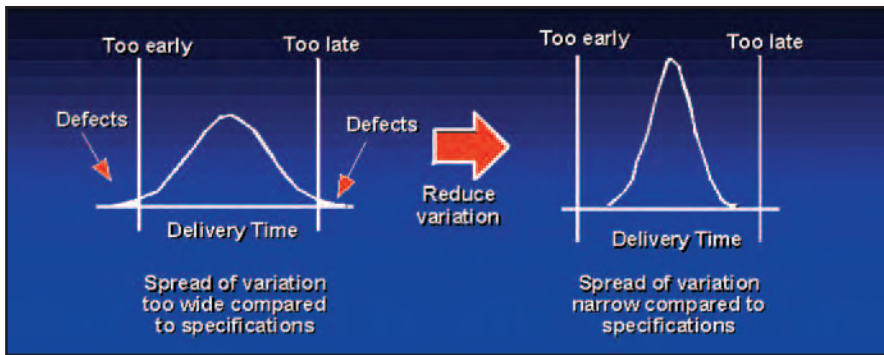
Anton: There's nothing new in Six Sigma: it's another way of problem solving and process improvement. Taking his own unique slant on the process, Mikel Harry, author of *Six Sigma*, has made a lot of money and developed a \$100 million a year consulting business. Companies like GE, DuPont and Caterpillar have gotten a lot of good results from Six Sigma, and I'm sure others have as well. There's nothing wrong with that, we just need to realize what it is: something that was done at Motorola over 20 years ago.

Mikel Harry used statistical tools for manufacturing problems to determine the root causes, develop and implement solutions, and put controls in place to decrease the variability of processes. Addressing problems for process improvement is divided into five distinct steps or phases: define, measure, analyze, improve and control - DMAIC.

Since Six Sigma utilizes probability, statistical measurement techniques and systematic data gathering, it can be a powerful analytical and decision-making tool. We always support companies having different tools in their toolbox from which to choose. Six Sigma is one of those tools.

WJI: What is the difference between Lean Manufacturing and traditional quality programs?

Anton: Lean Manufacturing and traditional quality programs are actually very complementary processes. ISO is from a process perspective, and lean is from a small-lot or continuous production perspective. The goal of lean manufacturing is to eliminate non value-added activities or waste. Examples of waste are: over production, inventory, over processing, defects, scrap and rework, excess motion, transportation, and waiting time. ISO requires companies to look at every process and procedure with one basic goal in mind: to



To increase a process sigma level, a company must decrease variation to provide greater process predictability. This, in turn, should result in less waste and rework and lower costs, which leads to products and services that perform better and last longer.

produce a quality product. The most fundamental goal of ISO is quality, and when companies implement ISO properly, they meet, and exceed, that goal. Quality improvements are a requirement of lean manufacturing.

Lean companies sustain a competitive advantage not only by just keeping their costs down; they're also responsive and adaptable to customer demand. By continuing to focus on shorter cycle times and consistent product and service quality, they increase customer satisfaction and loyalty. The emphasis in successful lean companies is on continuous improvement.

WJI: What advice would you have for a company that is considering this direction?

Anton: Improvement in companies doesn't come from applying strategies. It really comes from analyzing your own situation and figuring out where you need help and what strategies will work with that. So, be conscious as you

start to look at these strategies. You have to fit what is right for you. I don't think companies are different, but each company is certainly unique, and they have to look at what's available and say what is going to work best. Ask, "Where are the priorities in our organization?"

Further thoughts on Lean Manufacturing/Six Sigma

Below is the second of two Q&A interviews on Lean Manufacturing/Six Sigma. This one is with Dr. Stanley Marash, CEO of STAT-A-MATRIX/The SAM Group, and Sheryl Greenberg, consultant.

WJI: What is the essence of Six Sigma, and how does it differ from traditional company efforts to train employees to be efficient at what they do? Can it be effective for any size company or does one need to be a certain size (say, 50 or more employees) to make it practical?

Dr. Marash: Successful companies

recognize the importance of training employees in what they do, making them aware of what customers expect, and having them understand how their tasks impact the quality of the final product. The concepts of quality assurance, TQM, and other modern quality initiatives have become ingrained in many major enterprises, even though the terms themselves are no longer in vogue.

