OUR PLANS MISCARRY BECAUSE THEY HAVE NO AIM. WHEN A MAN DOES NOT KNOW WHAT HARBOR HE IS MAKING FOR, NO WIND IS THE RIGHT WIND.

SENECA (4 B.C. - 65 A.D.)

Lean Six Sigma Goals

The subject of Lean Six Sigma Goals is presented in the following topic areas:

- **Value of lean six sigma**
- **Origins of six sigma and lean**
- **Lean pioneers**
- **Quality and six sigma gurus**
- **Organizational leadership**
- **Metrics and goals**

Value of Lean Six Sigma

There is an ongoing debate in some organizations regarding the difference between lean and six sigma, and whether they are mutually exclusive. Toyota in particular is credited with making lean a well-known approach as embodied in the Toyota Production System (TPS). Lean is about eliminating wastes, taking time out of processes, and creating better flow. Asked about the essence of lean (TPS), Taiichi Ohno summarized it as, "All we're trying to do is shorten the time line ... from order receipt to collecting the cash for the goods or services provided."

Six sigma has been defined in a variety of ways. One definition states, "Six sigma is ... a business strategy and philosophy built around the concept that companies can gain a competitive edge by reducing defects in their industrial and commercial processes." (Harry, 2000)[24]

A few key characteristics of lean and six sigma are discussed and compared below. There are some explanations from the points of view of lean and six sigma purists.

Topic	Six Sigma	Lean
Improvement	Reduce Variation	Reduce Waste
Justification	Six Sigma (3.4 DPMO)	Speed (velocity)
Main Savings	Cost of Poor Quality	Operating Costs
Learning Curve	Long	Short
Project Selection	Various Approaches	Value Stream Mapping
Project Length	2 - 6 Months	1 Week - 3 Months
Driver	Data	Demand
Complexity	High	Moderate

Table 2.1 Comparison of Lean and Six Sigma Characteristics

Value of Lean Six Sigma (Continued)

Both six sigma and lean focus heavily on satisfying customers. Six sigma makes customers the primary driver for action in a "war on variation" and identifies opportunities that promise a large, fairly immediate, financial reward. Lean considers customer inputs and conducts a "war on waste."

One of the selling points that some six sigma gurus tout is that six sigma zeroes in better on "big bang" improvements. Black belts are expected to target and achieve large bottom line savings in projects every year.

Both six sigma and lean empower people to create process stability and a culture of continuous improvement. The cornerstones of a lean strategy are tools such as value stream mapping (VSM), workplace organization (5S), total productive maintenance (TPM), kanban/pull systems, kaizen, setup reduction, teamwork, error proofing, problem solving, cellular manufacturing, and one-piece flow.

Many problem identification and problem solving techniques are commonly used with both lean and six sigma methodologies. These include brainstorming, cause-and-effect diagrams, 5 "whys", Pareto analysis, 8-Ds, FMEAs, and others. Both six sigma and lean methodologies have a heavy emphasis on careful problem definition. Six sigma better promotes a rigorous, systematic process to find the true root cause(s) of the problem.

Value stream mapping (VSM) is the principal lean diagnostic tool. It is credited to Toyota, who called it material and information flow mapping. The methodology was developed into a viable tool for the masses by Rother and Shook in 1998 in the text *Learning to See* (2003)[50]. VSM creates a visual representation of what is happening in a process to improve system performance. Process mapping is a tool favored by the six sigma community and is best used to identify the inputs, outputs, and other factors that can affect a process. (Crabtree, 2004)[9]

Should six sigma and lean coexist in any organization? Ron Crabtree feels the answer to this question is self-evident: Yes. He feels that lean approaches should precede and coexist with the application of six sigma methods. Why? Put simply, lean provides stability and repeatability in many basic processes. Once stability has taken hold, much of the variation due to human processes goes away. The data collected to support six sigma activities thereby becomes much more reliable and accurate.

