LEAN SIX SIGMA'S EVOLUT

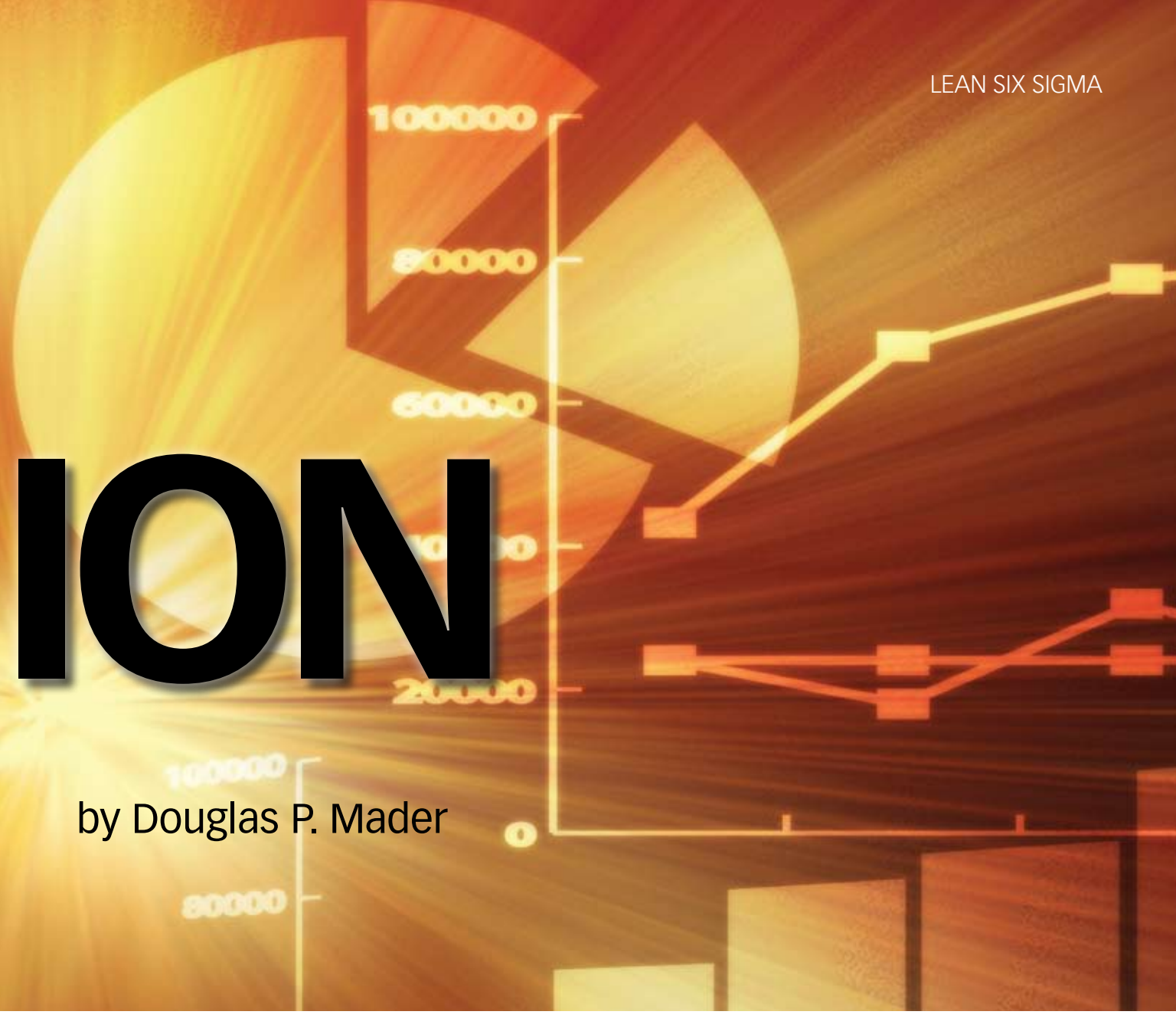
Integrated method uses different deployment models

In 50 Words Or Less

- Six Sigma started as a way to improve an operation's quality but has expanded to become a way to increase financial performance.
- Many organizations have integrated lean with Six Sigma, but deployment models vary widely.
- A body of knowledge for different lean Six Sigma models is recommended.

