PART I

S^4/IEE DEPLOYMENT AND DEFINE PHASE FROM DMAIC

Part I (Chapters 1 and 2) discusses the meaning and benefits of a *wisely* implementing Six Sigma. Benefits of an S^4/IEE implementation and execution strategy are discussed. S^4/IEE implementation and project execution roadmap is presented.

Also within this part of the book, the DMAIC define steps, which are described in Section A.1 (part 1) of the Appendix, are discussed. A checklist for the completion of the define phase is:

Define Phase Checklist

Description	Questions	Yes/No
Tool/Methodology		
Project Selection Matrix	Does the project clearly map to business strategic goals/customer requirements?	
	Is this the best project to be working on at this time and supported by business leaders?	
COPQ/CODND	Was a rough estimate of COPQ/CODND used to determine potential benefits?	
	Is there agreement on how hard/soft financial benefits will be determined?	
Project Description	Completed a problem statement, which focuses on symptoms not solutions?	
	Completed a gap analysis of what the customer of the process needs versus what the process is delivering?	

Define Phase Checklist (*continued*)

Description	Questions	Yes/No
Project Description (*continued*)	Completed a goal statement with measurable targets?	
	Created an SIPOC which includes the primary customer and key requirements of the process?	
	Completed a drill down from a high-level process map to the focus area for the project?	
	Completed a visual representation of how the project's 30,000-foot-level metrics align with the organizations satellite-level metrics	
Project Charter	Are the roles and goals of the team clear to all members and upper management?	
	Has the team reviewed and accepted the charter?	
	Is the project scoped sufficiently?	
Communication Plan	Is there a communication plan for communicating project status and results to appropriate levels of the organization?	
	Has the project been recorded in an S^4/IEE project database?	
Team		
Resources	Does the team include cross-functional members/process experts?	
	Are all team members motivated and committed to the project?	
	Is the process owner supportive of the project?	
	Has a kickoff team meeting been held?	
Next Phase		
Approval to Proceed	Did the team adequately complete the above steps?	
	What is the detailed plan for the measure phase?	
	Are barriers to success identified and planned for?	

1

SIX SIGMA OVERVIEW AND S^4/IEE IMPLEMENTATION

As business competition gets tougher, there is much pressure on product development, manufacturing, and service organizations to become more productive and efficient. Developers need to create innovative products in less time, even though the products may be very complex. Manufacturing organizations feel growing pressure to improve quality while decreasing costs and increasing production volumes with fewer resources. Service organizations must reduce cycle times and improve customer satisfaction. A Six Sigma approach, if conducted wisely, can directly answer these needs. Organizations need to adopt an S^4/IEE implementation approach that is linked directly to bottom-line benefits and the needs of customers. One might summarize this as:

> *S^4/IEE is a methodology for pursuing continuous improvement in customer satisfaction and profit that goes beyond defect reduction and emphasizes business process improvement in general.*

One should note that the word *quality* does not appear in this definition. This is because the word *quality* often carries excess baggage. For example, often it is difficult to get buy-in throughout an organization when Six Sigma is viewed as a quality program that is run by the quality department. We would like S^4/IEE to be viewed as a methodology that applied to all functions within every organization, even though the *Six Sigma* term orginated as a quality initiative to reduce defects and much discussion around Six Sigma now includes the *quality* word.

The term *sigma* (σ), in the name *Six Sigma,* is a Greek letter used to describe variability, in which a classical measurement unit consideration of the initiative is defects per unit. Sigma quality level offers an indicator of how often defects are likely to occur: a higher sigma quality level indicates a process that is less likely to create defects. A Six Sigma quality level is said to equate to 3.4 defects per million opportunities (DPMO), as described in Section 1.5.

An S^4/IEE business strategy involves the measurement of how well business processes meet their organizational goal and offers strategies to make needed improvements. The application of the techniques to all functions results in a very high level of quality at reduced costs with a reduction in cycle time, resulting in improved profitability and a competitive advantage. Organizations do not necessarily need to use all the measurement units often presented within a Six Sigma. It is most important to choose the best set of measurements for their situation and to focus on the wise integration of statistical and other improvement tools offered by an S^4/IEE implementation.

Six Sigma directly attacks the cost of poor quality (COPQ). Traditionally, the broad costing categories of COPQ are internal failure costs, external failure costs, appraisal costs, and prevention costs (see Figure 1.21). Within Six Sigma, the interpretation for COPQ has a less rigid interpretation and perhaps a broader scope. COPQ within Six Sigma addresses the cost of not performing work correctly the first time or not meeting customer expectations. To keep S^4/IEE from appearing as a quality initiative, I prefer to reference this metric as the cost of doing nothing different (CODND), which has even broader costing implications than COPQ. It needs to be highlighted that within a traditional Six Sigma implementation a defect is defined, which impacts COPQ calculations. Defect definition is not a requirement within an S^4/IEE implementation or CODND calculation. Not requiring a defect for financial calculations has advantages since the non-conformance criteria placed on many transactional processes and metrics such as inventory and cycle times are arbitrary. Within a Six Sigma implementation, we want to avoid arbitrary decisions. In this book I will make this reference as COPQ/CODND.

Quality cost issues can very dramatically affect a business, but very important issues are often hidden from view. Organizations can be missing the largest issues when they focus only on the tip of the iceberg, as shown in Figure 1.1. It is important for organizations to direct their efforts so these hidden issues, which are often more important than the readily visible issues, are uncovered. Wisely applied Six Sigma techniques can help flatten many of the issues that affect overall cost. However, management needs to ask the right questions so that these issues are effectively addressed. For management to have success with Six Sigma they must have a need, vision, and plan.

This book describes the S^4/IEE business strategy: executive ownership and leadership, a support infrastructure, projects with bottom-line results, full-time black belts, part-time green belts, reward/motivation considerations, finance engagement (i.e., to determine the COPQ/CODND and return on investment for projects), and training in all roles, both "hard" and "soft" skills.

1.1 BACKGROUND OF SIX SIGMA

Bill Wiggenhorn, senior Vice President of Motorola, contributed a foreword to the first edition of *Implementing Six Sigma.* The following is a condensed version of his historical perspective about the origination of Six Sigma at Motorola.

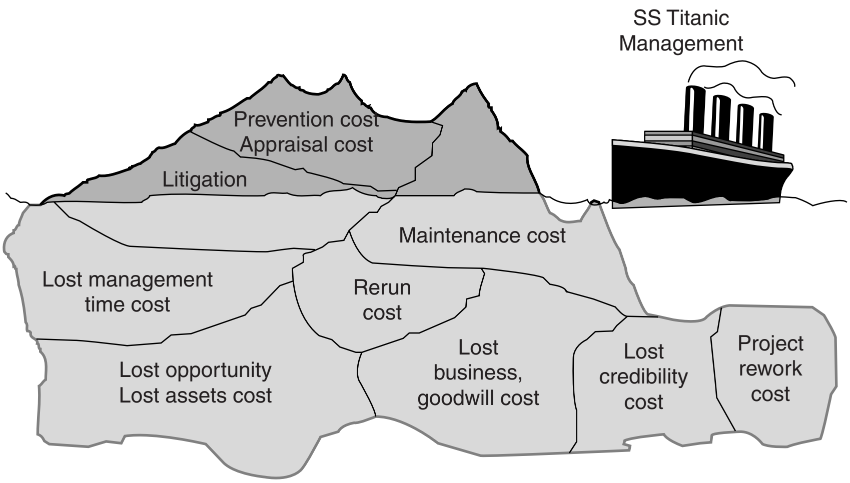


FIGURE 1.1 Cost of poor quality. (Reproduced with permission: Johnson, Allen, "Keeping Bugs Out of Software (Implementing Software Reliability)," ASQ Meeting, Austin, TX, May 14, 1998. Copyright © RAS Group, Inc., 1998.)

> The father of Six Sigma was the late Bill Smith, a senior engineer and scientist. It was Bill who crafted the original statistics and formulas that were the beginning of the Six Sigma culture. He took his idea and passion for it to our CEO at the time, Bob Galvin. Bob urged Bill to go forth and do whatever was needed to make Six Sigma the number one component in Motorola's culture. Not long afterwards, Senior Vice President Jack Germaine was named as quality director and charged with implementing Six Sigma throughout the corporation. So he turned to Motorola University to spread the Six Sigma word throughout the company and around the world. The result was a culture of quality that permeated Motorola and led to a period of unprecedented growth and sales. The crowning achievement was being recognized with the Malcolm Baldrige National Quality Award (1988).

In the mid-1990s, Jack Welsh, the CEO of General Electric (GE), initiated the implementation of Six Sigma in the company so that the quality improvement efforts were aligned to the needs of the business. This approach to implementing Six Sigma involves the use of statistical and nonstatistical tools within a structured environment for the purpose of creating knowledge that leads to higher-quality products in less time than the competition. The selection and execution of project after project that follow a disciplined execution approach led to significant bottom-line benefits to the company. Many other large and small companies have followed GE's stimulus by implementing various versions for Six Sigma (see Six Sigma benchmarking study in Section A.2).

This book describes the traditional methodologies of Six Sigma. However, I will also challenge some of these traditional approaches and expand on other techniques that are typically beyond traditional Six Sigma boundaries. It has been my observation that many Six Sigma implementations have pushed *proj-*

ects (using a lean manufacturing term) into the system. This can lead to projects that do not have value to the overall organization. The described S^4/IEE approach in this book expands upon traditional balanced scorecard techniques so that projects are *pulled* (using another lean term) into the system. This can lead to all levels of management asking for the creation of Six Sigma projects that improve the numbers against which they are measured. This approach can help sustain Six Sigma activities, a problem many companies who have previously implemented Six Sigma are now confronting. In addition, S^4/IEE gives much focus to downplaying a traditional Six Sigma policy that all Six Sigma projects *must have* a defined defect. I have found that this policy can lead to many nonproductive activities, playing games with the numbers, and overall frustration. This practice of not defining a defect makes the S^4/IEE strategy much more conducive to a true integration with general workflow improvement tools that use lean thinking methods.

Various steps have been proposed by organizations when executing Six Sigma. Motorola frequently referenced a 6-step approach to implementing Six Sigma. I have seen several versions to these 6 steps. I referenced a 10-step Motorola approach in *Statistical Methods for Testing Development and Manufacturing* (Breyfogle 1992), which I preferred over their 6-step approach, since this roadmap linked the steps with statistical and nonstatistical application tools.

Most of the chapters in this book focus on using the S^4/IEE project execution roadmap for process improvement/reengineering projects. This roadmap is described in Section A.1. Chapters 48–50 discuss both product DFSS and process DFSS along with applicable roadmaps, which utilize the tools and techniques described in earlier chapters.

The statistical community often comments that most of the Six Sigma statistical procedures that are suggested in these roadmaps are not new. I do not disagree. However, the Six Sigma name has increased the awareness of upper-level management to the value of using statistical concepts, and the structure of the S^4/IEE roadmap provides an efficient linkage of the tools that help novice and experienced practitioners utilize Six Sigma tools effectively.

1.2 GENERAL ELECTRIC'S EXPERIENCES WITH SIX SIGMA

General Electric (GE) CEO Jack Welch describes Six Sigma as "the most challenging and potentially rewarding initiative we have ever undertaken at General Electric" (Lowe 1998). The GE 1997 annual report states that Six Sigma delivered more than $300 million to its operating income. GE listed in their annual report the following to exemplify these Six Sigma benefits (GE 1997):

- “Medical Systems described how Six Sigma designs have produced a ten-fold increase in the life of CT scanner x-ray tubes, increasing the ‘uptime’ of these machines and the profitability and level of patient care given by hospitals and other health care providers.”
- “Superabrasives, our industrial diamond business, described how Six Sigma quadrupled its return on investment and, by improving yields, is giving it a full decade’s worth of capacity despite growing volume—without spending a nickel on plant and equipment capacity.”
- “Our railcar leasing business described a 62% reduction in turnaround time at its repair shops: an enormous productivity gain for our railroad and shipper customers and for a business that’s now two or three times faster than its nearest rival because of Six Sigma improvements. In the next phase across the entire shop network, black belts and green belts, working with their teams, redesigned the overhaul process, resulting in a 50% further reduction in cycle time.”
- “The plastics business, through rigorous Six Sigma process work, added 300 million pounds of new capacity (equivalent to a ‘free plant’), saved $400 million in investment, and will save another $400 million by 2000.”

More recent annual reports from GE describe an increase in monetary benefits from Six Sigma, along with a greater focus on customer issues.

1.3 ADDITIONAL EXPERIENCES WITH SIX SIGMA

A *USA Today* article presented differences of opinions about the value of Six Sigma in “Firms Air for Six Sigma Efficiency” (Jones 1998). One stated opinion was Six Sigma is “malarkey,” while Larry Bossidy, CEO of AlliedSignal, counters: “The fact is, there is more reality with this (Six Sigma) than anything that has come down in a long time in business. The more you get involved with it, the more you’re convinced.” Other quotes from the article include:

- “After four weeks of classes over four months, you’ll emerge a Six Sigma ‘black belt.’ And if you’re an average black belt, proponents say you’ll find ways to save $1 million each year.”
- “Six Sigma is expensive to implement. That’s why it has been a large-company trend. About 30 companies have embraced Six Sigma including Bombardier, ABB (Asea Brown Boveri) and Lockheed Martin.”
- “[N]obody gets promoted to an executive position at GE without Six Sigma training. All white-collar professionals must have started training by January. GE says it will mean $10 billion to $15 billion in increased annual revenue and cost savings by 2000 when Welch retires.”