Value of Lean Six Sigma (Continued)

In management presentations, Ron Crabtree (2006)[10] depicts lean and six sigma tools on a linear continuum with lean six sigma in the middle. Mr. Crabtree asks if major business problems fall into the following categories:

- **There seems to be a lot of waste**
- **There is a need to minimize inventories and redundancies**
- **There is a need to improve work flows**
- **There is a need to speed up processes**
- **There are human mistakes**

If so, then lean tools should be utilized to:

- **Eliminate wastes**
- **Increase speeds**
- **Minimize inventories**
- **Simplify processes**
- **Improve flows**
- **Mistake proof processes**

However, if organization challenges exhibit the following attributes:

- **There are quality issues**
- **There is excessive variation**
- **There are complex problems**
- **There are challenging root cause identifications**
- **There are numerous technical considerations**

In these cases, six sigma tools should be utilized to:

- **Minimize variation**
- **Apply scientific problem solving**
- **Utilize robust project chartering**
- **Focus on quality issues**
- **Employ technical methodologies**

Most executives recognize that they have a combination of both sets of issues. Placing lean six sigma in the middle of this continuum reflects a more holistic and synergistic approach. If a specific problem requires only lean or six sigma tools, then that is perfectly ok. Lean six sigma is a relatively new paradigm providing broader selection approaches. If the only tool in a company's bag is a hammer, then all problems start to look like a nail. It is best to have a tool kit with a broader set of tools, principles, and ways of thinking. (Crabtree, 2006)[10] (Crabtree, 2004)[9]

Value of Lean Six Sigma (Continued)

What has been occurring for some time (at least the past several years) is a marriage of lean and six sigma initiatives into a unified approach called lean six sigma or some variant of this nomenclature. Presented graphically, if lean specific projects represent a 6% corporate improvement over time, and six sigma initiatives represent another 6% improvement, then a combination could potentially represent an improvement of 12% (or more). Refer to Figure 2.2.

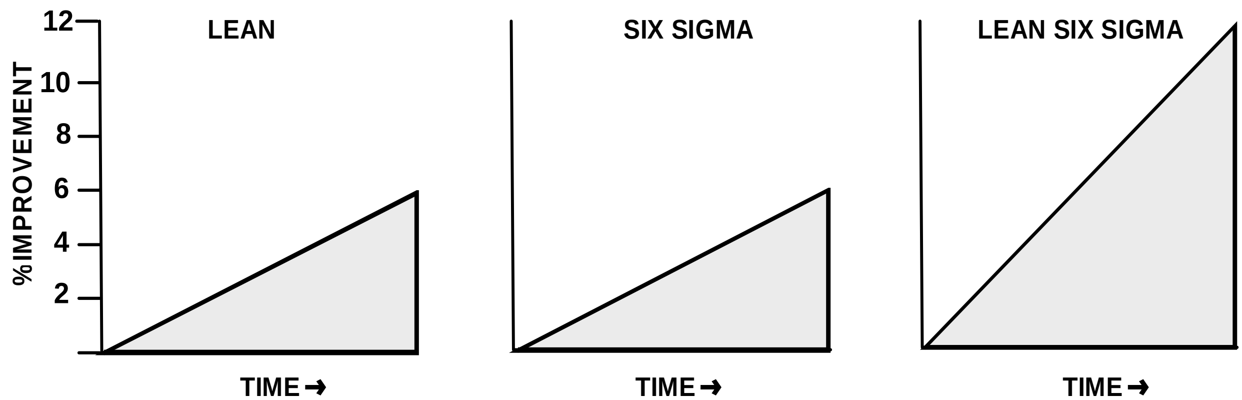

Figure 2.2 The Graphical Marriage of Lean and Six Sigma

Various authorities tout improvements (margins, inventory reductions, waste eliminations, etc.) ranging from 2% to 20%. These percentages depend upon the industry and the initial measurement base.

Quality Digest (November, 2006)[48] cites research from Avery Point Group (a search firm specializing in lean and six sigma placement) indicating that lean and six sigma are destined for eternal togetherness. According to Avery Point Group approximately one-half of employers are looking for employees with both lean and six sigma skill sets.

