
Six Sigma: A framework for successful implementation in South African firms

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LIST OF ABBREVIATIONS

CEO	Chief executive officer
CFO	Chief financial officer
COPQ	Cost of poor quality
C_p & C_{pk}	Process capability indexes
CQI	Continuous quality improvement
CTQ	Critical to quality
CSFs	Critical success factors
DMAIC	Define Measure Analyse Improve Control
DOE	Design of experiments
DPMO	Defects per million opportunities
FTY	First time yield
GE	General Electric
ISO	International Organization of Standardization
IT	Information technology
PPM	Parts per million
QFD	Quality function deployment
QM	Quality management
R&D	Research and development
ROI	Return on investment
SMART	Specific, Measurable, Achievable, Relevant, Time-Bound

SMEs	Small and medium sized enterprises
SPC	Statistical Process Control
TQM	Total Quality Management
σ	Sigma

Abstract

Title: Six Sigma: A framework for successful implementation in South African firms.

Key terms: Six Sigma, quality improvements, continuous improvement, return on investment (ROI), financial benefits, competitive strategy, critical success factors.

There can be little doubt that Six Sigma is far more than just another novelty concept; in fact, it can be considered as a proven quality philosophy and if applied correctly, ensures a competitive advantage. A rapidly increasing number of firms, from all industries and of all sizes, are now reporting significant savings or returns on their program and training investments, because of the implementation of Six Sigma.

This paper investigates the origin, definition, financial benefits and challenges of Six Sigma and its implementation. Certain critical success factors determine the successful implementation of Six Sigma in any firm. Many firms have reported significant benefits as a result of six sigma project implementation, though not all are yet success stories. This paper reviews the literature related to the critical success factors for the effective implementation of Six Sigma.

This research will provide the useful information for firms, which are willing to implement Six Sigma and help firms avoid the risks during the process of Six Sigma implementation.

The primary objective of this exploratory research is to identify the critical success factors required for the successful implementation of Six Sigma. Then, based on the critical success factors identified in literature and the survey, the purpose is to develop and propose an applicable framework for firms to successfully implement Six Sigma.

The research is explorative of nature and a survey research design was used with a questionnaire as data-gathering instrument.

Descriptive statistics (e.g. means and standard deviations) were used to analyse the data.

The results confirmed that the most critical success factors for successful Six Sigma implementation include management commitment, change management, effective communication and alignment. The proposed framework presents six interlinking components of Six Sigma which is dependent on these four critical success factors.

Limitations in the research are identified and recommendations for future research are made.

CHAPTER ONE: NATURE AND SCOPE OF THE STUDY

1.1 INTRODUCTION

In the growing competitive market environment, customers are always demanding high quality of products or services offered to them. In this situation, quality improvement activities have become a part of the business culture and a way of life. (Gijo and Rao, 2005: 721)

There can be little doubt that Six Sigma is far more than just another novelty concept, in fact, it can be considered as a proven quality philosophy and if applied correctly, ensures a competitive advantage. A rapidly increasing number of firms, from all industries and of all sizes, are now reporting significant savings or returns on their programs and training investments, because of the implementation of Six Sigma. (*Strategic Direction*, 2003: 34)

Antony (2006) points out that the adoption of Six Sigma as a business strategy by large multinational corporations has resulted in reports in professional magazines and journals and on websites of the success achieved by firms such as General Electric (GE), Honeywell, Motorola, Seagate Technology, Caterpillar, Raytheon, ABB, Bombardier and Sony, to name a few.

Coronado and Antony (2002: 92) however argues that, not all firms can claim to have had the same benefits. Coronado and Antony refer, according to David Fitzpatrick, worldwide leader of Deloitte Consultant's Lean Enterprise practice:

... fewer than 10 per cent of the firms are doing it to the point where it's going to significantly affect the balance sheet and the share price in any meaningful period of time. These contrast results making Six Sigma implementation a complex and central process, where the critical success factors (CSFs) in the implementation of Six Sigma must be recognised.

In the context of Six Sigma project implementation, CSFs represent the essential ingredients without which a project stands little chance of success.

Byrne (2003: 43) also suggests that, regardless of the particular goal—whether it is to reduce process variation, cut costs, improve efficiencies, or deploy key business strategies—many Six Sigma initiatives either fail entirely or never live up to their full potential because firms do not follow an appropriate roadmap to ensure their full success.

Oke (2007: 109) suggests that, understanding the key features, obstacles and shortcomings of Six Sigma methods allows top management better to support their strategic directions and increasing needs for coaching, mentoring, and training.