WHEN MOTOROLA ROLLED out its initial Six Sigma system in 1987, there were no Green Belts (GBs), Black Belts (BBs), Master Black Belts (MBBs), Champions or any of the infrastructure or focused training we have come to associate with modern practices in Six Sigma.

What Motorola did have was strong executive support, a training requirement of 40 hours per year per employee,



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its Six Steps to Six Sigma and, most notably, a large opportunity for improvement, which translated to an exceptional return on investment.

What most people do not remember is that, in addition to its Six Sigma initiative, Motorola had a secondary initiative to reduce cycle time. But, the cycle time reduction effort did not use the lean tools or structure we know today.

During Motorola's first five years of Six Sigma deployment, there was no formal MAIC training, let alone formal lean training. MAIC was the predecessor to today's define, measure, analyze, improve and control (DMAIC) strategy. However, in 1991, Motorola's Six Sigma Research Institute developed and delivered Motorola's very first BB and MBB training using the MAIC model.

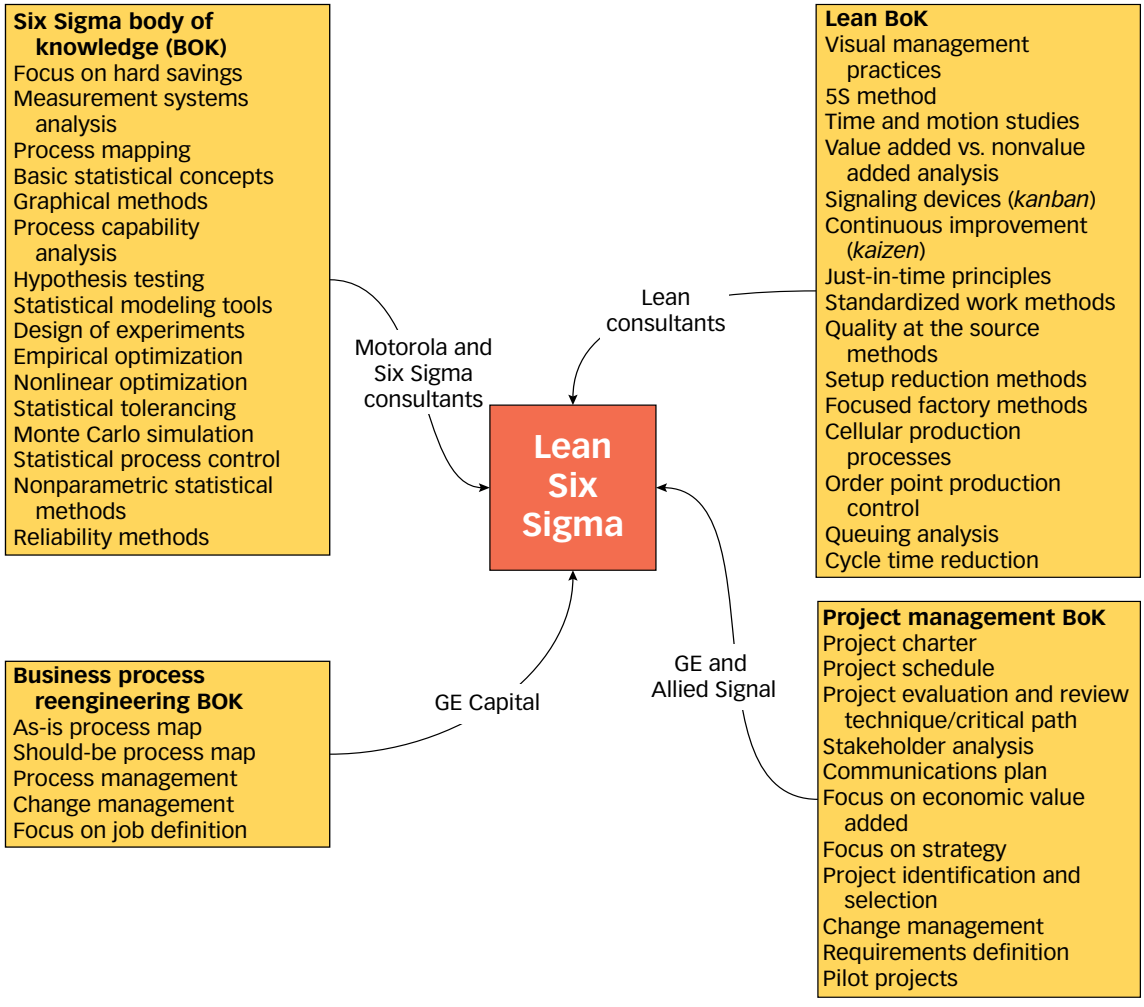
Six Sigma use expanded beyond the Motorola deployment in the mid-1990s via the Six Sigma Academy. Allied Signal and General Electric (GE) were two of the first organizations to deploy Six Sigma with the primary intent of improving financial performance rather than quality. Other large organizations followed, and once they showed significant return on investment with the improved Six Sigma model, the revised method gained widespread acclaim.[1]