Six years ago, books published on the combined use of lean and six sigma were virtually nonexistent. Today, they represent almost one-half of the lean books and 25% of the six sigma books published. Tim Noble, manager of the Avery Point Group states, "Those companies that perpetuate the divide between six sigma and lean are clearly missing the point. The two are clearly complementary tool sets, not competing philosophies."

Value of Lean Six Sigma (Continued)

An increasing number of organizations (manufacturing, service, hospitals, municipalities, military, insurance, etc.) have been unifying their efforts into a lean six sigma approach. The mechanisms of these combinations vary widely. The most effective approaches include management direction and involvement, a cadre of trained specialists, the use of teamwork, the use of project management, team member training, the humane treatment of people, an understandable problem solving methodology, and some mechanism to apply the appropriate tool(s).

On the following pages are additional descriptions of six sigma and lean enterprise. This book unifies the discussion of lean six sigma by use of the DMAIC problem solving approach. Obviously, other systems would work equally well, as long as they are communicated and known to the organization. Refer to Figure 2.3 below for some applications of the various lean six sigma tools at various problem solving stages.

Define	Measure	Analyze	Improve	Control
Value Stream Mapping	Prioritization Matrices	Regression Analysis	DOE	SPC
Charter - Problem Statement	MSA Studies	5 - Whys	Kaizen Events	Visual Controls
Voice of the Customer	Capability Studies	Cause - Effect Diagrams	TOC	Control Plans
Communication Plans	Videotaping	Root Cause Analysis	Pull Systems	TPM
CTQ Issues	Time Studies	ANOVA	SMED/SUD	Standard Work
Business Results	SIPOC	Multi-Vari Analysis	5S or 6S	Procedures and Work Instructions
Benchmarking	Collecting Data	Hypothesis Testing	Work Flow Improvement	Training Requirements

(Missouri Enterprise, 2007)[40]

Table 2.3 Lean Six Sigma Tools in a DMAIC Matrix.

The student should note that there are a multitude of effective tools in addition to those listed above.

Six Sigma Introduction

Six sigma is a highly disciplined process that focuses on developing and delivering near-perfect products and services consistently. Six sigma is also a management strategy to use statistical tools and project work to achieve breakthrough profitability and quantum gains in quality. It has been stated that product characteristics with six sigma process capabilities ($C_{pk} > 1.5$) are of world-class performance. The average American company is at a four sigma level. (Harry, 1998)[23]. This would be the equivalent of 0.6% defective or 6,210 defects per million opportunities. Snee (1999)[59] describes six sigma as, "A business improvement approach that seeks to find and eliminate causes of mistakes or defects in business processes by focusing on outputs that are of critical importance to customers."

Motorola, under the direction of Chairman Bob Galvin, used statistical tools to identify and eliminate variation. From Bill Smith's yield theory in 1984, Motorola developed six sigma as a key business initiative in 1987. Many credit the resulting improvements as a key factor in Motorola winning the Malcolm Baldrige Award for Business Excellence in 1988. Dr. Mikel Harry, who had led the corporate effort, subsequently left Motorola and later founded the Six Sigma Academy. The purpose of the Six Sigma Academy is to accelerate the efforts of corporations to achieve world-class standards. (Harry, 1998)[23]

Sigma is a statistical term that refers to the standard deviation of a process with regard to it's mean. In a normally distributed process, 99.73% of measurements will fall within ± 3.0 sigma and 99.99932% will fall within ± 4.5 sigma.

Motorola noted that many operations, such as complex assemblies, tended to shift 1.5 sigma over time. So a process, with a normal distribution and normal variation of the mean, would need to have specification limits of ± 6 sigma in order to produce less than 3.4 defects per million opportunities. This failure rate can be referred to as defects per opportunity (DPO), or defects per million opportunities (DPMO).

Six Sigma Introduction (Continued)

Figure 2.4 illustrates the ±1.5 sigma shift and Table 2.5 provides some indications of possible defect levels.