- ‘‘Raytheon figures it spends 25% of each sales dollar fixing problems when it operates at four sigma, a lower level of efficiency. But if it raises its quality and efficiency to Six Sigma, it would reduce spending on fixes to 1%.’’
- ‘‘It will keep the company (AlliedSignal) from having to build an $85 million plant to fill increasing demand for caprolactam used to make nylon, a total savings of $30–$50 million a year.’’
- ‘‘Lockheed Martin used to spend an average of 200 work-hours trying to get a part that covers the landing gear to fit. For years employees had brainstorming sessions, which resulted in seemingly logical solutions. None worked. The statistical discipline of Six Sigma discovered a part that deviated by one-thousandth of an inch. Now corrected, the company saves $14,000 a jet.’’
- ‘‘Lockheed Martin took a stab at Six Sigma in the early 1990s, but the attempt so foundered that it now calls its trainees ‘program managers,’ instead of black belts to prevent in-house jokes of skepticism. . . . Six Sigma is a success this time around. The company has saved $64 million with its first 40 projects.’’
- ‘‘John Akers promised to turn IBM around with Six Sigma, but the attempt was quickly abandoned when Akers was ousted as CEO in 1993.’’
- ‘‘Marketing will always use the number that makes the company look best. . . . Promises are made to potential customers around capability statistics that are not anchored in reality.’’
- ‘‘Because managers’ bonuses are tied to Six Sigma savings, it causes them to fabricate results and savings turn out to be phantom.’’
- ‘‘Six Sigma will eventually go the way of other fads, but probably not until Welch and Bossidy retire.’’
- ‘‘History will prove those like [Brown] wrong, says Bossidy, who has been skeptical of other management fads. Six Sigma is not more fluff. At the end of the day, something has to happen.’’

Example projects with the expected annual return on investment (ROI) if a full-time black belt were to complete three projects per year:

Projects	Benefits
Standardization of hip and knee joint replacements in hospital	$1,463,700
Reduction of job change down time	$900,000
Reduction of forge cracks	$635,046
Computer storage component test and integration	$1,000,000
Reducing post class survey defects regarding instructor expertise	$462,400

Projects	Benefits
Reducing the manufacturing/brazing costs of tail cone assembly	$194,000
Reducing defects ppm to cell phone manufacturer	$408,000
Reducing power button fallout	$213,000
Thermal insulator pad improvement	$207,400
Wave solder process improvements	$148,148
Reduction of specific consumption of fuel gas in the cracking furnaces	$1,787,000
Decreased disposal cost of the dirty solvent	$330,588
Analyzing help desk ticket volume	$384,906
Laser test time cycle reduction	$500,000
Reduction of fuel gas consumption through efficiency improvement into furnaces	$195,000
Increase productivity by reducing cycle time of paint batches	$119,000
Inside sales quote turnaround project	$43,769
Interactive voice recognition service (IVRS) program development, cycle	$1,241,600
Improve delivery credibility/reduce past due orders	$1,040,000
Reduction of nonuse material in end bar	$221,000
Wash water generation reduction at manufacturing facility	$83,690
Reduction in loss on the transportation of propane to the chemical plant	$606,800
Reduce fuel oil consumed by using natural gas in utility unit's boilers	$353,000
Electricity consumption reduction at aromatics unit	$265,000
Local contract renewal project and product profitability	$1,400,000
Average project value	$568,122
Number of projects per year	3
Annual investment	$200,000
ROI	900%

I believe that Six Sigma implementation can be the best thing that ever happened to a company. Or a company can find Six Sigma to be a dismal failure. It all depends on implementation. The S^4/IEE roadmap within this text can lead an organization away from a Six Sigma strategy built around playing games with the numbers to a strategy that yields long-lasting process improvements with significant bottom-line results.

1.4 WHAT IS SIX SIGMA AND S^4/IEE?

Every day we encounter devices that have an input and output. For example, the simple movement of a light switch causes a light to turn on. An input to this process is the movement of the switch, internally within the switch a process is executed where internal electrical connections are made, and the output is a light turning on. This is just one example of an input-process-out (IPO), which is illustrated in Figure 1.2.

As a user of a light switch, toaster, or a radio, we are not typically interested in the details of how the process is executed, i.e., the mechanics of the light switch, toaster, or radio. We typically view these processes like a black box. However, there are other processes that we are more involved with—for example, the process we use when preparing for and traveling to work or school. For this process, there can be multiple outputs, such as arrival time to work/school, whether we experienced an automobile accident or other problems, and perhaps whether your kids or spouse also arrived to school on time. The important outputs to processes can be called key process output variables (KPOVs), critical to quality (CTQ) characteristics, or *Y*s.

For both a black box process and other processes we can track output over time to examine the performance of the system. For our go-to-work/school process, consider that we daily quantified the difference between our arrival time and our planned arrival time and then tracked this metric over time. For this measure we might see much variability in the output of our process. We might then wish to examine why there is so much variability by either consciously or unconsciously trying to identify the inputs to the process that can affect the process output. For reducing the variability of commuting time, we might list inputs to our process as departure time from home, time we got out of bed, traffic congestion during the commute, and whether someone had an accident along our route to work/school.

Inputs to processes can take the form of *inherent process inputs* (e.g., raw material), *controlled variables* (e.g., process temperature), and *uncontrolled*

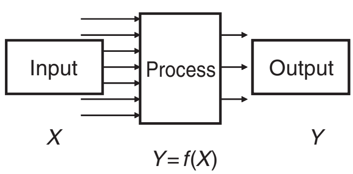


FIGURE 1.2 Input-process-output (IPO).

noise variables (e.g., raw material lots). For our go-to-work/school process a controllable input variable might be setting the alarm clock, while an uncontrollable input variable might be whether someone had an accident on our route that affected our travel time. By examining our arrival times as a function of the time departing home, we might find that if we left the house 5 minutes earlier we could reduce our commute time by 25 minutes. For this situation, departure time is a key process input variable (KPIV) that is an important *X*, which affects our arrival time. When this KPIV is controlled in our go-to-work/school process, we can reduce the amount of variability in our arrival time at work/school (KPOV).

Another tactic to reduce the variability of our arrival time is to change our process so that we can reduce the commute time or make our process robust to uncontrollable/noise input variables. For example, we might change our travel route to work or school such that our travel time is reduced during the high-traffic hours of the day. This change could also reduce the likelihood of lengthy delays from accidents; i.e., we made our process robust to the occurrence of accidents, which was a noise input variable.

Similarly, within business and other organizations we have processes or systems. For the go-to-work/school process the identification of inputs and potential process changes that would positively impact our process output is not too difficult. Easy fixes can also occur within business processes when we view our process systematically through a Six Sigma or S^4/IEE strategy. However, the identification and improvement systems for some business process can be more involved. For these more complex situations within S^4/IEE, I view this search for KPIVs and process improvement strategies as a murder mystery where we use a structured S^4/IEE approach for the uncovering of clues that leads us to how we can improve our process outputs.

Let us now consider the following example KPOVs (*Y*s) that a company could experience along with one, of perhaps many, KPIV (*X*s) for each of these processes:

	*Y*s or KPOVs	*X*s or KPIVs
1	Profits	Actions taken to improve profits
2	Customer satisfaction	Out of stock items
3	Strategic goal	Actions taken to achieve goal
4	Expense	Amount of WIP
5	Production cycle time	Amount of internal rework
6	Defect rate	Inspection procedures
7	Critical dimension on a part	Process temperature

These *Y*s are at various levels within an organization's overall system of doing business. Within S^4/IEE, a cascading measurement system can be created, which aligns metrics to the overall needs of the organization. The tracking of these measurements over time can then pull (using a lean term) for the creation of S^4/IEE projects, which addresses common cause variability improvement needs for the process output. Through this pragmatic approach, where no games are played with the numbers, organizations have a systematic way to improve both customer satisfaction and their bottom line. S4/IEE is much more than a quality initiative; it is a way of doing business.

I will be using the term 30,000-foot-level metric (see Sections 1.8 and 10.3) to describe a Six Sigma KPOV, CTQ, or *Y* variable response that is used in S4/IEE to describe a high-level project or operation metric that has infrequent subgrouping/sampling such that short-term variations, which might be cause by KPIVs, will result in charts that view these perturbations as common cause issues. A 30,000-foot-level *XmR* chart can reduce the amount of firefighting in an organization when used to report operational metrics.

1.5 THE SIX SIGMA METRIC

The concepts described in this section will be covered in greater depth later in this book (see Chapter 9). This section will give readers who have some familiarity with the normal distribution a quick understanding of the source for the Six Sigma metric. Section 1.19 describes some shortcomings and alternatives to this metric.

First, let us consider the level of quality that is needed. The "goodness level" of 99% equates to

- 20,000 lost articles of mail per hour
- Unsafe drinking water almost 15 minutes per day
- 5,000 incorrect surgical operations per week
- Short or long landing at most major airports each day
- 200,000 wrong drug prescriptions each year
- No electricity for almost 7 hours per month (Harry 1987)

I think that most of us agree that this level of "goodness" is not close to being satisfactory. An S4/IEE business strategy, among other things, can offer a measurement for "goodness" across various products, processes, and services.

The sigma level (i.e., sigma quality level) sometimes used as a measurement within a Six Sigma program includes a $\pm 1.5\sigma$ value to account for "typical" shifts and drifts of the mean. This sigma quality level relationship is not linear. In other words, a percentage unit improvement in parts-per-million (ppm) defect rate does not equate to the same percentage improvement in the sigma quality level.

Figure 1.3 shows the sigma quality level associated with various services (considering the 1.5σ shift of the mean). From this figure we note that the sigma quality level of most services is about four sigma, while world class is considered six. A goal of S4/IEE implementation is continually to improve processes and become world class.

Figures 1.4 to 1.6 illustrate various aspects of a normal distribution as it applies to Six Sigma program measures and the implication of the 1.5σ shift.

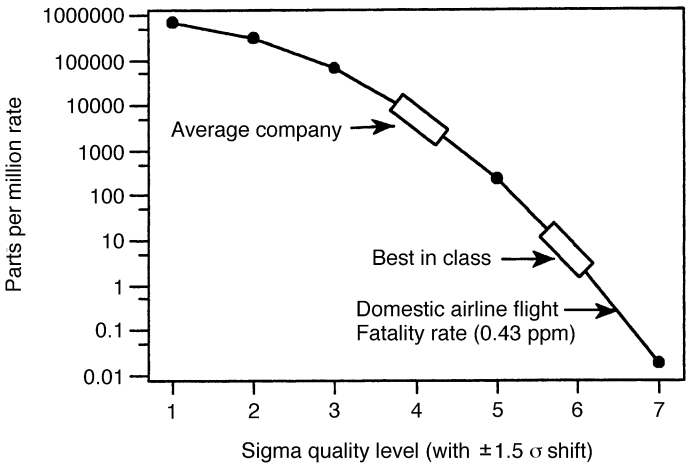


FIGURE 1.3 Implication of the sigma quality level. Parts per million (ppm) rate for part or process step.

Figure 1.4 illustrates the basic measurement concept of Six Sigma according to which parts are to be manufactured consistently and well within their specification range. Figure 1.5 shows the number of parts per million that would be outside the specification limits if the data were centered within these limits and had various standard deviations. Figure 1.6 extends Figure 1.4 to noncentral data relative to specification limits, in which the mean of the data is shifted by 1.5σ. Figure 1.7 shows the relationship of ppm defect rates versus sigma quality level for a centered and 1.5σ shifted process, along with a

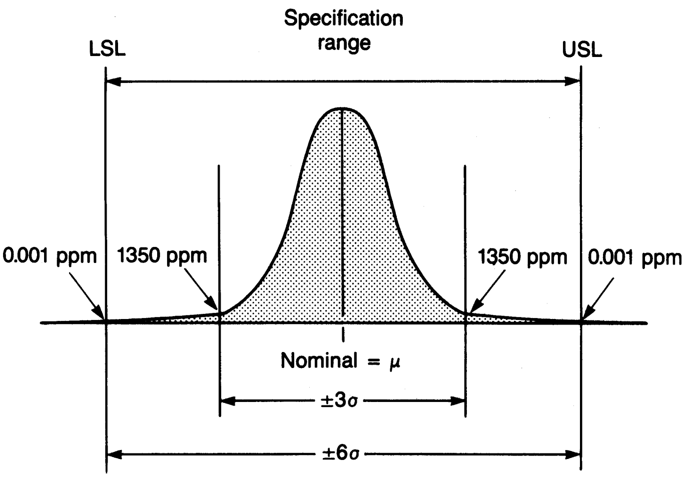
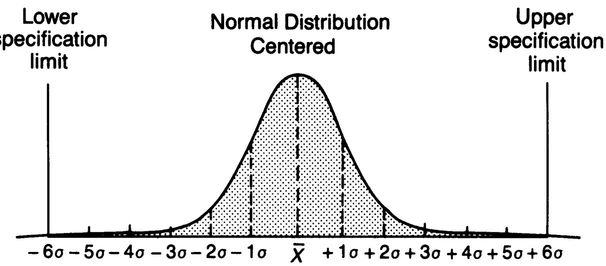
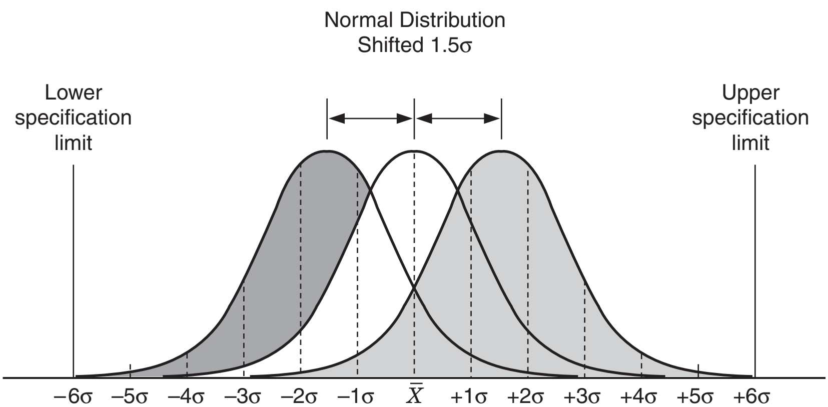


FIGURE 1.4 Normal distribution curve illustrates the Three Sigma and Six Sigma parametric conformance. (Copyright of Motorola, Inc., used with permission.)