Several Six Sigma Academy clients made significant contributions to the Six Sigma method:

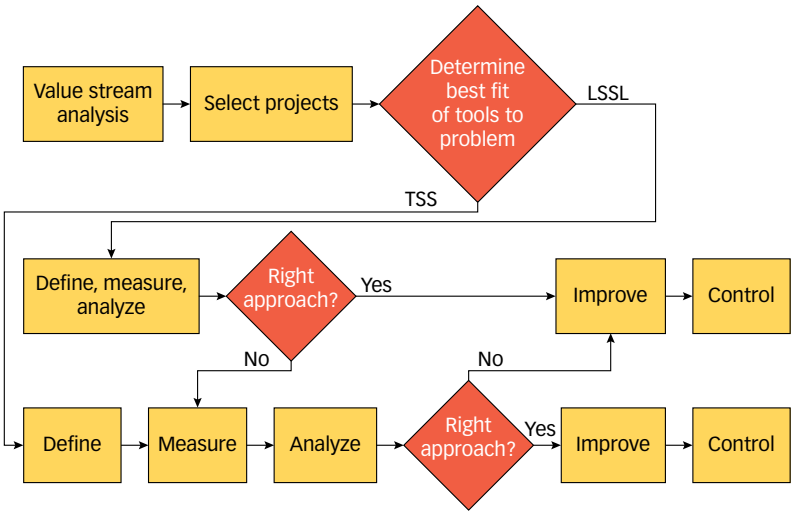
- Allied Signal was the first to implement the Champion infrastructure.
- GE added the define phase to the MAIC methodology.
- GE Capital brought a strong focus to voice of the customer (VOC) methods and integrated DMAIC with the business process reengineering (BPR) model advocated by Rummler-Brache[2] and Michael Hammer.[3]

Several divisions of GE as well as other Six Sigma Academy clients, such as Seagate and Toshiba, intro-

Integrated BoKs / FIGURE 1



LSS+ flowchart / FIGURE 2



duced customized programs intended to integrate Six Sigma tools and methods into new product development, thus giving rise to several similar but distinct design for Six Sigma (DFSS) approaches.[4]

Also in the mid-1980s, the Toyota Production System (TPS) method was gaining popularity among traditional manufacturing companies as they responded to Japanese competition.

Beginning in machining operations and expanding the scope accordingly, Taiichi Ohno, Toyota's chief of production, led the development of TPS at Toyota throughout the 1950s and 1960s. Subsequently, Toyota deployed TPS to its supply base during the 1960s and 1970s.

In the United States, the spread of TPS began in 1984 with the creation of the Toyota-General Motors joint venture called New United Motor Manufacturing Inc. in California. These tools and methods were then adopted by many U.S. and international companies.[5]

The lean tools tended to require less quantitative analysis than Six Sigma tools, and they were mainly applicable to improvement in operations pertaining to constraints in the flow of physical product or work units.