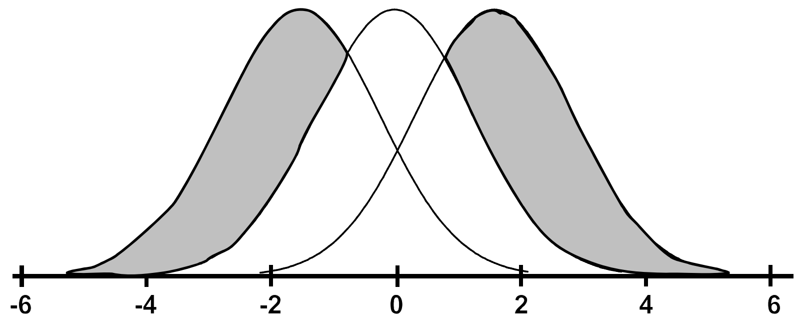

Figure 2.4 The ± 1.5 Sigma Shift

Sigma Level	ppm
6 sigma	3.4 ppm
5 sigma	233 ppm
4 sigma	6,210 ppm
3 sigma	66,810 ppm
2 sigma	308,770 ppm
1 sigma	697,672 ppm

Table 2.5 Defect Levels

Note that Table II in the Appendix provides defect levels at other sigma values. Various authors report slightly different failure rates based mainly upon rounding effects and slight miscalculations. Most of the differences occur at levels less than 3 sigma. However, in looking at this situation objectively, companies with less than 3 sigma capability, and with ± 1.5 sigma shifts, probably won't be around long enough to undertake a six sigma improvement effort anyway.

It should be noted that the term "six sigma" has been applied to many operations including those with distributions that are not normal, for which a calculation of sigma would be inappropriate. The principle remains the same, deliver near-perfect products and services by improving the process and eliminating defects. The end objective is to delight customers.

Six Sigma Introduction (Continued)

The six sigma steps for many organizations are described as DMAIC:

Define: Select the appropriate responses (the "Ys") to be improved.

Measure: Data must be gathered to measure the response variable.

Analyze: Identify the root causes of defects, defectives, or significant measurement deviations whether in or out of specifications. These are the "Xs" (independent variables).

Improve: Reduce variability or eliminate the cause.

Control: With the desired improvements in place, monitor the process to sustain the improvements.

Modified from (Hahn, 1999)[22]

Harry (2000)[24] proposes that the entire six sigma breakthrough strategy should consist of the following eight elements:

- **R** Recognize the true state of your business
- **D** Define what plans must be in place to realize improvement of each state
- **M** Measure the business systems that support the plans
- **A** Analyze the gaps in system performance benchmarks
- **I** Improve system elements to achieve performance goals
- **C** Control system-level characteristics that are critical to value
- **S** Standardize the systems that prove to be best in class
- **I** Integrate best in class systems into the strategic planning framework

Because of the integration of a number of tools, such as lean manufacturing, DOE (design of experiments), and DFSS (design for six sigma), six sigma has been referred to as TQM (total quality management) on steroids.

The business successes that result from a six sigma initiative include:

- Cost reductions
- Market share growth
- Defect reductions
- Culture changes
- Productivity improvements
- Customer relations improvements
- Product and service improvements
- Cycle time reductions

(Pande, 2000)[44]

Six Sigma Results

Motorola credits the six sigma initiative for savings of $940 million over three years. AlliedSignal (now Honeywell) reported an estimated $1.5 billion in savings in 1997. GE has invested a billion dollars with a return of $1.75 billion in 1998 and an accumulated savings of $2.5 billion for 1999. (Hahn, 1999)[22]

Harry (1998)[23] reports that the average black belt (or green belt) project will save about $175,000. There should be about 5 to 6 projects per year, per black belt. The ratio of 1 black belt per 100 employees, can provide a 6% cost reduction per year. For larger companies, there is usually 1 master black belt for every 100 black belts.

Snee (1999)[59] provides some reasons why six sigma works:

- **Bottom line results**
- **Senior management is involved**
- **A disciplined approach is used (DMAIC)**
- **Short project completion times (3 to 6 months)**
- **Clearly defined measures of success**
- **Infrastructure of trained individuals (black belts, green belts)**
- **Customers and processes are the focus**
- **A sound statistical approach is used**

Organizations that follow a six sigma improvement process for several years find that some operations achieve greater than six sigma quality. When operations reach six sigma quality, defects become so rare that when defects do occur, they receive the full attention necessary to determine and correct the root cause. As a result, key operations frequently end up realizing better than six sigma quality.