Spec. limit	Percent	Defective ppm
±1 sigma	68.27	317300
±2 sigma	95.45	45500
±3 sigma	99.73	2700
±4 sigma	99.9937	63
±5 sigma	99.999943	0.57
±6 sigma	99.9999998	.002

FIGURE 1.5 With a centered normal distribution between Six Sigma limits, only two devices per billion fail to meet the specification target. (Copyright of Motorola, Inc., used with permission.)



Spec. limit	Percent	Defective ppm
±1 σ	30.23	697700
±2 σ	69.13	308700
±3 σ	93.32	66810
±4 σ	99.3790	6210
±5 σ	99.97670	233
±6 σ	99.999660	3.4

FIGURE 1.6 Effects of a 1.5σ shift where only 3.4 ppm fail to meet specifications. (Copyright of Motorola, Inc., used with permission.)

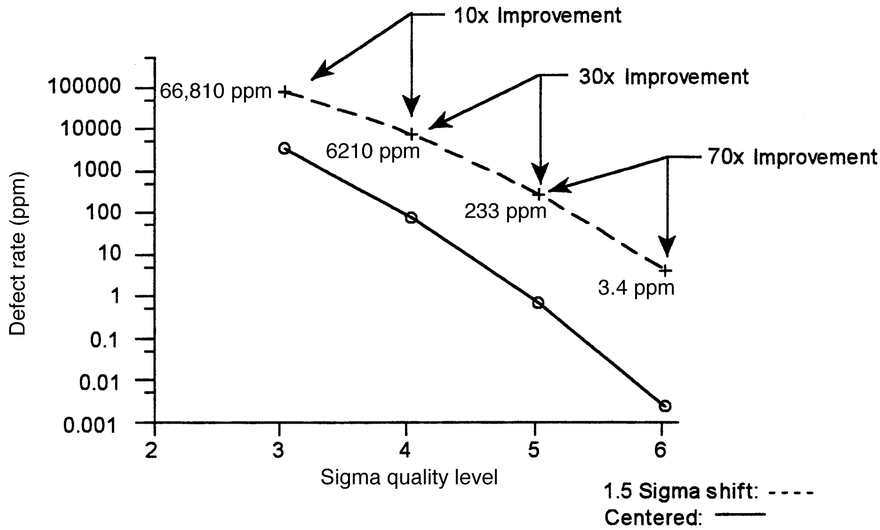


FIGURE 1.7 Defect rates (ppm) versus sigma quality level.

quantification for the amount of improvement needed to change a sigma quality level.

A metric that describes how well a process meets requirements is process capability. A Six Sigma quality level process is said to translate to process capability index values for C_p and C_{pk} requirement of 2.0 and 1.5, respectively (see Chapter 11). To achieve this basic goal of a Six Sigma program might then be to produce at least 99.99966% quality at the process step and part level within an assembly; i.e., no more than 3.4 defects per million parts or process steps if the process mean were to shift by as much as 1.5σ. If, for example, there were on the average 1 defect for an assembly that contained 40 parts and four process steps, practitioners might consider that the assembly would be at a four sigma quality level from Figure 1.7, because the number of defects in parts per million is: $(1/160)(1 \times 10^6) \approx 6250$.

1.6 TRADITIONAL APPROACH TO THE DEPLOYMENT OF STATISTICAL METHODS

Before the availability and popularity of easy-to-use statistical software, most complex statistical analysis was left to a statistical consultant within an organization. An engineer needs to know what questions to ask of a statistical consultant. If the engineer does not realize the power of statistics, he or she might not solicit help when statistical techniques are appropriate. If an engineer who has no knowledge of statistics approaches a statistical consultant for assistance, the statistician should learn all the technical aspects of the dilemma in order to give the best possible assistance. Most statisticians do not have the time, background, or desire to understand all engineering dilemmas within their corporate structure. Therefore, engineers need to have at a minimum some basic knowledge of the concepts in this book so that they can first identify an application of the concepts and then solicit help, if needed, in an effective manner.

In any case, detailed knowledge transfer to statisticians can be very time-consuming and in most cases will be incomplete. Engineers who have knowledge of basic statistical concepts can intelligently mix engineering concepts with statistical techniques to maximize test quality and productivity. Earlier problem detection and better quality can then be expected when testing is considered as an integral part of the design and manufacturing process development.

Now easy-to-use statistical software has made the whole process of statistical analyses more readily available to a larger group of people. However, the issue of problem definition and dissemination of the *wise* use of statistical techniques still exists. Even though great accomplishments may be occurring through the use of statistical tools within an organization, there is often a lack of visibility of the benefits to upper management. Because of this lack of visibility, practitioners often have to fight for funds and may be eliminated whenever times get rough financially.

Typically in this situation, executive management does not ask questions that lead to the *wise* application of statistical tools; hence, an internal statistical consultant or practitioner has to spend much of his or her time trying to sell others on how basic problems could be solved more efficiently using statistical methods. In addition, internal statistical consultants or practitioners who help others will only have the time or knowledge to assist with problem resolution as it is currently defined. In a purely consultant role, statistical practitioners will often not be involved in project or problem definition. In addition, the benefits of good statistical work that has been accomplished are not translated into the universal language understood by all executives—namely, money. Hence, the benefits of *wisely* applying statistical techniques are limited to small areas of the business, do not get recognition, and are not accepted as general policy.

1.7 SIX SIGMA BENCHMARKING STUDY

In addition to learning from traditional statistical method deployments, there are also lessons to be learned from previous organizational deployments of Six Sigma. Because of this, I am now noting a Six Sigma benchmarking study that I was involved with.

I was selected as the Subject Matter Expert (SME) for an APQC Six Sigma benchmarking study that was conducted in 2001. In September 2001 I gave a presentation during the knowledge transfer section, which summarized my observations during the study. A summary of this presentation is included in Section A.2.

1.8 S^4/IEE BUSINESS STRATEGY IMPLEMENTATION

Organizations create strategic plans and policies. They also create organizational goals that describe the intent of the organization. These goals should have measurable results, which are attained through defined action plans. The question of concern is: How effective and aligned are these management system practices within an organization? An improvement to this system can dramatically impact an organization's bottom line.

An S^4/IEE approach measures the overall organization at a high level using satellite-level and 30,000-foot-level metrics as illustrated in Figure 1.8. Physically, these metrics can take on many responses, as illustrated in Figure 1.9. Satellite-level and 30,000-foot-level metrics (see Chapter 10) permit management with the right information. An organization can use theory of constraints (TOC) metrics (see Chapter 45) and/or traditional business measures for their satellite-level metrics, where measures are tracked monthly using an *XmR* chart (see Chapter 10) that is not bounded by any quarterly or annual time frame.

More information can be gleaned from business data presented in the S^4/IEE format at the satellite level, as opposed to comparing quarterly results in a tabular format. This approach tracks the organization as a system, which can lead to focused improvement efforts and a reduction of firefighting activities. Data presented in this format can be useful for executives when creating their strategic plans and then tracking the results of these strategic plans. With an S^4/IEE strategy, action plans to achieve organizational goals center around the creation and implementation of S^4/IEE projects, as illustrated in Figure 1.10.

The following S^4/IEE *results orchestration* (RO) process to select projects that are aligned with the business needs is called an *enterprise business planning methodology* (EBPM):

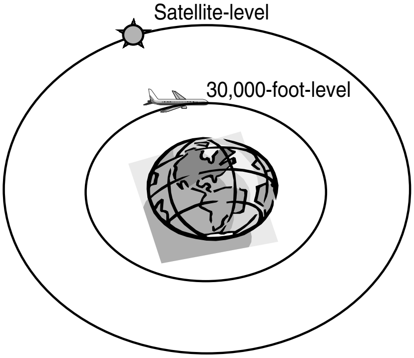
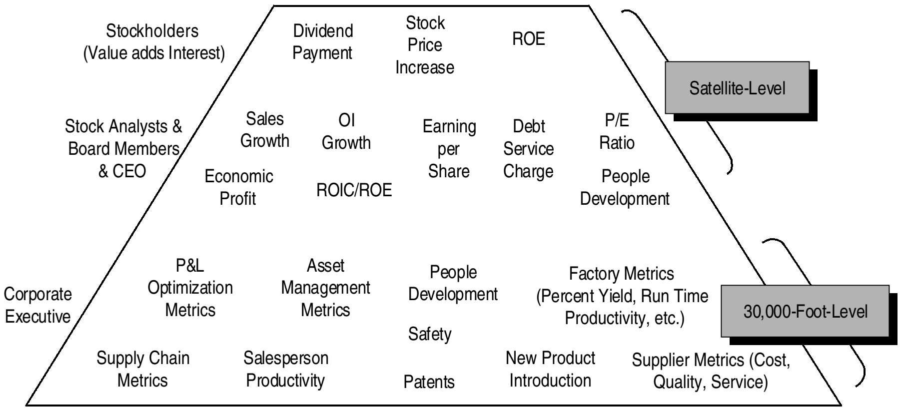


FIGURE 1.8 Satellite-level and 30,000-foot-level metrics.



ROE = Return on Equity; OI = Operating Income; P/E = Price to Earnings; ROIC = Return on Invested Capital
P&L = Profit & Loss

FIGURE 1.9 Satellite-level and 30,000-foot-level metrics.

- Create satellite-level metrics for the past two to five years.
- Select goals that are in alignment with improvement desires for the satellite-level metrics.
- Select strategies that are in alignment with goals.
- Examine supply chain process map.
- Choose high-potential areas for focusing improvement efforts using goals and supply chain process map to help guide the selection process.
- Select and create 30,000-foot-level operational metrics that are in alignment with the high potential areas for improvements.
- Select S4/IEE project areas that are in alignment with operational metrics.

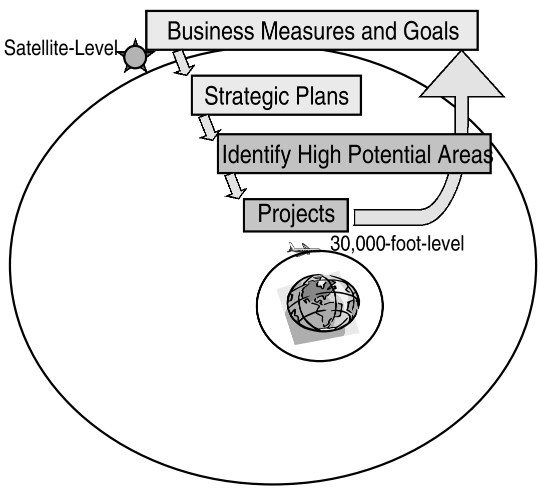


FIGURE 1.10 Aligning improvement activities with business needs.

- Drill down project areas to well-scoped projects (project scope) that are not too large or too small.
- Create 30,000-foot-level project metrics for base-lining projects and tracking impact from S^4/IEE project work.

S^4/IEE 30,000-foot-level metrics are high-level operational or Six Sigma/lean project metrics. The right metrics are needed for the orchestration of the right activities. The above-described EBPM process accomplishes this by linking Six Sigma improvement activities to business strategies and goals.

As noted in Figure 1.9, traditional business metrics that could be classified as satellite-level metrics are capital utilization, growth, revenue, equity valuation, and profit. Traditional operational metrics at the 30,000-foot level are defective/defect rates, cycle time, waste, days sales outstanding, customer satisfaction, on-time delivery, number of days from promise date, number of days from customer-requested date, dimensional property, inventory, and head count. Organizations can find it to be very beneficial when they decide to align project selection with satellite-level measures from theory of constraint (TOC) metrics; i.e., TOC throughput (see Glossary for definition), investment/inventory, and operating expense.

Within S^4/IEE the alignment and management of metrics throughout an organization is called an *enterprise cascading measurement methodology* (ECMM). With ECMM meaningful measurements are statistically tracked over time at various functional levels of the business. This leads to a cascading and alignment of important metrics throughout the organization from the satellite-level business metrics to high-level KPOV operational metrics, which can be at the 30,000-foot level, 20,000-foot level, or 10,000-foot level (infrequent subgrouping/sampling), to KPIVs at the 50-foot level (frequent subgrouping/sampling). The metrics of ECMM can then be used to run the business so that organizations get out of the firefighting mode and pull (used as a lean term) for the creation of projects whenever improvements are needed to these operational metrics.

An S^4/IEE business strategy helps organizations understand and improve the key drivers that affect the metrics and scorecards of their enterprise.

1.9 SIX SIGMA AS AN S^4/IEE BUSINESS STRATEGY

We do things within a work environment. A response is created when things are done, but the way we do things may or may not be formally documented. One response to doing something is how long it takes to complete the task. Another response might be the quality of the completed work. We call the important responses from a process key process output variables (KPOVs), sometimes called the *Y*s of the process (see Section 1.4).

Sometimes the things that are completed within a work environment cause a problem to our customers or create a great deal of waste (e.g., overproduction, waiting, transportation, inventory, overprocessing, motion, and defects), which can be very expensive to an organization.