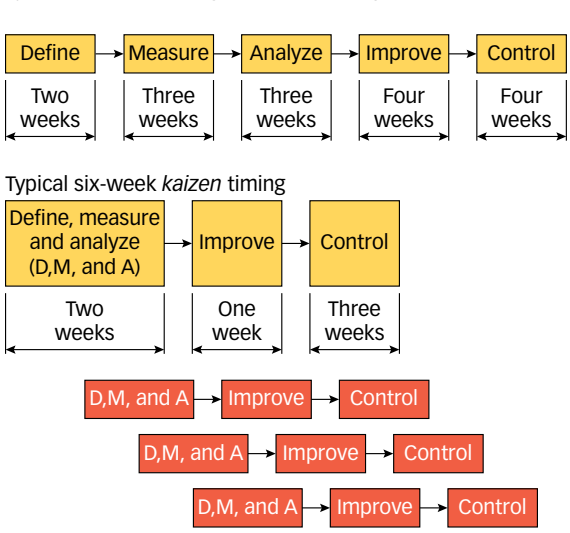
Six Sigma and lean systems tended to be viewed as separate and distinct improvement methods in the mid- to late 1990s. Today, many organizations have begun to integrate Six Sigma and lean along with project management and business process reengineering (see Figure 1).

The integration of the bodies of knowledge (BoKs) shown in Figure 1 has been accomplished using several viable models to be explained later.

The U.S. educational system is one of the reasons the Six Sigma and lean tools have taken so long to become integrated. In most major universities in the 1980s and 1990s, it was typical to have separate departments for statistics and industrial engineering. The result was that two generations of consultants and practitioners probably were trained on one method or the other, but not both.

Today, we see much more integration of the methods as consultants and organizations have developed expertise in both areas, and universities have adapted to how industrial and service organizations allocate resources to improvement.

Comparison of TSS and LSSL timing / FIGURE 3



Current practices

There are currently four major Six Sigma and lean deployment models:

1. Traditional Six Sigma (TSS).
2. Lean Six Sigma plus (LSS+).
3. Lean Six Sigma light (LSSL).
4. Traditional lean (TL).

TSS: The TSS model was introduced to Motorola by its Six Sigma Research Institute in 1991, but it was not widely practiced at Motorola until 1999.

The TSS model was implemented at Allied Signal, GE and other large organizations through the efforts of various consulting firms in the mid-1990s.

Through various refinements by many organizations and consultants, the TSS model has come to be a very effective problem solving strategy for existing processes and products. It effectively integrates the Six Sigma, BPR and project management BOKs. It has also been effectively tailored to financial services, healthcare and other specialized industries and is no longer limited to typical brick and mortar manufacturing companies.

BB projects run under the TSS model are typically scoped to last four months under the assumption that the BB is allocated to the TSS improvement full time.

Recommended lean Six Sigma skill sets / TABLE 1

Phase	Lean Six Sigma core skills	Service		Industrial		TSS	LSS+	LSSL	TL
		BB	GB	BB	GB				
Define	The LSS context	•	♦	•	♦	√	√	√	√
	Strategic planning and critical to quality drilldown	•	♦	•	♦	√	√		
	Basic lean Six Sigma metrics	•	♦	•	♦	√	√	√	√
	Hidden factory	•	♦	•	♦	√	√	√	√
	Financial analysis for lean Six Sigma projects	•	♦	•	♦	√	√	√	
	Identifying and selecting lean Six Sigma projects	•	♦	•	♦	√	√	√	
	Planning lean Six Sigma projects	•	♦	•	♦	√	√	√	
	Executing lean Six Sigma project and the DMAIC method	•	♦	•	♦	√	√	√	
	Change management for LSS practitioners	•	♦	•	♦	√	√		
Measure	Voice of the customer methods	•	♦	•	♦	√	√		
	Standard process mapping	•	♦	•	♦	√	√	√	
	Value stream mapping	•	♦	•	♦		√	√	√
	Qualitative tools for evaluating process	•	♦	•	♦	√	√	√	
	Qualitative tools for selecting process variables	•	♦	•	♦	√	√	√	
	Introduction to Minitab (or other statistical software)	•	♦	•	♦	√	√	√	
	Basic probability and statistics models	•	♦	•	♦	√	√		
	Discrete probability models	•	♦	•	♦	√	√		
	Continuous probability models	•	♦	•	♦	√	√		
	Graphical analysis	•	♦	•	♦	√	√	√	√
	Survey design	•	♦	•	♦		√		
Analyze	Sampling distributions and confidence intervals	•	♦	•	♦	√	√		
	Hypothesis testing	•	♦	•	♦	√	√	√	
	Process capability analysis	•	♦	•	♦	√	√	√	√
	Analysis of variance	•	♦	•	♦	√	√	√	
	Two variable probability models	•	♦	•	♦	√	√		
	Simple linear regression	•	♦	•	♦	√	√	√	
	Multiple linear regression	•	♦	•	♦	√	√	√	
	Sequential regression and best subsets	•		•		√	√		
	Categorical data analysis	•		•		√	√		
	Overview of lean systems	•	♦	•	♦	√	√	√	√
	Visual management and 5S	•	♦	•	♦		√	√	√
	Standard operations	•	♦	•	♦		√	√	√
	One-piece flow	•		•			√	√	√
	Kanban systems	•		•			√	√	√
	Mixed level production			•					√
	Inventory system basics								√
	Setup time reduction methods								√
	Error proofing (*poka-yoke*)	•		•		√	√	√	√