Companies that have embraced six sigma include:

- **Motorola**
- **General Electric**
- **Dupont**
- **Polaroid**
- **Kodak**
- **Sony**
- **Toshiba**
- **AlliedSignal**
- **Black & Decker**
- **Dow Chemical**
- **Federal Express**
- **Boeing**
- **Johnson & Johnson**
- **Navistar**

GE is a registered trademark of General Electric Corporation.
AlliedSignal and Honeywell are trademarks of Honeywell International, Inc.

Lean Enterprise *

The lean enterprise encompasses the entire production system, beginning with the customer. It includes sales outlets, the final assembler, product or process design, and all tiers of the supply chain (including raw materials). Any truly lean system is highly dependent on the demands of its customers and the reliability of its suppliers. No implementation of lean manufacturing can reach its full potential without including the entire enterprise in its planning.

Lean Manufacturing / Lean Production

Lean techniques are, in their most basic form, the systematic identification and elimination of wastes, the implementation of the concepts of continuous flow, and customer pull. The touted benefits of lean production systems include lower production costs, fewer personnel, quicker product development, higher quality, higher profitability, and greater system flexibility. By continually focusing on waste reduction, there is truly no end to the benefits that can be achieved.

Generally, five areas drive the lean producer: cost, quality, delivery, safety, and morale. Just as mass production is recognized as the production system of the 20th century, lean production is viewed as the production system of the 21st century.

Typically, Japanese terms are used in defining lean principles in order to convey broad concepts with iconic (representative) terminology. Once properly explained, the term "kanban" can be more descriptive than "those little cards which help control product moves." However, use of these terms can have a negative effect, especially if the culture of a particular organization is predisposed against all things non-American. One should choose carefully the training methods (and terms) for conveying lean tools and methods.

Lean Techniques in Service

Are lean techniques applicable in a service-oriented industry or office environment? Every system contains waste. Whether one is producing a product, processing a material, or providing a service, there are elements which are considered waste. The techniques for analyzing systems, identifying and reducing waste, and focusing on the customer are applicable in any system, and in any industry. Any implementation of lean techniques will be different, depending on various factors such as industry, internal culture, and internal business considerations. The tools used to implement lean operations, and the order in which one combines them, are highly dependent on whether a company is a discrete manufacturer, continuous producer, or provider of a service.

*** Modified from Northwest Lean Networks, (2006)[41]**

Lean Pioneers

The following is a list of major contributors to the concept of lean enterprise.

Lean Pioneer	Contribution
Frederick W. Taylor	Wrote *Principles of Scientific Management* Divided work into component parts Was the foremost efficiency expert of his day Applied scientific methods to maximize output
Henry Ford	Known as the father of mass production Advocated waste reduction Founded Ford Motor Company Brought affordable transportation to the masses
Sakichi Toyoda	Known as a hands-on inventor Developed the jidoka concept Initiated the Toyota Motor Company (TMC)
Kiichiro Toyoda	Continued the work of his father Sakichi Promoted mistake proofing concepts Became president of Toyota Motor Company
Eiji Toyoda	Was the cousin of Kiichiro Toyoda Developed an automotive research lab Hired outstanding people within TMC Became the Chairman of TMC
Taiichi Ohno	Created the Toyota production system (TPS) Integrated the TPS into the supply chain Had the vision and focus to eliminate waste
Shigeo Shingo	Developed the SMED system Assisted in the development of other TPS elements
James Womack Daniel Jones	Well-known promoters of lean enterprise Co-authors of major lean thinking books
Anand Sharma	CEO of TBM Consulting Group Author of prominent books on lean enterprise
Michael L. George	Widely known for lean six sigma books Founder of the George Group

Figure 2.6 Matrix of Lean Pioneers and Their Contributions