Organizations often work to solve this type of problem. However, when they do this work, organizations do not often look at their problems as the result of current process conditions. If they did, their work activities might not be much different from Figure 1.11. They might also have a variety of KPOVs, such as a critical dimension, overall cycle time, a DPMO rate (i.e., a defect-per-million opportunities rate could expose a "hidden factory" rework issue that is not currently being reported), customer satisfaction, and so on.

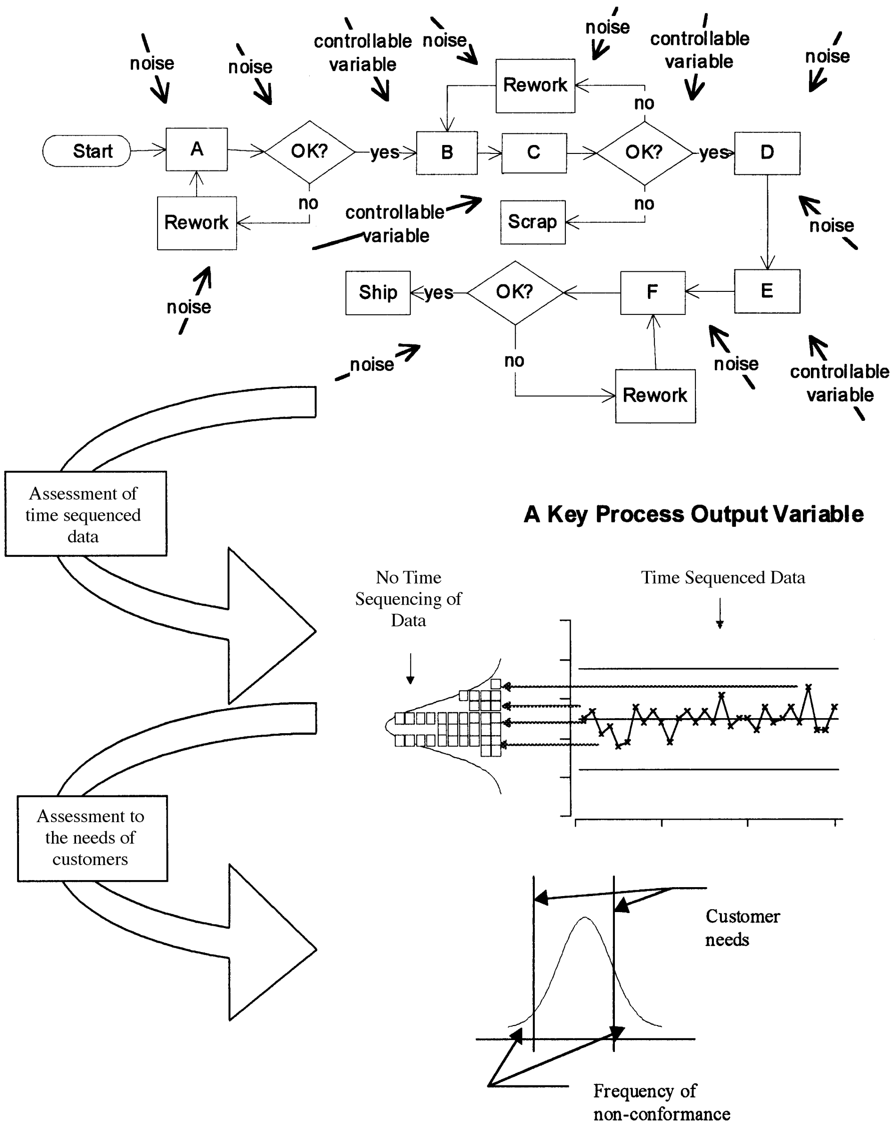


FIGURE 1.11 Example process with a key process output variable.

For this type of situation, organizations often react over time to the up-and-down movements of the KPOV level in a firefighting mode, fixing the problems of the day. Arbitrary tweaks to controllable process variables that are made frequently and noise (e.g., material differences, operator-to-operator differences, machine-to-machine differences, and measurement imprecision) can cause excess variability and yield a large nonconforming proportion for the KPOV. Practitioners and management might think that their day-to-day problem-fixing activities are making improvements to the system. In reality, these activities often expend many resources without making any improvements to the process. Unless long-lasting process changes are made, the proportion of noncompliance, as shown in the figure, will remain approximately the same.

Organizations that frequently encounter this type of situation have much to gain from the implementation of an S^4/IEE business strategy. They can better appreciate this potential gain when they consider all the direct and indirect costs associated with their current level of nonconformance.

The S^4/IEE methodology described in this book is not only a statistical methodology but also a deployment system of statistical and other techniques that follows the high-level S^4/IEE project execution roadmap depicted in Figure 1.12 and further described in Section A.1 in the Appendix. In this execution roadmap, one might note that S^4/IEE follows the traditional Six Sigma DMAIC roadmap. In addition to the project execution roadmap shown in Figure A.1, there is a 21-step integration of the tools roadmaps for the following disciplines:

- Manufacturing processes: Section 46.1
- Service/transactional processes: Section 47.2
- Product DFSS: Section 49.2
- Process DFSS: Section 50.1

In S^4/IEE and a traditional DMAIC, most Six Sigma tools are applied in the same phase. However, the S^4/IEE project execution roadmap offers the additional flexibility of breaking down the measure phase to the components noted in the figure. In addition, the term *passive analysis* is often used in S^4/

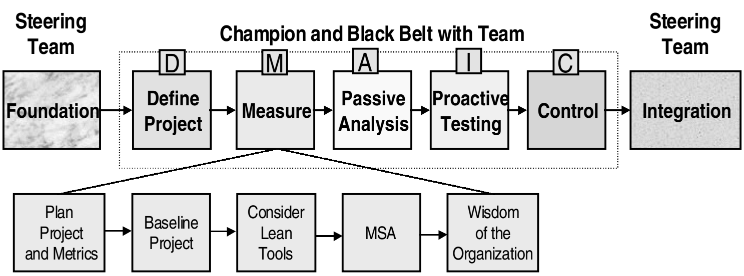


FIGURE 1.12 S^4/IEE DMAIC project execution roadmap.

IEE to describe the analyze phase, where process data are observed passively (i.e., with no process adjustments) in an attempt to find a causal relationship between input and output variables. Finally, the descriptive term *proactive testing* is often used within S^4/IEE to describe the tools associated with the improve phase. The reason for this is that within the improve DMAIC phase design of experiments (DOE) tools are typically used. In DOE you can make many adjustments to a process in a structured fashion, observing/analyzing the results collectively (i.e., proactively testing to make a judgment). It should be noted that *improvements* can be made in any of the phases. If low-hanging fruit is identified during a brainstorming session in the measure phase, this improvement can be made immediately, which could yield a dramatic improvement to the 30,000-foot-level output metric.

In an S^4/IEE business strategy, a practitioner applies the project execution roadmap either during a workshop or as a project after a workshop, as described in Figures 1.13 and 1.14. From this effort, Figure 1.15 illustrates how the process has been simplified, designed to require less testing, and designed to become more robust or indifferent to the noise variables of the process. This effort can result in an improvement shift of the mean along with reduced variability leading to quantifiable bottom-line monetary benefits.

For an S^4/IEE business strategy to be successful, it must have upper-level management commitment and the infrastructure that supports this commitment. Deployment of the S^4/IEE techniques is most effective through individuals, sometimes called black belts or agents, who work full time on the implementation of the techniques through S^4/IEE projects selected on business needs (i.e., they have a very beneficial ROI). Direct support needs to be given by an executive management committee that has high-level managers who champion S^4/IEE projects.

1.10 CREATING AN S^4/IEE BUSINESS STRATEGY WITH ROLES AND RESPONSIBILITIES

For Six Sigma to become a successful business strategy, it needs to have executive management support and an effective organizational structure. Six Sigma needs to become a business process management system that:

1. Understands and addresses process components and boundaries
2. Identifies and collectively utilizes process owners, internal customers/external customers, and other stakeholders effectively
3. Creates an environment for effective project management where the business achieves maximum benefits
4. Establishes project measures that include key performance metrics with appropriate documentation

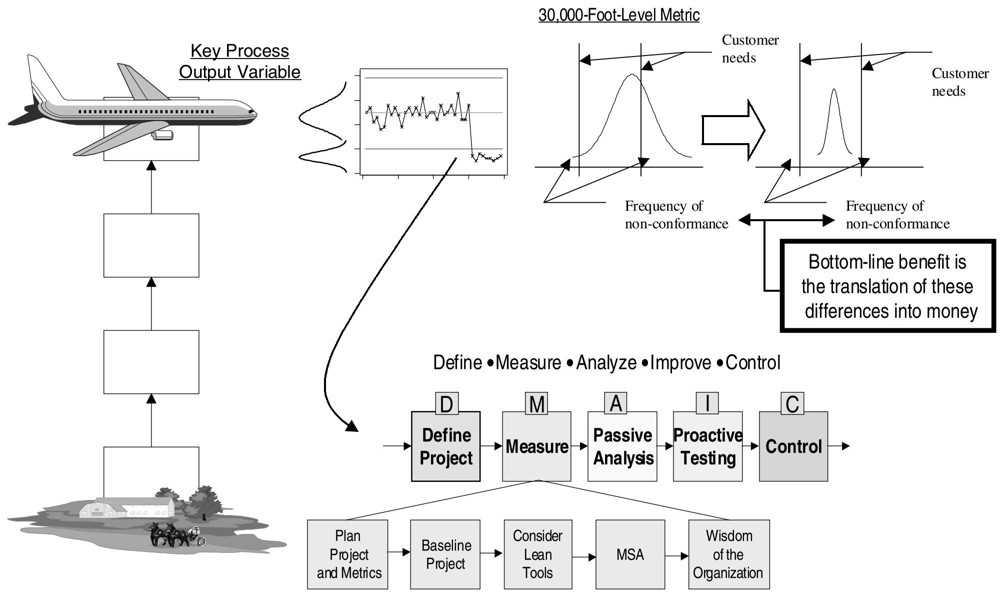


FIGURE 1.13 S^4/IEE project tracking, execution, and the benefits: continuous data.

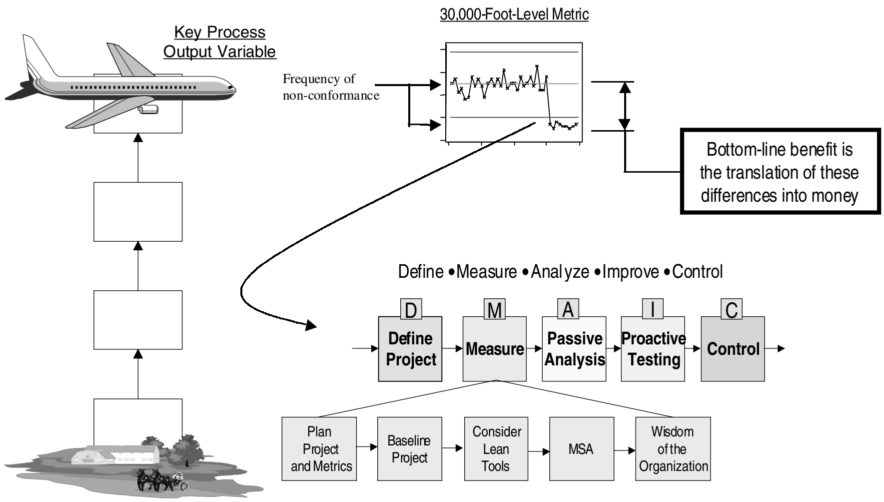


FIGURE 1.14 S^4/IEE project tracking, execution, and the benefits: attribute data.

A force field analysis (see Section 5.10) can be conducted to highlight the driving and restraining forces for a successful implementation of S^4/IEE within your organization. Action plans need to be created to address large restraining forces.

S^4/IEE projects need to focus on areas of the business that can yield a high ROI and address the needs of customers. Project black belt implementers are typically expected to deliver annual benefits of between \$500,000 and \$1,000,000, on average, through four to six projects per year. The value of maintaining and improving customer satisfaction must not be overlooked by organizations within their S^4/IEE activities.

To achieve success, organizations must *wisely* address Six Sigma metrics and its infrastructure. The success of Six Sigma is linked to a set of cross-functional metrics that lead to significant improvements in customer satisfaction and bottom-line benefits. Companies experiencing success with Six Sigma have created an infrastructure to support the strategy.