BBs can run more than one project at a time with sufficient support resources. GBs typically pursue projects with a smaller scope and are not allocated full time to TSS activities.

LSS+: Many organizations have found the TSS model effective for the majority of improvement issues (see Figure 2, p. 43). But, there are always certain improvement activities that do not require detailed quantitative analysis or that pertain mainly to the flow of work rather than the quality of work.

For such opportunities, the TSS model would be effective, but many of the tools involved would be deemed unnecessary. Therefore, leading organizations have found that the lean BoK can be effectively taught and integrated into the DMAIC method so BBs, GBs and team members can employ tools that are appropriate to the opportunity. The LSS+ model provides flexibility in problem solving and economy of scale in deployment costs.

Under the LSS+ model, Champions and MBBs determine the type of problem under consideration and then determine the method best suited to the problem in terms of time, cost and quality, as well as the predicted results.

TABLE 1 (CONTINUED)

Phase	Lean Six Sigma core skills	Service		Industrial		TSS	LSS+	LSSL	TL
		BB	GB	BB	GB				
Improve	Design for Six Sigma overview	•	♦	•	♦	√	√		
	Generating and selecting concepts	•	♦	•	♦	√	√		
	2^k full factorial experimentation	•	♦	•	♦	√	√		
	2^(k-p) fractional factorial experimentation			•	♦	√	√		
	Monte Carlo simulation			•	♦	√	√		
	Measurement systems for service applications			•	♦	√	√		
	Empirical optimization			•		√	√		
	Response surface models			•		√	√		
	General nonlinear optimization			•		√	√		
	Measurement systems for industrial applications	•	♦			√	√		
	Survey analysis techniques	•	♦				√		
	Queuing analysis	•	♦				√	√	√
	Lean office	•	♦				√	√	
	Cycle time reduction	•	♦			√	√	√	√
	Forecasting techniques	•	♦				√		
	Discrete event simulation	•					√		
	Strategy maps and scorecarding	•		•			√	√	
	Piloting concepts	•		•		√	√	√	
	Implementing new designs	•		•		√	√	√	
Control	Performance measurement	•		•			√	√	
	Nonparametric statistical methods	•		•		√	√		
	Reliability for industrial and service applications	•		•		√	√		
	Reliability distribution analysis	•		•		√	√		
	Total productive maintenance	•		•					√
	Rational subgrouping	•	♦	•	♦	√	√		
	Variables control charts	•	♦	•	♦	√	√	√	√
	Attributes control charts	•	♦	•	♦	√	√	√	√
	Test plans	•	♦	•	♦	√	√		
	Control plans	•	♦	•	♦	√	√	√	
	Closing projects	•	♦	•	♦	√	√	√	
	Sustaining the gains	•	♦	•	♦	√	√	√	√

If a Six Sigma approach is warranted, a project is launched under the traditional DMAIC model. However, after the analyze phase is completed, the Champion and BB could decide that lean tools might provide a more effective solution.

On the other hand, if a lean approach is warranted, then the duration of the define, measure and analyze phases of the DMAIC process can be shortened. If the lean tools will provide an appropriate solution, the time involved in the improve phase can also be shortened.

The DMA phases typically take between six and eight weeks for a traditional DMAIC project versus two to three weeks for a lean oriented DMAIC project. The improve phase can often be accomplished in five days for a lean DMAIC project, whereas it could run three to five weeks for a TSS project (see Figure 3, p. 43).

The main benefit of the LSS+ model is that an organization can develop the skill sets of its BBs, GBs and team members in all four BoKs. This allows cost-effective training and flexibility in approaching different types of problems that could exist throughout the organization.