Six Sigma, however, goes beyond traditional quality approaches. It attempts to identify the problems (or challenges) that offer the greatest opportunities for cost savings, cycle time reduction, and product or process improvement and to prioritize them and concentrate on their solutions. To accomplish this, certain executives are identified as "Champions," who are capable of selecting, reviewing, and evaluating projects. Others are selected as "Blackbelts" (project team leaders) and "Greenbelts" (team members). All of them receive appropriate training in problem-solving and statistical skills, and are then assigned to specific teams—blackbelts for longer periods and greenbelts as required.

We have seen Six Sigma applied successfully to different sizes and types of organizations. However, the concepts and tools need to be tailored specifically to an organization's needs. A small service company or job shop manufacturer may not need the more advanced statistical tools or a large number of blackbelts. Some organizations train only greenbelts and occasionally call in a consultant to assist when they need

A combined approach proves a success ... (cont'd.)

by 70 percent, saving nearly \$100,000 the first quarter. Another project, improving distribution frame wire production, led to an innovative dimple bow technology to reduce drag and copper elongation issues. Annual savings were estimated at \$35,000 for one plant, with further savings to come as this is done at other company plants. Another LeanSigma Team that focused on reducing twinner setup errors assembled a team of operators to develop a color-coded gear Kanban system that led to a

work area reorganization. Set-up errors for 100 pair cable were reduced by 76 percent.

"Beyond the financial benefits, this has brought a significant positive shift to the way we do business," said Bill Wilson, General Cable's corporate director of quality and a certified blackbelt. "It has caused our associates to be more proactive in seeking opportunities for improving the process. Also, people think differently and seek to resolve problems rather than simply fixing the symptoms."

The improvements gained through these methods were cited by General Cable for its plant in Altoona, Pennsylvania, USA, being recognized by *Industry Week* in its "Best Plants" awards.

Simmons said that without the tools, "many of the gains realized would not have been experienced. The tools allow for greater focus and precision in identifying improvement opportunities and sets for making the lasting improvement."

more help. But greenbelts can often run small (but vital) improvement projects. The common ingredient is using a formalized structure to identify, analyze, and complete projects that result in both measurable cost savings and enhanced customer satisfaction.

WJI: What aspect(s) tend to be the hardest part of the process for your clients, both in terms of designing/implementation and employee acceptance?

Dr. Marash: The most difficult aspect of Six Sigma—as it was for TQM, Zero Defects, SPC, and all the predecessor methods—is gaining true management commitment, involvement, and support. If management makes clear that it has really bought into the process and is actively participating in project reviews and implementing the results, employees will accept it. If it becomes clear that management is using Six Sigma as a public relations ploy and that blackbelt training is just something that looks good on a resume, employees will do

what they often do—go through the motions, with no real commitment.

WJI: What are the keys to Six Sigma being successful? If a company is going to encounter difficulties with the program, what are the most likely places they could go wrong?

Dr. Marash: Other than management commitment, the other major key is management comprehension—that is, their understanding of Six Sigma and how it fits into the overall business management process. Many companies mistakenly view Six Sigma as “another” program, separate and distinct from regulatory requirements, quality management systems, design controls, and so forth. We stress our philosophy of Fusion Management™, which views all of an organization’s processes as an integrated whole.

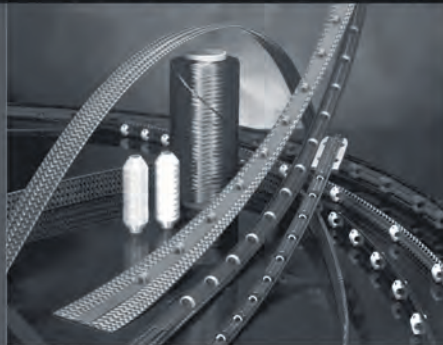
WJI: Traditional quality improvement programs consume many hours and generate many reports. If Six Sigma requires those same basics, where does

The SAM Group’s top 10 ‘musts’ to have for a good Six Sigma program

1. Management commitment
2. Management comprehension
3. Management support
4. Access to knowledgeable coaches for ongoing guidance
5. Communication strategy and plan
6. Open discussions about defects
7. Data analysis
8. Team environment
9. Well-trained Greenbelts and Blackbelts
10. Well-defined projects

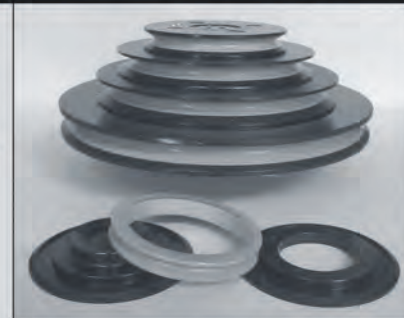
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it return the value? Do most companies that attain this level stick with it?