The affinity diagram in Figure 5.3 shows a grouping of issues that a team believed was important to address when creating an S^4/IEE business strategy. The interrelationship digraph (ID) in Figure 5.4 shows a further subdivision of issues and the interrelationship of these issues:

- Executive leadership and involvement
- Delivered results
- Customer focus
- Strategic goals
- Project selection
- Training and execution

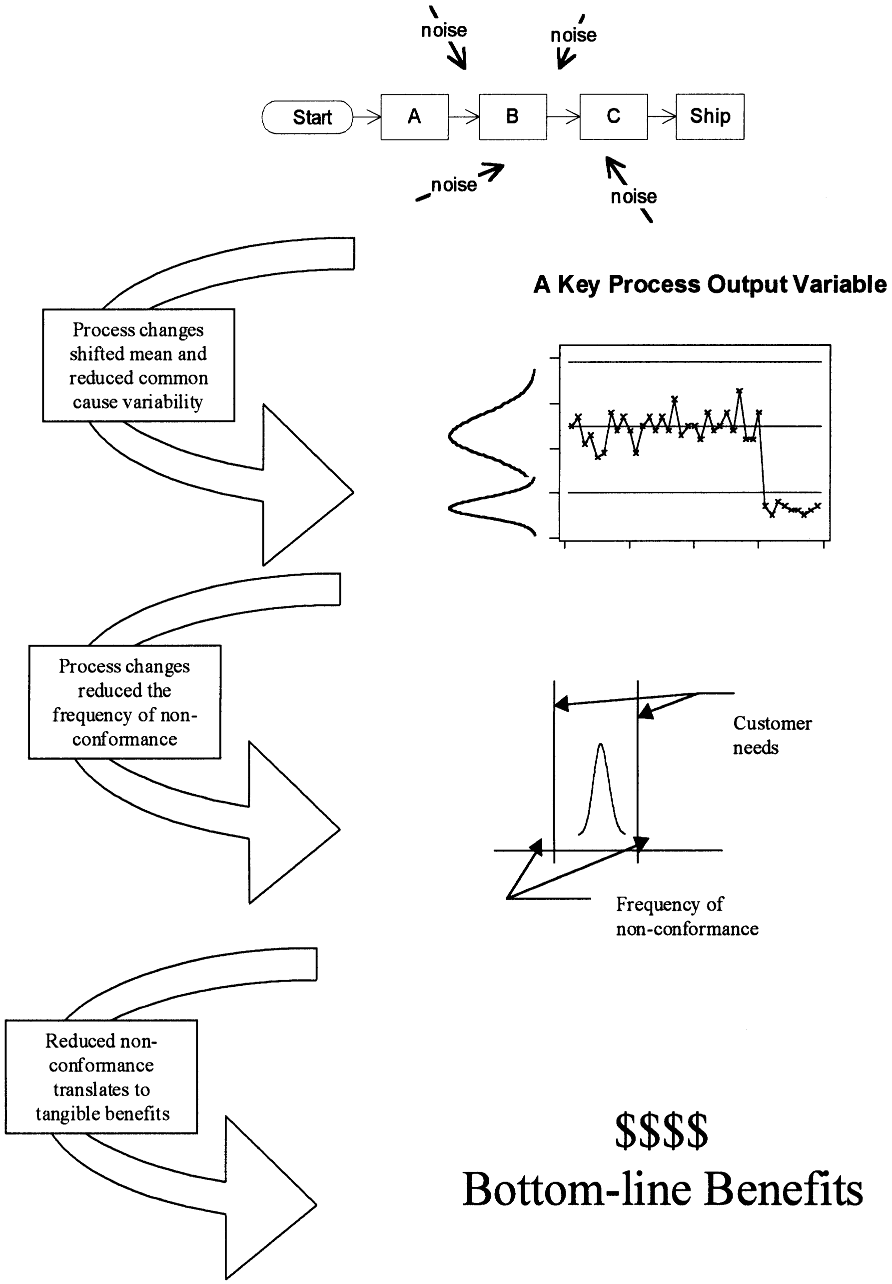


FIGURE 1.15 Example process improvement and impact to a key process output variable.

- Resources
- Black belt selection
- Communications
- Culture
- Metrics (and feedback)
- Planning

Within an S^4/IEE infrastructure, several roles and responsibilities need to be addressed. Some of these roles and possible technical and organizational interrelationships are shown in Figures 1.16 and 1.17. These roles and responsibilities for the organizational structure include:

- Executive:
  - Motivate others toward a common vision.
  - Set the standard, demonstrate the behaviors.
  - Use satellite-level and 30,000-foot-level metrics.
  - Ask the right questions.
  - Use S^4/IEE tools in day-to-day operations.
  - Be visible.
  - Give a short presentation for each S^4/IEE training wave.
  - Attend project-completion presentations conducted by S^4/IEE team.
  - Stay involved.
- Steering team:
  - Same as executive roles and responsibilities, plus:
  - Develop project selection criteria.
  - Set policies for accountability for project results.
  - Develop policies for financial evaluation of project benefits.
  - Establish internal and external communication plan.
  - Identify effective training and qualified trainers.
  - Develop human resource policies for S^4/IEE roles.

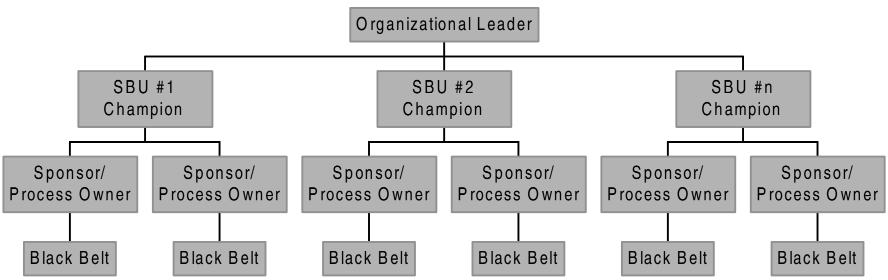


FIGURE 1.16 Possible S^4/IEE organizational interrelationship.

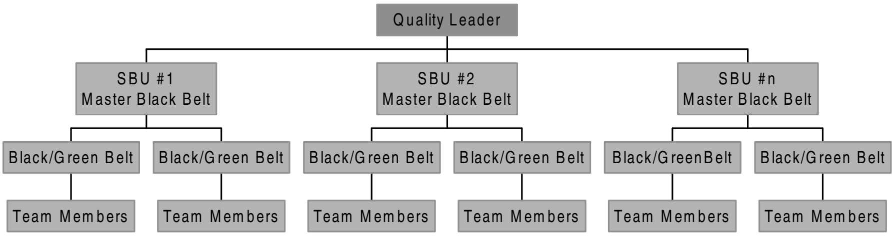


FIGURE 1.17 Possible S4/IEE technical relationships.

    - Determine computer hardware and software standards.
    - Set policies for team reward and recognition.
    - Identify high potential candidates for S4/IEE roles.
- Champion:
    - Remove barriers to success.
    - Develop incentive programs with executive team.
    - Communicate and execute the S4/IEE vision.
    - Determine project-selection criteria with executive team.
    - Identify and prioritize projects.
    - Question methodology and project-improvement recommendations.
    - Verify completion of phase deliverables.
    - Drive and communicate results.
    - Approve completed projects.
    - Leverage project results.
    - Reward and recognize team members.
- Master black belt:
    - Function as change agents.
    - Conduct and oversee S4/IEE training.
    - Coach black belts/green belts.
    - Leverage projects and resources.
    - Formulate project-selection strategies with steering team.
    - Communicate the S4/IEE vision.
    - Motivate others toward a common vision.
    - Approve completed projects.
- Black belt:
    - Lead change.
    - Communicate the S4/IEE vision.
    - Lead the team in the effective utilization of the S4/IEE methodology.
    - Select, teach, and use the most effective tools.
    - Develop a detailed project plan.

  - Schedule and lead team meetings.
  - Oversee data collection and analysis.
  - Sustain team motivation and stability.
  - Deliver project results.
  - Track and report milestones and tasks.
  - Calculate project savings.
  - Interface between finance and information management (IM).
  - Monitor critical success factors and prepare risk-abatement plans.
  - Prepare and present executive-level presentations.
  - Complete four to six projects per year.
  - Communicate the benefit of the project to all associated with the process.
- Green belt: Similar to black belt except they typically:
  - Address projects that are confined to their functional area.
  - Have less training than black belts.
  - Are involved with S^4/IEE improvement in a part-time role.
- Sponsor:
  - Function as change agents.
  - Remove barriers to success.
  - Ensure process improvements are implemented and sustained.
  - Obtain necessary approval for any process changes.
  - Communicate the S^4/IEE vision.
  - Aid in selecting team members.
  - Maintain team motivation and accountability.
- Other recommended team resources:
  - Overall quality leader to deploy and monitor the S^4/IEE business strategy on a broad level.
  - Information management support to aid hardware and software procurement and installation for black belts and teams, to establish data-collection systems that are easily reproducible and reliable.
  - Finance support to approve monetary calculations.
  - Human resources—employee career path and job descriptions.
  - Communications—internal and external.
  - Training—to coordinate S^4/IEE training for the organization and to implement training recommended by black belt teams.

Some larger companies have both deployment and project champion roles. Within this book I will make reference to black belt as the S^4/IEE practitioner. However, many of the tasks could similarly be executed by green belts.

When implementing S^4/IEE, organizations need to create a plan that addresses these issues and their interrelationship. For this to occur, an organization needs to be facilitated through the process of creating all the internal process steps that address these issues, as illustrated within Figure 1.18. Within this strategy, it is also very beneficial to integrate Six Sigma strategies with existing business incentives such as lean manufacturing, total quality management (TQM), Malcolm Baldrige Assessments, and ISO-9000:2000 improvements (Breyfogle et al. 2001b). This integration with lean is described in the next section, while the other topics are discussed in Chapter 54.

Let us now address an issue that I believe is important to the success of implementing Six Sigma within an organization. It has been my experience that within many Six Sigma programs projects are *pushed* (used as a lean manufacturing term) into the system through the Six Sigma infrastructure. This approach creates an environment in which it is difficult for Six Sigma to sustain its effectiveness. I believe a much better approach is to create an environment that has satellite-level metrics and 30,000-foot-level metrics that are cascaded throughout the organization. All levels of management would then ask questions of their subordinates as to what they are doing to improve their processes; i.e., address common cause issues, as described in Chapter 3. This question, as opposed to the typical firefighting question of what are you doing to fix today's problems, can lead to *pulling* (used as a lean term) for the creation of S^4/IEE projects that address issues that are important to the success of the business.

It needs to be emphasized that S^4/IEE black belts need to be selected who not only have the capability of learning and applying statistical methodologies but also are proactive people good at the so-called soft skills of working with people. S^4/IEE black belts will not only need to analyze information and use statistical techniques to get results but will also need to be able to work with others through mentoring, teaching, coaching, and selling others on how they can benefit from S^4/IEE techniques. Six skills I think are important to consider when selecting a black belt are:

- Fire in the belly: They have an unquenchable desire to improve the way an organization does its business.
- Soft skills: They have the ability to work effectively with people in teams and other organizations.
- Project management: They have the ability to get things done well and on time.
- Multitasking: They can manage multiple tasks at one time and maintain focus.
- Big picture: They don't focus on insignificant details, losing sight of the big picture.
- Analytical skills: They have good analytical skills.

The first five characteristics are very difficult to teach since these traits are closely linked with personalities. The statistical methodologies used within S^4/IEE can be easily taught if a person has good analytical skills. When implementing an S^4/IEE business strategy, organizations need to create a

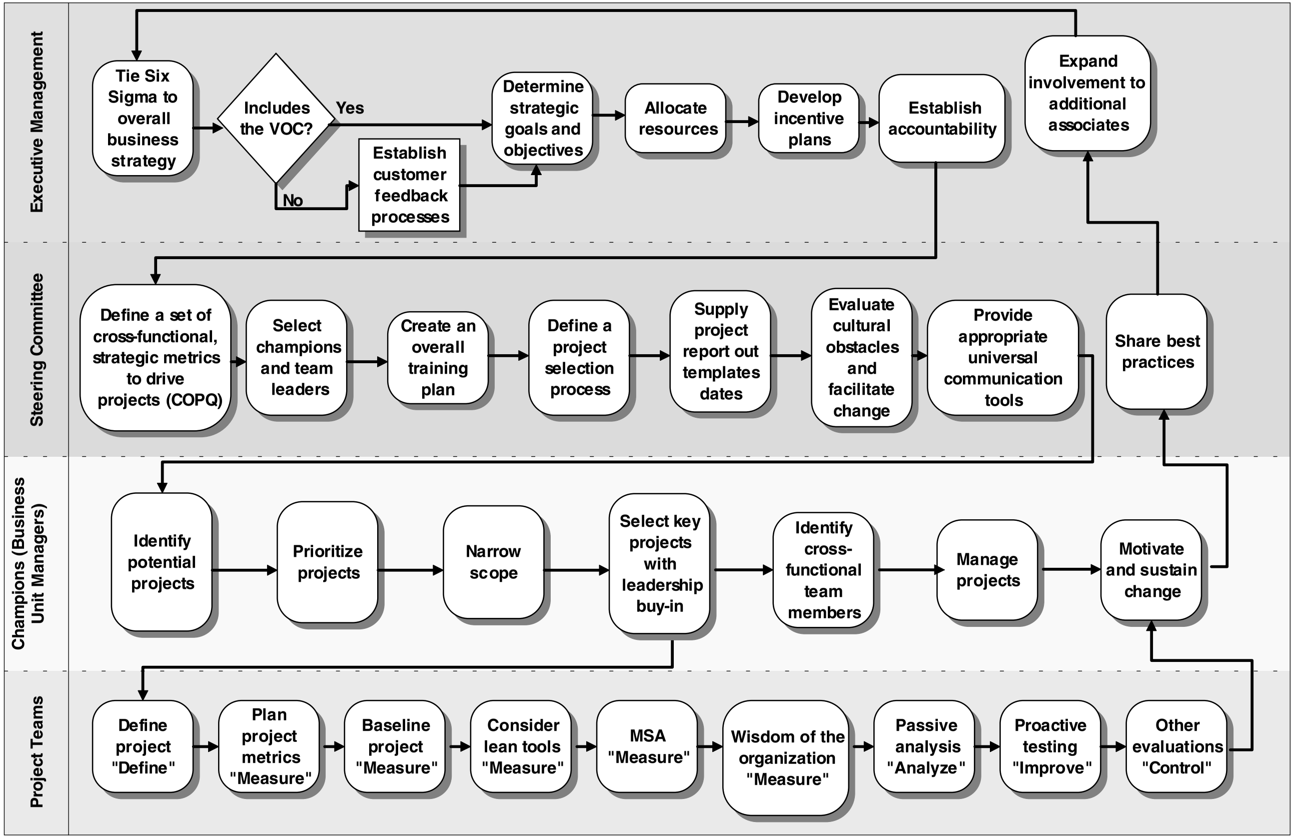


FIGURE 1.18 S^4/IEE infrastructure roadmap.

process for selecting black belts. Organizations initially need to create their own skill set needs for black belts with a prioritization of these skills (see Figure 5.6). One means to rank black belt candidates is then to use a prioritization matrix/cause-and-effect matrix (see Sections 5.16 and 13.4).