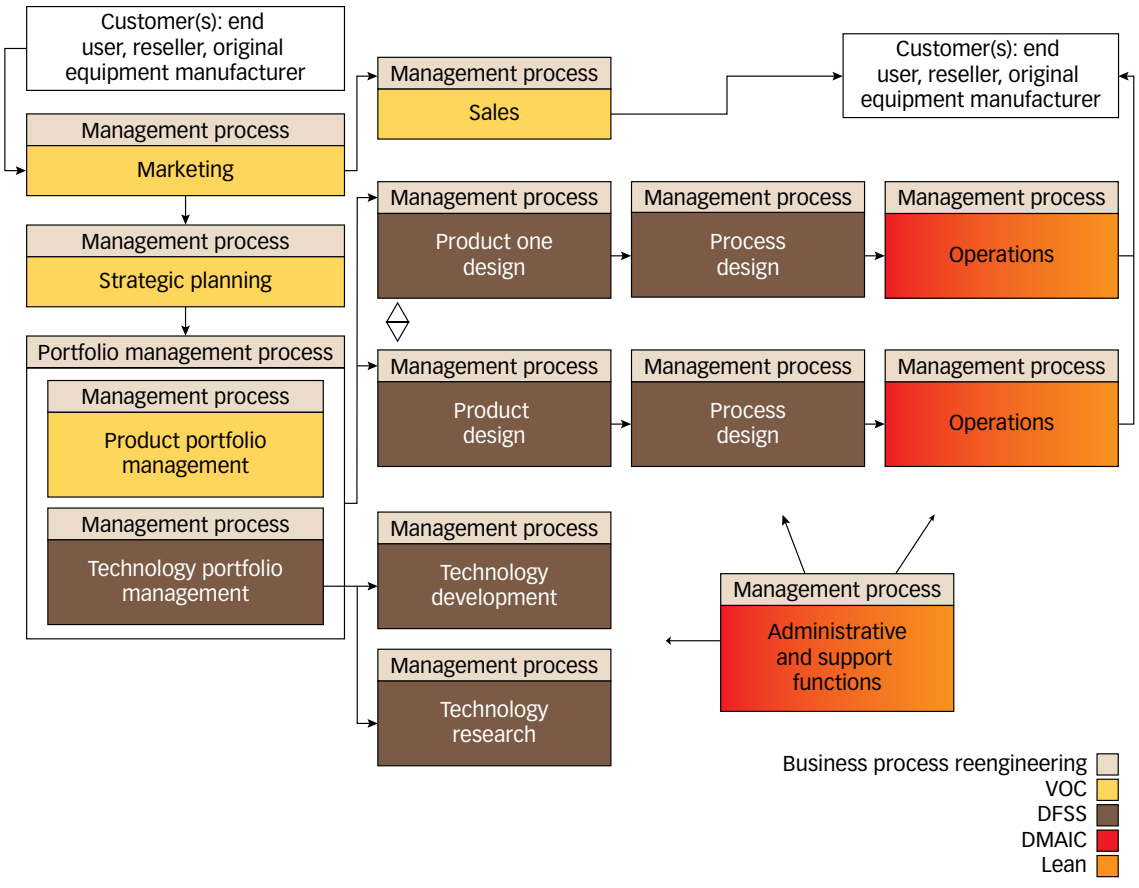
LSSL: This model entails use of the DMAIC structure, a limited set of Six Sigma tools (tending toward the simpler ones) and the mainstream lean tools.

This method can be effective on well-understood problems related to the flow of product or work units though a multistep process. But the number and types of problems that can be solved with the LSSL method are limited to issues pertaining to flow of work or material and to solutions that can be brainstormed without detailed quantitative analysis.

The LSSL method might not be well suited as a general method for solving all problems in operations, but it has a definite benefit when applied to smaller-scope projects under a *kaizen* philosophy.

The main benefit of this approach is that smaller-scale

Business functions and most relevant methods / FIGURE 4



The **lean tools** tended to require less quantitative analysis **than Six Sigma tools.**

improvement activities can be scheduled so a five-day improve phase can be executed in a different work cell each week. This helps to formalize a culture of improvement and instill organizational learning.