Dr. Marash: Six Sigma shouldn't be creating new paperwork. It should be part of the normal paperwork system, and if it is successful it should be eliminating unnecessary or redundant paperwork. It provides return on investment by introducing breakthrough changes that provide dramatic cost savings (the average return per project



Dr. Stanley Marash, CEO of STAT-A-MATRIX/The SAM Group.

should be \$175,000–\$200,000) and/or product improvements. Attaining a targeted level and sticking to it is not the goal of Six Sigma. Its purpose is, rather, to always seek new opportunities for improvement.

WJI: If a certain group of employees are trained, can it result in friction from those who do not undergo training?

Dr. Marash: We haven't witnessed employee friction as a significant problem with any of our client companies. Many people are being trained at differ-

ent levels and the technical aspects of the tools utilized by the blackbelts ensure that the best of the best are chosen for blackbelt training and extensive deployment of project and business results. All employees of an organization should undergo basic Six Sigma awareness training to understand what is happening in their organization and how they are a part of the success.

WJI: How hard is it to sell the Lean Manufacturing concept to potential customers?

Sheryl Greenberg: This depends on the individual organization and the leadership of that organization. Greenfield organizations may be more willing to adopt a lean approach than brownfield organizations, simply because there is less to "unlearn" or change. Some industries are more open than others based on availability of benchmark data and known success stories (i.e., automotive). Whether an organization is union or nonunion may also be a factor. It is interesting to note the growing utilization of lean in nonmanufacturing groups (healthcare, transactional, etc.).

WJI: Has Lean Manufacturing become easier to implement over the years? What is the learning curve like?

Sheryl Greenberg: Like any system, implementation requires discipline to sustain. It takes time and training to understand the nuances of the system and to institutionalize the concepts; there is a steep learning curve. It has been our experience that organizations that fully embrace lean with visible leadership commitment and support tend to have an easier time in implementation.

WJI: Please provide a specific example of how Lean Manufacturing made a difference in one or two areas:

Sheryl Greenberg: There are many organizations that could be used as benchmarks for successful lean implementation. The NUMMI plant (New United Motor Manufacturing, Inc., Fremont, CA) and other Toyota North American affiliates such as TMMK (Toyota Motor Manufacturing Kentucky) or TMMC (Toyota Motor Manufacturing Canada) have consistently ranked in the top 10 of the JD Power automotive surveys. These organizations adopted the lean methodology and philosophy and have outperformed their Japanese counterparts on several occasions.

As a general example, implementation of just-in-time as an element of lean manufacturing results in producing only what's needed, in the quantity needed and at just the right time. The effects of minimum inventories result in reduced cost and higher quality. Changing customer requirements can be addressed more quickly and accurately in terms of product type and volume.

WJI: What is the difference between Lean Manufacturing and traditional quality programs?

Sheryl Greenberg: Lean Manufacturing is a system not a program. It is a holistic approach based on the components described above.

WJI: What advice would you have for a company that is considering this direction?

Sheryl Greenberg: Don't wait—commit to lean now. Identify up front the resources and potential barriers, and

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The eight major categories of waste found at every level of an organization.

develop a realistic implementation plan. Involve the union leadership early on (where applicable). Maintain communication with all levels of the organization and clarify roles and responsibilities. Celebrate successes.

WJI: There are many trainers available for Lean Manufacturing/Six Sigma: what

should a company look for/ask about to make sure they choose one that is suited for a manufacturing operation?

Sheryl Greenberg: First, make sure the proposed trainer has manufacturing background and experience as well as training experience (conceptual).

Second, make sure their experience is relevant to your situation. Is it high-tech? Is it in electronics? Plastics? Chemicals? How close is it to what you do? Is it consumer-oriented or business-to-business? Is it in a highly specialized industry, such as aerospace, telecommunications, medical devices, or automotive, with its own quality and regulatory requirements?

Third, and most important, review the resumes of the actual trainers/consultants who will be working with your organization. Do they have the background and experience for your organization, including experience in the application of Lean/Six Sigma concepts?

For Lean Manufacturing, make sure the proposed trainer has a good understanding

of the Toyota Production System and the ability to work with outside groups such as labor unions. ■

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