A rule of thumb for the number of black belts within an organization is 1–2% of the total number of employees. Black belts are supported technically through a master black belt and through the management chain of an organization by way of a champion. Individuals who are given S^4/IEE training to a lesser extent and support black belts are called green belts.

When an organization chooses to implement Six Sigma, it should use a group outside its company to help it get started. This group can help with setting up a deployment strategy, conducting initial training, and providing project coaching. The decision on which group is chosen can dramatically affect the success of the implementation of Six Sigma. However, choosing the best group to help an organization implement Six Sigma can be a challenge. Some items for consideration are covered in Section A.3 of the Appendix.

1.11 INTEGRATION OF SIX SIGMA WITH LEAN

There has been much contention between Six Sigma and lean functions. I will use *lean* or *lean thinking* to describe the application of lean manufacturing, lean production, and/or lean enterprise principles to all processes. People from the Six Sigma community typically say that Six Sigma comes first or is above lean, relative to application within an organization. People from a lean discipline typically say that lean comes first or is above Six Sigma, relative to application within an organization.

The S^4/IEE approach integrates the two concepts, where high-level Six Sigma metrics dictate which of the lean or Six Sigma tools should be used within an S^4/IEE define-measure-analyze-improve-control (DMAIC) roadmap. The application of lean tools is a step within this execution roadmap, as illustrated within Figure 1.12. When a lean methodology is used to achieve the goal of a project, the 30,000-foot-level metrics will quantify the benefit of the change statistically on a continuing basis.

One reason why this integration works especially well within the S^4/IEE approach is that this Six Sigma approach does not require the definition of a defect for a project. This is very important because lean metrics involve various waste measures, such as inventory or cycle time, that do not have true specification criteria like manufactured components. Defect definitions for these situations can lead to playing games with the numbers.

It is beneficial to dissolve any separate Six Sigma and lean functions that exist, having the same person work using the most appropriate tool for any given situation, whether the tool is lean or Six Sigma.

1.12 DAY-TO-DAY BUSINESS MANAGEMENT USING S^4/IEE

Organizations often experience much firefighting where they react to the problems of the day (see Example 3.1). These organizations need a system where they can replace much of their firefighting activities with fire prevention. This can be accomplished by way of an S^4/IEE cascading measurement strategy.

With this strategy, metrics are orchestrated through a statistical-based high-level measurement system. Through the alignment of 30,000-foot-level with satellite-level and other high-level metrics, organizations can yield meaningful metrics at the operational level, which have a direct focus on the needs of the business. The wise use of these metrics can improve the orchestration of day-to-day activities for organizations.

When we view our system using a set of cascading high-level *XmR* charts that has infrequent subgrouping/sampling (see Section 10.3), behaviors can change. Often previous situations had individual day-to-day out-of-specification conditions, which were caused by common-cause variability, were fought as a special-cause event fires. These fires needed immediate attention and often only later reappeared after the extinguishing.

When there are common cause variability problems such that a specification is not consistently met, the overall process needs to be changed in order to improve the metrics. Long-lasting improvements can be accomplished through S^4/IEE projects that address the overall system's process steps and its metrics, including the measurement system itself and a control mechanism for the process that keeps it from returning to its previous unsatisfactory state.

With the S^4/IEE approach, process management teams might meet weekly to discuss their high-level 30,000-foot-level operational metrics. When an *XmR* chart that has infrequent subgrouping/sampling shows a predictable process that does not yield a satisfactory capability/performance (see Chapter 11) measurement level, an S^4/IEE project can be created; i.e., the S^4/IEE project is pulled (using a lean term) by the need to improve the metrics.

This S^4/IEE project could become a green belt project that is executed by a part-time S^4/IEE project practitioner who is within a function. Alternatively, the project might become a larger black belt project that needs to address cross-functional issues. When improvements are made to the overall system through the S^4/IEE project, the 30,000-foot-level operational metric should change to an improved level.

Awareness of the 30,000-foot-level metrics and the results of S^4/IEE project improvement efforts should be made available to everyone, including those in the operations of the process. This information could be routinely posted using the visual factory concept typically encountered within lean implementations (see Chapter 44). This posting of information can improve the awareness and benefits of S^4/IEE throughout the organization, which can lead more buy-in to the S^4/IEE methodology throughout the function. This can result in the stimulation of other improvement efforts, resulting in a dramatic improvement in the overall satellite-level measures.

With this approach to the tracking of metrics and the creation of improving activities, management can change its focus, which might currently be on the problems of the day. This approach can lead to asking questions about the status of S^4/IEE projects that will improve the overall capability/performance of their operational metrics. That is, focus will be changed from firefighting to fire prevention.

1.13 S^4/IEE PROJECT INITIATION AND EXECUTION ROADMAP

S^4/IEE DMAIC Application: Appendix Section A.1, Project Execution Roadmap, Steps 1.2, 1.3, 1.5, 1.7, 2.2, and 9.9

One problem frequently encountered by organizations when implementing Six Sigma is that all activities can become Six Sigma projects. Organizations need a process for addressing the classification of projects. The S^4/IEE roadmap clarifies this decision-making process of what is and what is not a project through the subprocess shown in Figure 1.19, which is a drill down of a process step shown in Figure 1.18 for the champion. This subprocess also helps determine whether a project should follow a product design for Six Sigma (DFSS) or process DFSS execution roadmap (see Chapters 46–49).

Upon completion of the decision that a project will be undertaken, it is critical that the stakeholders (finance, managers, people who are working in the process, upstream/downstream departments, suppliers, and customers) agree to a project problem statement as part of the S^4/IEE define phase.

The project scope needs to be sized correctly and documented in a project charter format. Pareto charts (see Section 5.6) can help prioritize drill-down opportunities, which often occur when scoping a project. Theory of constraints (TOC) (see Chapter 45) techniques can also help identify bottleneck improvement opportunities, which can dramatically affect the overall system output.

The project scope should be aligned with improvement needs of its high-level supply chain map; e.g., the supply chain process decision program chart (PDPC) shown in Figure 5.8. An *SIPOC* (*suppliers, inputs, process, outputs, and customers*) *diagram* is a high-level process map that adds supplier and customer to the IPO described earlier. SIPOC can be useful as a communication tool that helps team members view the project the same way and helps management know where the team is focusing its efforts. For each category of SIPOC, the team creates a list. For example, the input portion of SIPOC would have a list of inputs to the process. The process portion of SIPOC should be high-level, containing only four to seven high-level steps (see Chapter 4). How the SIPOC diagram aligns with the high-level supply chain map and its needs should be demonstrated.

An example S^4/IEE DMAIC project charter format is shown in Figure 1.20. All involved must agree to the objectives, scope, boundaries, resources,

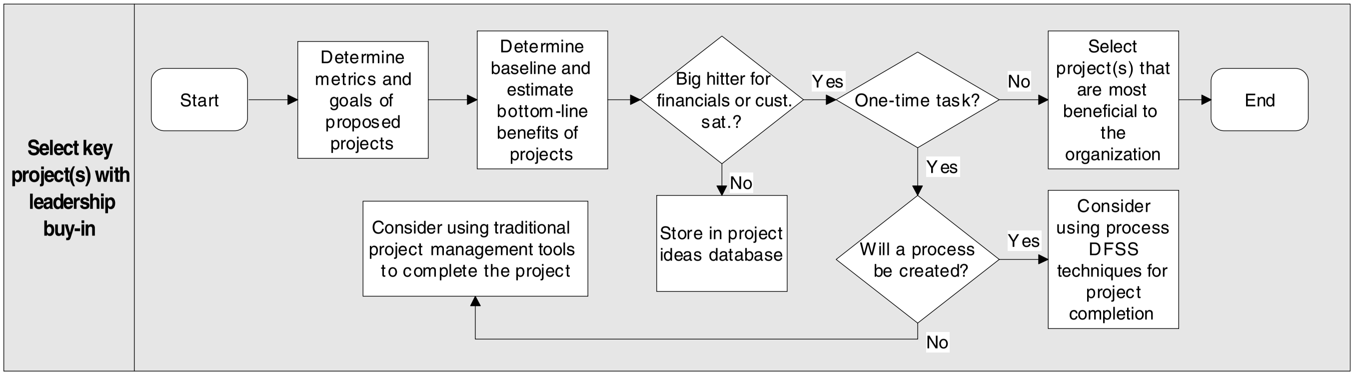


FIGURE 1.19 Project identification subprocess.

S⁴/IEE Project Charter		
Project Description		Project name and problem statement
Start and Completion Date		Project kick-off date and completion date
Baseline Metrics		Identify KPOVs that will be used for process metrics
	Primary Metrics	30,000-foot-level, COPQ/CODND, process capability metric
	Secondary Metrics	Include RTY, DPMO as needed
Goal		Describe improvement goals for these metrics
Benefits	Customer	Describe the impact and benefits to the final customer
	Financial	Estimated financial impact to the business
	Internal Productivity	Describe the expected business performance improvement
Phase Milestones	Define	Define phase deliverables and report out date
	Plan Project and Metrics	Plan project and metrics phase deliverables and report out date
	Baseline Project	Baseline project deliverables and report out date
	Consider Lean Tools	Consider lean tools deliverables and report out date
	MSA	MSA deliverables and report out date
	Wisdom of the Org.	Wisdom of the organization deliverables and report out date
	Analyze	Passive analysis deliverables and report out date
	Improve	Proactive testing deliverables and report out date
	Control	Control phase deliverables and report out date
Team Support		Sponsor, champion, MBB, process owner, financial analyst
Team Members		Black belt, team members and roles

FIGURE 1.20 S⁴/IEE project charter.

project transition, and closure. The details on this charter should be updated as the project proceeds within the overall S⁴/IEE execution roadmap. The champion needs to work with the black belt so that the project status is sufficiently documented within a corporate database that can be conveniently accessed by others.

At the beginning stages of an S⁴/IEE project, the champion needs to work with the black belt and process owner so that the right people are on the team. Team selection should result in team members being able to give different insights and provide the skills (e.g., self-facilitation, technical/subject matter expert) needed to the completion of the project in a timely fashion.

The champion, belt belt, and team need to agree on the gap that currently exists between the process output and the expectations of the customer of the process, along with a tangible project improvement goal. A drill down from a high-level process map is to show the area of project focus. A visual representation of the project's 30,000-foot-level metrics needs to show alignment with the satellite-level metrics for the organization.

Chapter 53 summarizes project management issues that need to be addressed for timely project completion. Upon project completion, the champion needs to work with the black belt to get a final project report that is timely posted in their organization's project tracking database.

Figure 1.12 showed the S4/IEE high-level project execution roadmap that addresses the overall DMAIC roadmap, while Section A.1 in the Appendix shows the next-level drill-down from this roadmap. However, when executing a project, novices can have difficulty determining the next step to take when working on projects. Also, they can have difficulty determining what Six Sigma tool to use for the various situations that they encounter. To aid users of this book, I make reference to where tools that are described in this book fit into this overall roadmap, which is shown in Figure A.1. Shadowed boxes identify subprocesses that have a further description in another flowchart, which is covered within our training/coaching at Smarter Solutions, Inc.

Although there are many effective problem-solving tools, the use and application benefits from them are not often linked to the overall business needs or objectives. Because of this, teams that completed valuable projects often do not get the credit and recognition that they deserve. Many traditional problem-solving tools are described as part of the overall S4/IEE roadmap. When the application of these tools is part of an S4/IEE infrastructure, the benefits for making improvements can have more visibility throughout the organization. This visibility can be very desirable to a team that applied the techniques, as well as to the organization, since success builds on success.

1.14 PROJECT BENEFIT ANALYSIS

S4/IEE DMAIC Application: Appendix Section A.1, Project Execution Roadmap Steps 1.6, 3.7, and 9.6

Traditional COPQ calculations look at costs across the entire company using the categories of prevention, appraisal, internal failure, and external failure, as described in Figure 1.21. Organizations often do not disagree with these categories, but they typically do not expend the effort to determine this costing for their particular situations.

Organizations need to determine how they are going to determine the benefit of projects. The procedure that they use can affect how projects are selected and executed. I think that other categories need to be considered when making these assessments. Hence, I prefer the term *cost of doing nothing different* (CODND) to *COPQ*. The reason I have included the term *different* is that organizations often are doing something under the banner of process improvements. These activities could include lean manufacturing, TQM, ISO 9000, and so on.

Let's use a Days Sales Outstanding (DSO) S4/IEE project example to illustrate two options for conducting a project benefit analysis. For an individ-

PREVENTION
Training
Capability Studies
Vendor Surveys
Quality Design
APPRAISAL
Inspection and Test
Test Equipment and Maintenance
Inspection and Test Reporting
Other Expense Reviews
INTERNAL FAILURE
Scrap and Rework
Design Changes
Retyping Letters
Late Time Cards
Excess Inventory Cost
EXTERNAL FAILURE
Warranty Costs
Customer Complaint Visits
Field Service Training Costs
Returns and Recalls
Liability Suits

FIGURE 1.21 Traditional quality cost categories and examples.

ual invoice, its DSO would be from the time the invoice was created until payment was received. CODND considerations could include the monetary implications of not getting paid immediately (e.g., costs associated with interest charges on the money due and additional paperwork charges) while COPQ calculations typically involve the monetary implications beyond a criterion (e.g., costs associated with interest charges on the money due after the due date for the invoice and additional paperwork/activity charges beyond the due date).