The main drawback to this approach is that when we encounter a problem that cannot be readily addressed using the lean and basic Six Sigma tools, the solution tends to be a Band-Aid. We end up putting in place a suboptimal solution that might necessitate further improvement efforts in the future.

TL: As shown in Figure 1 (p. 42), the traditional lean model involves the use of a number of tools that have been adapted from the TPS approach. The TL model has proven quite effective when applied systematically to repetitive processes involving flow of material, transactions or physical product.

The TL model usually involves some basic statistical methods, such as control charting, but the main Six Sigma tools involving data analysis and quantifying root cause are uncommon. This method has proven most effective for operations involving the production, processing or distribution of work or product.

Recommended BoK

There are obviously many opinions about what lean Six Sigma is and how certification criteria should be developed. Even so, there seem to be trends based on how multiple private, governmental and consulting organizations tend to practice lean Six Sigma.

One key thing to remember goes all the way back to the very first DMAIC BB training developed at Motorola's Six Sigma Research Institute in 1991. The thinking then, as it should be now, was that lean Six Sigma training should provide the right tools and skills for the task at hand, and that we do not teach tools simply for their academic value.

The main decision that deployment Champions should make is to choose what mix of skills is best, given the development costs for those skills and the problems that can be solved as a result of the investment.

Some organizations—financial services, healthcare and government services to name a few—could perhaps benefit most from the LSSL model at the GB level if BBs are trained and certified at the LSS+ level. Other organizations—namely manufacturing and design companies, could benefit most from training all BBs and GBs at the LSS+ level.

Furthermore, the need for varied skill sets among lean Six Sigma practitioners might well be different based on line of business. The key is to perform a proper needs analysis prior to making any significant investment in LSS deployment and training.

Table 1 (pp. 44-45) shows the BoK for various certification levels, types of organizations and recommended lean Six Sigma model. Note that the TSS, LSS+ and LSSL models typically involve certification based on demonstrated competence of the tools within the DMAIC structure. The list of tools found in the TL model, however, is based simply on how many companies train their personnel in lean methods, for which no certification is typically granted.

What the future holds

Figure 4 shows the general relationship between the various business functions within a typical organization. If we examine what has taken place since Motorola's initial Six Sigma deployment in 1987, perhaps some future trends will become evident.

A business will conduct market research prior to strategic planning to gain insight into the market conditions and performance of its existing lines of business. Once a strategic plan is conceived, marketing and R&D personnel will formulate a way to meet the strategic objectives in terms of such aspects such as products to be released and revenue to be generated through a process known as portfolio management.

For future product and process dvelopment programs, true research and development will support the technology side of portfolio management, and marketing will determine the business case for each activity.

Do **not teach tools** simply for **their academic value.**

From the portfolio management process, the organization will launch and define new product development programs in which it develops the product, designs the process and begins to produce saleable units.

Most knowledgeable people will admit that when Six Sigma was conceived at Motorola, it was an initiative aimed at improving operations through increased product and process quality. Motorola saw tangential benefits in areas such as cost savings and customer goodwill, but the training that was developed and delivered at Motorola's Six Sigma Research Institute was definitely manufacturing and product oriented.

When Six Sigma was deployed at GE by various consultants, the corporation had the foresight to realize that Six Sigma principles could be pushed further into the value stream. Starting in the late 1990s, several GE divisions developed similar but competing methods for DFSS.

Today, many organizations have developed their own DFSS methods, which have shown tangible benefits in increased effectiveness in product development, including decreased development cost and time, and increased product and process quality.

GE made another contribution to the current practice of lean Six Sigma by integrating the BPR method and adding the define phase to the standard MAIC method being used in the mid-1990s.

If we boil down what has transpired, organizations have simply been tailoring the Six Sigma method and the use of tools to suit different business functions—first operations, then administrative and support functions, and finally development processes.

This leaves two areas of the functional arrangement that typical companies have generally not addressed by quantitative business improvement methods such as lean Six Sigma:

1. The upfront processes related to market research, strategic planning and portfolio management.
2. The supply chain.

Granted, many organizations have run projects in these areas, and some organizations have even pushed lean Six Sigma into the supply chain. However, there do not appear to be structured methods for accomplishing these aims that can be readily adapted across many organizations. These two areas would seem to be good opportunities for further expansion of quantitative improvement in the future.

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