One might take the position that we should not consider incurred costs until the due date of an invoice since this is the cost of doing business. This could be done. However, consider that some computer companies actually get paid before products are built for their Internet on-line purchases and their suppliers are paid much later for the parts that are part of the product assembly process. If we look at the total CODND opportunity costs, this could lead to out-of-the-box thinking. For example, we might be able to change our sales and production process so that we too can receive payment at the time of an order.

I like the categories that Iomega used to determine the benefits of projects:

- Bottom-line hard dollar:
  - Decreases existing business costs
  - Example: defects, warranty, maintenance, labor, freight
  - Takes cost off the books or adds revenue to the books
- Cost avoidance:
  - Avoids incremental costs that have not been incurred but would have occurred if project were not performed
  - Example: enhanced material or changes that would affect warranty work
- Lost profit avoidance:
  - Avoids lost sales that have not been incurred, but would have occurred if project had not occurred
  - Example: a project reduces frequency of line shutdowns
- Productivity:
  - Increases in productivity which improves utilization of existing resources
  - Example: redeployment of labor or assets to better use
- Profit enhancement:
  - Potential sales increase, which would increase gross profit
  - Example: change that was justifiable through a survey, pilots, or assumptions
- Intangible:
  - Improvements to operations of business which can be necessary to control, protect, and or enhance company assets but are not quantifiable
  - Example: Administrative control process that could result in high legal liability expense if not addressed

Further financial analysis basics will be described in the Project Management chapter of this book (see Chapter 52).

1.15 EXAMPLES IN THIS BOOK THAT DESCRIBE THE BENEFITS AND STRATEGIES OF S^4/IEE

Many examples included in this book illustrate the benefits of implementing S^4/IEE techniques through projects. The following partial list of examples is included to facilitate the reader's investigation and/or give a quick overview of the benefits and implementation methodologies for use within S4/IEE training sessions.

- Generic Process Measurement and Improvement
  - Process measurement and improvement within a service organization: Example 5.3.
  - A 20:1 return on investment (ROI) study leads to a methodology that has a much larger benefit through the changing or even the elimination of the justification process for many capital equipment expenditures: Example 5.2.
  - Tracking a product to a specification and then fixing the problem does not reduce the frequency of product nonconformance but can cost a great deal of money. A better summary view of the process, as opposed to only measuring the product, can give direction for design improvements and poka-yoke: Example 43.5.
  - Improving internal employee surveys to get more useful results with less effort. The procedure described would also work with external surveys: Example 43.7.
  - A described technique better quantifies the output of a process, including variability, in terms that everyone can understand. The process is a business process that has no specifications: Example 11.5.
  - The bottom line can be improved through the customer invoicing process: Example 43.8.
  - An improvement in the tracking metric for change order times can give direction to more effective process change needs. Example 43.6.
  - Illustrating how the application of S4/IEE techniques improves the number in attendance at a local ASQ section meeting. The same methodology would apply to many process measurement and improvement strategies: Example 11.5 and Example 19.5.
  - Improving product development: Example 43.1.
  - A conceptual example can help with a problem that frequently is not addressed, such as answering the right question: Example 43.9.
- Design of Experiments (DOE)
  - A DOE strategy during development uses one set of hardware components in various combinations to represent the variability expected from future production. A follow-up stress to fail test reveals that design changes reduce the exposure to failure: Example 31.5.
  - Several DOEs are conducted to understand and fix a manufacturing problem better. A follow-up experiment demonstrates that the implemented design changes not only improve average performance but also reduce the variability in performance between products: Examples 19.1, 19.2, 19.3, 19.4.

  - The integration of quality functional deployment (QFD) and DOE leads to better meeting customer needs: Example 43.2.
  - Implementing a DOE strategy within development can reduce the number of no-trouble-founds (NTFs) later reported after the product is available to customers: Example 30.2.
- Testing Products and Product Reliability
  - Improving a process that has defects: Example 5.1.
  - A DOE expedites the testing process of a design change: Example 30.1.
  - A strategy to capture combinational problems of hardware and software can quickly identify when design problems exist. The strategy also provides a test coverage statement: Example 42.4.
  - An expensive reliability test strategy requiring many prototype machines is replaced by a test that gives much more useful results in a shorter period of time. The results from this test reveal design issues that could have been diagnosed as NTF, which in many organizations can cost manufacturing a great deal of money: Example 43.3.
  - A customer ongoing-reliability test (ORT) requirement is created to satisfy a customer requirement so that the activity gives more timely information leading to process improvement with less effort than typical ORT plans: Example 40.7.
  - A reduced test of preproduction machines indicates that in order to have 90% confidence that the failure criterion will be met, a total number of 5322 test hours is needed during which two failures are permitted: Example 40.3.
  - An accelerated reliability test consisting of seven components indicates a wear-out failure mode according to which 75% of the units are expected to survive the median life specifications. Example 41.1.
  - Data from the field indicate a nonconstant failure rate for a repairable system: Example 40.6.
- Product Design for Six Sigma (DFSS)
  - Defining a development process: Example 4.1.
  - 21-step integration of the tools for product DFSS: Section 49.2.
  - Notebook computer development: Example 49.1.
  - An illustration of integration of lean and Six Sigma methods in developing a bowling ball: Example 44.1.
  - A reliability and functional test of an assembly, which yields more information with less traditional testing: Example 43.3.
  - In a DFSS DOE one set of hardware components is configured in various combinations to represent the variability expected from future production. A follow-up stress-to-fail test reveals that design changes reduce the exposure to failure: Example 31.5.

- The integration of quality functional deployment (QFD) and a DOE leads to better meeting customer needs and the identification of manufacturing control variables: Example 43.2.
- Implementing a DFSS DOE strategy within development can reduce the number of no-trouble-founds (NTFs) later reported after the product is available to customers: Example 30.2.
- Conducting a reduced sample size test assessment of a system failure rate: Example 40.3.
- Postreliability test confidence statements: Example 40.5.
- Reliability assessment of systems that have a changing failure rate: Example 40.6.
- Zero failure Weibull test strategy: Example 41.3.
- Pass/fail system functional testing: Example 42.2.
- Pass/fail hardware/software system functional test: Example 42.3.
- A development strategy for a chemical product: Example 43.4.
- A stepper motor development test that leads to a control factor for manufacturing: Example 30.1.

1.16 EFFECTIVE SIX SIGMA TRAINING AND IMPLEMENTATION

Section A.4 in the Appendix exemplifies a basic agenda using the topics in this book to train executives (leadership), champions, black belts, green belts, and yellow belts. However, there are many additional issues to be considered in training sessions.

For successful implementation of Six Sigma techniques, the training of black belt candidates needs to be conducted so that attendees can apply the concepts to their project soon after the techniques are covered in the S^4/IEE workshop. An effective approach to the training of the Six Sigma concepts described in this book is four weekly modules spread over four months. Between workshop sessions, attendees apply to their projects the concepts previously learned. During this time they also get one-on-one coaching of the application of the S^4/IEE techniques to their project.

In this training process, it is also very important that attendees have the resources to learn the concepts quickly and to apply the concepts to their projects. A portable computer should be assigned to all black belts with the following software installed:

- An easy-to-use statistical program
- Office suite (programs for word processing, spreadsheets, and presentations)
- Process flowcharting program

The most effective basic format to deliver the concepts is as follows:

- Present a topic using a computer projector system in conjunction with a presentation software package.
- Show an example (e.g., using the statistical software).
- Present application exercise in which each student is to analyze a given set of data on his/her computer in the class.
- Periodically present an application exercise in which teams in the class work together on a generic application of the concepts recently described; e.g., four or five team members collect and analyze data from a catapult exercise; students use this teaching tool that was developed by Texas Instruments to shoot plastic golf balls and measure the distance they were projected. [*Note:* Team catapult exercises will be described as exercises throughout this book. See the Glossary for a description of the catapult.]
- Periodically discuss how the techniques are applicable to the projects.

I have found that it is very beneficial for participants to create a presentation of how they applied S^4/IEE techniques to their projects. Each person gives a presentation of his/her project using a computer projector system and presentation software during weeks 2, 3, and 4. The instructor can evaluate the presentation and give the presenter written feedback.

Each organization needs to create a process that establishes guidelines for the selection, execution, and reporting of projects. Some things to consider and related issues when determining these guidelines are the following:

- Metrics and Monetary Issues:
  - Consider how to quantify and report in simple terms how the process is doing relative to customer and business needs (see Section 1.19). Consider also how defects-per-million opportunities (DPMO) would be reported if this metric were beneficial. With an S^4/IEE strategy, we do not force measurements on projects that do not make sense.
  - Decisions must be made relative to how monetary S^4/IEE project benefits are determined. Consider whether hard, soft, or both types of savings will be tracked; e.g., hard savings have to show an impact to the accounting balance sheet before reported. Soft savings would include an efficiency improvement that in time would save money because fewer people would later be required to conduct the task. Before making this decision, I suggest first reviewing Examples 5.2 and 5.3. I believe that it is important to have a measurement that encourages the right activity. For the black belts, one of the primary measurements should be a monetary saving. When a strict accounting rule of only "hard money" is counted, the wrong message can be sent. A true hard money advocate would probably not allow for cost avoidance. For ex-

ample, a black belt who reduced the development cycle time by 25% would get no credit because the savings were considered soft money.

- Target S^4/IEE Project Completion Dates and Stretch Goals:
  - Consider having a somewhat flexible amount of time, one to three months, after the last S^4/IEE workshop session, to account for project complexity.
  - Consider having stretch goals for projects, both individually and collectively. It is very important that management not try to drive improvement only through these numbers. Management must instead orchestrate efforts that lead to the most effective activities that can positively affect these metrics.
- Recognition/Certification:
  - Consider the certification process for someone to become a black belt. Perhaps she should have demonstrated a savings of at least $100,000 in projects, obtained a level of proficiency using S^4/IEE tools, and given good documentation of project results in a format that could be published.
  - Consider how black belts and others involved within an S^4/IEE implementation will be recognized.

1.17 COMPUTER SOFTWARE

Most tedious statistical calculations can now easily be relegated to a computer. I believe that for a Six Sigma business strategy to be successful, practitioners must have good versatile statistical software used in their training and readily available for use between and after training sessions. The use of statistical software in training sessions expedites the learning of techniques and application possibilities. The availability and use of a common statistical software package in an organization following a training session will improve the frequency of application of the techniques and communications within/between organizations and their suppliers/customers.

An organization should choose a common computer program that offers many statistical tools, ease of use, good pricing, and technical support. *Quality Progress* (a magazine published by the American Society for Quality [ASQ], Milwaukee, WI) periodically publishes an article describing the features of computer program packages that can aid the practitioner with many of these tasks. The charts, tables, and analyses produced in this book were created with Minitab or Excel.

Reiterating, I believe that black belt workshops should include only the minimal number of manual exercises needed to convey basic understanding. Typically, we no longer do manual manipulation of statistical data; hence, a majority of instruction within an S^4/IEE workshop should center around use of this computer program on a laptop computer assigned to the individual. After workshop sessions are complete, the student will then have the tools to efficiently apply S4/IEE techniques immediately.

It needs to be emphasized that even though computer software packages are now very powerful, problem solutions and process improvements are not a result of statistical computer programs. Unfortunately, computer program packages do not currently give the practitioner the knowledge to ask the right question. This book addresses this most important task along with giving the basic knowledge of how to use computer program packages most effectively.

1.18 SELLING THE BENEFITS OF SIX SIGMA

All the CEOs of partnering companies within the Six Sigma benchmarking study described in Section A.2 in the Appendix were a driving force for the initiation of Six Sigma within their company. However, there are many situations in which someone in an organization believes in the methodology but does not have top executive buy-in. For this case, consider the following strategies to gain executive buy-in:

Strategy 1: Present the alternatives.
Strategy 2: Illustrate an application.

With strategy 1 the monetary impact of the following alternatives is determined and presented to influential managers within the company.

- Do nothing different: This might be the best alternative, but before making this decision the cost of doing nothing different (CODND) needs to be determined and compared to the cost-of-doing-something. When calculating the CODND, consider future trends that might even drive a company out of business.
- Implement Six Sigma as a business strategy: With this approach, an infrastructure is created, in which key improvement projects follow a structured methodology and are tied to strategic business metrics. Executive support is a necessary element! The Six Sigma business strategy has the most benefit, if it is executed wisely.
- Implement Six Sigma as a program: With this approach, there is focus on the training of Six Sigma tools and their application. Application project selection does not necessarily align with the needs of the business. This approach is easier than implementing Six Sigma as a business strategy but risks becoming the "flavor of the month" and does not capture the buy-in necessary to reap large bottom-line benefits.

With strategy 2 a highly visible situation is chosen. The selected situation should have caused much anguish and firefighting within a company over time. Data are then collected and presented in a high-level (30,000-foot-level) control chart. The following topics are included in a presentation to influential managers.

- COPQ/CODND, including costs of firefighting and implications of future trends if something is not done different
- Roadmap of how this situation could be improved through the *wise* implication of Six Sigma techniques

For companies, improvement messages, strategies, or discussions with executives need to be undertaken when the timing is right. We need to have a *pull* (used as a lean term) for a solution attitude, as opposed to pushing information. That usually occurs when the pain is so great that the feeling is that something has to be done for survival.

1.19 S^4/IEE DIFFERENCE

I am including this section early in this book so the practitioner can easily see the differences and advantages of the S^4/IEE over traditional Six Sigma strategies. A novice to the techniques may wish to only scan this section since he or she may encounter terms that are unfamiliar, which will be discussed later.

Traditionally, within Six Sigma effort is given to identifying critical to quality (CTQ) characteristics issues (or process *Y* outputs), which are to be in alignment to what the customer wants. A defect is then considered any instance or event in which the product or process fails to meet a customer requirement. One problem with this approach is that Six Sigma is viewed as a quality program, which can lead to playing games with the numbers if there is no undisputable definition for what a defect truly is.

Six Sigma should be viewed as more than a quality improvement program. The methodologies of Six Sigma should be an integral part of the operations and measurements of a company. A Six Sigma business strategy should lead to projects that can involve either simple process improvements or complex reengineering that is aligned to business needs.

In lieu of defining a CTQ parameter for each project, I prefer to identify an important process output variable generically as a key process output variable (KPOV). When this is done, the implication to others is that Six Sigma is more than a quality initiative.

An S^4/IEE strategy would track the KPOV metric at a high level, e.g., 30,000-foot level. This would be the *Y* output of a process that is expressed as $Y = f(x)$; i.e., Y is a function of x. In S4/IEE, an important x in this equation is referred to as a key process input variable (KPIV). In S4/IEE, the tracking of this metric would be at a 50-foot level.

S4/IEE discourages the use of the commonly used metric, sigma quality level; e.g., a 3.4 parts per million defect rate equals a six sigma quality level. There are several reasons for taking this position. One issue is that this metric is a quality metric. To apply this metric to the other measures of the business, such as a reduction of cycle time and waste, one has to define a specification. This creation of a specification often leads to playing games with a value in order to make the sigma quality level number look good. This is one reason why many organizations are having trouble integrating Six Sigma with lean methodologies; i.e., cycle time and waste do not really have specification limits as manufactured products do. In addition, the logistics and cost to calculate this metric, which has little if any value, can be very expensive. See Example 43.10 for a more in-depth discussion of these issues.

I will next describe the approach for measurements within S4/IEE. With the S4/IEE methodology, key business enterprise metrics such as ROI and inventory (as a TOC metric) are tracked at a high level; e.g., *XmR* statistical control chart (see Chapter 10), where there is a subgrouping/sampling rate that is infrequent, perhaps monthly (see infrequent subgrouping/sampling description in Glossary). Our satellite-level measurement strategy for these high-level business metrics separates common cause variability from special cause variability. The separation of these two variability types offers organizations a means to get out of the firefighting mode, where common cause variability issues can be treated as though they were special cause.

When common cause variability with a satellite-level metric is unsatisfactory, the organization should then define a Six Sigma project(s) leading to improvement of this business measurement. With an S4/IEE strategy, the output from the processes that these projects are to improve would be tracked using a 30,000-foot-level measurement strategy. With this strategy, at least one key process output variable (KPOV) metric for each project is tracked using an *XmR* statistical control chart that has an infrequency subgrouping/sampling period, e.g., perhaps one unit or group of units collective analyzed per day or week on an *XmR* statistical control chart.

The purpose of a Six Sigma project is to find key process input variables (KPIVs) that drive the KPOV. For example, temperature (KPIV) in a plastic injection-molding machine affects the overall dimension of a part (KPOV). With an S4/IEE strategy, we would focus on what should be done to control this KPIV through our 50-foot-level measurement and improvement strategy. The tracking of this metric would utilize an *XmR* statistical control chart that has a frequent sampling period, e.g., one unit sampled, measured, and tracked every minute or hour.

When an improvement is made to our process, the 30,000-foot-level measurement should show a sustainable shift to a new level of common cause variability for the KPOV of the project. In addition, the satellite-level metric should in time be impacted favorably. This approach creates a linkage and feedback methodology between processes and the enterprise system as a whole.

Within a Six Sigma business strategy, we are trying to determine the pulse of the business, which requires more than just a snapshot of the latest results from a process or business metric. There is a real need to create a continuous picture that describes key outputs over time, along with other metrics that give insight to focus areas for improvement opportunities. Unfortunately, organizational policy often encourages practitioners to compile data in a format that does not lead to useful information. This problem is overcome when an organization follows the S^4/IEE methodology and uses the described measurement strategy.

In addition to discouraging the use of the sigma quality level metric, I also highlight the confusion that can result from common process capability/performance indices such as C_p, C_{pk}, P_p, and P_{pk}. I realize that customers often ask for these metrics; hence, you may need to calculate these metrics and supply these numbers to your customers. Chapter 11 describes alternatives for making these calculations, as well as how these metrics can be very deceiving and why I believe that these metrics should not be used to drive improvement activities within organizations. Chapter 11 also discusses why I believe that a better metric is simply an estimate for the percentage or parts per million (ppm) beyond a desired response. Perhaps you can ask your customer to read sections of this book that describe my argument for why the C_p, C_{pk}, P_p, and P_{pk} metrics can be deceptive and expensive in that they can lead to the wrong activities. Perhaps this suggestion can be the stimulus for the creation of a new set of measures that you supply your customer.

I think that it can be a very detrimental requirement that all Six Sigma projects *must* define a defect. One reason for making this requirement with a Six Sigma initiative is that this is a requirement for a sigma quality level to be calculated. An attractive selling point for making this requirement is that now all organizations can be compared through this one metric, sigma quality level. This might sound good, but it is not practical. Consider how we might define the opportunity for a defect on a sheet of titanium metal. Would this be the number of defects per square inch, foot, meter, or millimeter? Consider also: how might we define a defect for days sales outstanding (DSO) for an invoice? Should we consider the specification to be 30 days late or 90 days late? These two situations are quite different. For the first situation, an S^4/IEE approach would suggest choosing a convenient area opportunity for the titanium sheet, tracking over time this defect rate, and translating this rate into monetary and customer dissatisfaction terms. For DSO, we could track this metric as a continuous response using a 30,000-foot-level metric sampling strategy. We could then quantify from a probability plot (see Chapter 8) the estimated percentage beyond our desired response, perhaps the number of days beyond the due date of an invoice, where this due date could be 30, 60, or 90 days. Note that this probability plot could be from normal, log-normal, Weibull, or multiple distributions (see Chapter 9).

The S^4/IEE approach to Six Sigma implementation leads to other opportunities. Consider customer relationship management (CRM). Integrating sales, marketing, and customer service channels is important to an organization. Historically, implementing these CRM applications can cost more than realized in time, money, and lost opportunities. Companies want to automate key customer-facing business functions to deliver greater efficiencies and provide better customer service. We need to work on fire prevention rather than firefighting when working with customers. To do this, we need to have metrics and a process improvement strategy that drives the right type of activities. An S^4/IEE implementation of Six Sigma can address these needs.

Another application for the S^4/IEE methodology is a structured improvement methodology required for ISO 9000:2000. An organization could address the requirement by stating that the processes that it would be focusing on for improvement would be identified by the S^4/IEE implementation infrastructure. The project execution would then follow the S^4/IEE roadmap.

It is best if the CEO of a company embraces Six Sigma methods from the start. However, we have found this is not a prerequisite to initiate Six Sigma. Sometimes a CEO or other management wants to experience the success of Six Sigma first before committing to a organization-wide deployment. For this situation, whether the company is large or small, we have found that a company can send one to five people to a public black belt workshop and work from there with their deployment. True, this is typically a harder path for the black belt. However, we have seen that if an influential executive who truly wants to assess Six Sigma sponsors the black belt, this approach can work. For this rollout model, we conduct on-site executive and infrastructure building workshops either in the same time frame or upon completion of the black belt training. Sometimes with this approach, especially in small companies, the black belt can have multiple Six Sigma roles.

1.20 S^4/IEE ASSESSMENT

Often people suggest that Six Sigma is the same as total quality management (TQM). I disagree. However, before making any generalities about the advantages of Six Sigma over TQM, emphasis needs to be given that there have been implementation and success/failure differences for both TQM and Six Sigma. Some generic advantages of using an S^4/IEE implementation are:

- Focus is given to bottom-line benefits for organizations, where project monetary benefits are verified by finance. At the executive level this breeds excitement since improvement work is being aligned to the primary measure of success.

- A support infrastructure is created where specific roles exist for people to be full-time practitioners (black belts) and to fill other support/leadership roles (e.g., champions, green belts, etc.).
- Practitioners follow a consistent project execution roadmap, i.e., DMAIC.
- Rather than a quality program it is a business strategy that helps drive the business to the right activities.
- Projects are *pulled* (used as a lean term) for creation by the metrics that drive the business. However, I must note that often companies *push* (used as a lean term) when creating Six Sigma projects, which may not be the best utilization of resources.
- Voice-of-the-customer focus is given at both the satellite-level business metrics and 30,000-foot-level project execution metrics.

When implementing Six Sigma we need to capitalize on the lessons learned from other implementations (see Section A.2). My experiences are consistent with the summary of common case study attributes from Snee and Hoerl (2003):

Very Successful Case Studies

- Committed leadership
- Use of top talent
- Supporting infrastructure
  - Formal project selection process
  - Formal project review process
  - Dedicated resources
  - Financial system integration

Less Successful Case Studies

- Supportive leadership
- Use of whoever was available
- No supporting infrastructure
  - No formal project selection process
  - No formal project review process
  - Part-time resources
  - Not integrated with financial system

When organizations are considering making a change, they will consider associated costs but will not give adequate focus to the cost of not making a change. When organizations are considering the costs of implementing an S^4/IEE business strategy, they should look not only at direct costs of implementation but also at the costs associated with not implementing S^4/IEE, i.e., CODND.

S^4/IEE projects need to be of a manageable size, with consideration of the impact on the overall system and bottom-line improvements. Consider also including cost avoidance and soft savings in the bottom-line improvement of projects.

In development, S^4/IEE techniques can lead to earlier problem detection and fewer problem escapes, with reduced development time. In manufacturing, these techniques can lead to a reduced number of problem escapes, the problem being fixed the first time, and better process understanding. The economics associated with these results can be very significant. Figure 1.22 shows how product DFSS and DMAIC align with a product's life cycle (Scherkenbach 2002). Chapters 48 and 49 discuss the product DFSS process, which uses many of the DMAIC tools only in a different sequence (see Section 49.4).

It is important that management not only drive through the metrics, but also focus on asking the right questions leading to the right activity. A Six Sigma program can fail because emphasis is only on output measurements, not on real process improvement. For example, the type of management focus that reprimands workers when they do not meet an arbitrarily set target will surely make the numbers look good while real process improvement falls by the wayside. Consider making the primary focus of a Six Sigma business strategy a structured strategy for improvement, not a bureaucratic system for data collection and reporting. When creating the organizational infrastructure that supports a Six Sigma business strategy, it is important to utilize Deming's 14 points (see Section 54.2).

Finally, let us consider communications between practitioners and executives. The quality community for years has complained that management has not listened and supported its quality initiatives. The quality professionals blame management. I do not agree. In my opinion, we in the quality and process improvement field are to blame because in the past we often showed a lack of ability to communicate well in terms that executives understand.

To illustrate my point, consider traveling to a country and not speaking the language of that country. We should not expect everyone in the country to learn our language to communicate with us. We either have to learn the language or figure out an alternative way to communicate through a common language, like hand gestures. Similarly, a quality professional should not expect executives to take the time to learn everything there is to know about the language of the quality profession. The quality practitioner often needs to do a better job of communicating to executives using a language that they understand, namely, money.

One might argue that this communication strategy in money terms cannot be done and should not be done in all situations. The statement might be

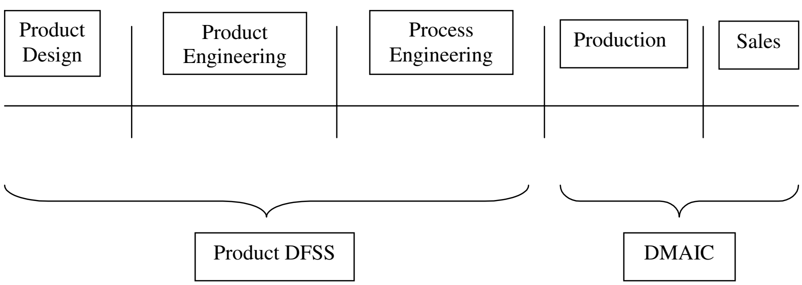


FIGURE 1.22 Product DFSS with DMAIC.

made that there are many activities that cannot be translated into money. I will not agree or disagree. However, I do believe that more issues can be translated into monetary terms than are currently receiving this translation. More importantly, consider a situation in which there are no communication problems between practitioners and the right things are getting done. For this situation, there is no reason to address changing the communication structure. However, if communication problems do exist between executive management and practitioners, perhaps more issues (and Six Sigma project work) should be communicated in monetary terms. Because of this change, a practitioner could receive more recognition for his or her accomplishments and additional support for future efforts.

Peter Senge (1990) writes that learning disabilities are tragic in children but fatal in organizations. Because of them, few corporations live even half as long as a person—most die before they reach the age of 40. ''Learning organizations'' defy these odds and overcome learning disabilities to understand threats and recognize new opportunities. If we choose to break a complex system into many elements, the optimization of each element does not typically lead to total system optimization; e.g., optimizing purchasing costs by choosing cheaper parts can impact manufacturing costs through an increase in defect rates. One focus of S^4/IEE is on avoiding optimizing subsystems at the expense of the overall system. With systems thinking we do not lose sight of the big picture. The methodologies of S^4/IEE offer a roadmap for changing data into knowledge that leads to new opportunities. With S^4/IEE, organizations can become learning organizations!

1.21 EXERCISES

1. Define satellite-level metrics for a for-profit company, nonprofit organization, school, religious organization, or political organization.
2. Create a strategic plan for improving a set of satellite-level metrics for one of the categories noted in Exercise 1.
3. Create a set of 30,000-foot-level operational metrics that are aligned with the Satellite-level metrics described in Exercise 1 and the strategic plan that is described in Exercise 2.
4. Describe an S^4/IEE project as a problem statement that you would expect would be pulled from the activities described in Exercises 1, 2, and 3.