1.2 PROBLEM STATEMENT

Rathey (2004) poses the question that, if Six Sigma is that powerful – and the success of firms like GE and 3M is hard too gainsay – then why isn't everyone doing it? According to consultant Tilla van der Walt, the awareness of the methodology is still fairly low. Although Six Sigma was developed in the U.S.A. more than 18 years ago, it has only been practised in South Africa since 2003. The few specialist consultants are too busy consulting to devote time to the promotion of Six Sigma, and in the past there were few forums at which firms could learn about it. This is changing, though, as multinationals drive change through to their local subsidiaries and a Six Sigma user group helps newcomers get to grips with the concept.

Substantial and quantifiable results are quoted in the literature in regard to savings achieved by firms adopting the Six Sigma approach. The question is: can these results be achieved by any firm which adopts this fairly fixed and rigid framework to quality improvement? (Rowlands, 2003: 18)

The challenge is to effectively structure, implement, and maintain a robust Six Sigma program, which is an integrated system to manage and control the quality of all processes that directly or indirectly produce products or services. The objective of this research is to identify and discuss what the critical factors that contribute to a successful Six Sigma program are.

1.3 RESEARCH OBJECTIVES

The objectives of this study is divided into a primary and secondary objectives.

1.3.1 Primary objective

The primary objective of this exploratory research is to identify the critical success factors (CSFs) required for the successful implementation of Six Sigma and to propose a framework for successful implementation of Six Sigma in South African firms. Thus, for top management, the Framework can serve as a guideline for them to plan and deploy their own Six Sigma program.

1.3.2 Secondary objectives

The secondary objectives of this study are to;

- Establish a sound knowledge of the Six Sigma methodology,
- Identify the financial benefits and cost implications of Six Sigma
- Evaluate the status of Six Sigma implementation in South Africa

1.4 RESEARCH METHODOLOGY

In this study, two techniques were applied in the execution of the research. In phase 1 a literature review was conducted and in phase 2 an empirical study was done.

1.4.1 Phase 1: Literature review

In the first phase, a literature study was undertaken to determine what Six Sigma is and to gain insight into the methodology of Six Sigma and its potential financial gains. This study also illustrates the essential or key ingredients which are necessary for the effective implementation of Six Sigma and identifies barriers towards implementation.

The literature research was conducted through the utilisation of the Internet, published books, journals, articles and previous studies conducted in the specific field of Six Sigma implementation.

The goal of this review was to build a sound theoretical foundation on Six Sigma. The literature review included the financial benefits reported by many firms.

1.4.2 Phase 2: Empirical study

In the second phase, an empirical study was undertaken. A predetermine short questionnaire (Appendix 3) to determine the CSFs for successful Six Sigma implementation and financial gains of Six Sigma for firms in South Africa.

The goal of the empirical research was thus to critically evaluate the current status of Six Sigma implementation locally.

- **Research Design**

The research is explorative of nature. The major purpose of exploratory research is the development and clarification of ideas and the formulation of questions for more precise investigation later. Typically, this type of research involves gathering a great deal of information from a small sample. (Struwig & Stead, 2004: 41)

A survey design is used to obtain information regarding the population's status of Six Sigma deployment. Participants were informed that the

purpose of the questionnaire (research instrument) was to gather voluntary responses about various aspects of their Six Sigma implementation.

Cooper and Schindler (1998: 18) illustrates that the advantages of a self-administered survey is, low cost and an expanded geographical coverage. The disadvantages however are a low response rate and that no illustrations are available.

Due to the nature and limitations of this study, the widely dispersed respondents, few Six Sigma firms and, limited resources an email survey was selected to reach most of the population.

- **Participants**

According to one of the Six Sigma consulting firms, there are currently 45 firms in South Africa who has implemented Six Sigma. Two Project Management / Consulting firms, who facilitate the implementation of Six Sigma, have established user group forums for their clients. The largest forum is represented by ± 55 percent of the firms. The second forum is represented by ± 30 percent of the firms. The questionnaire was emailed to the Project Management / Consulting firm, representing the largest forum, for distribution and completion amongst their clients. The second Project Management / Consulting firm hosted a symposium for their clients and the questionnaire was distributed at the symposium for completion, thus because of the relative ease of access convenience sampling was used in this case.

- **Statistical Analysis**

Descriptive statistics (e.g., means and frequencies) are used to explore the data. Correlation analyses are used to investigate the correlation between the variables in this study. Cleaning of the data was done by replacing missing values with the mean value of the total set.

1.5 LIMITATIONS OF THE STUDY

In this section, the limitations of the study are addressed:

- Six Sigma deployments in South Africa is still in its infant stages, thus the opinions of the respondents will be limited to their relatively short exposure period to Six Sigma. This may limit the representativeness of the findings. This implies that the proposed framework may be limited from the perspective of the respondents as to what are the critical success factors for Six Sigma implementation. Additional research will be needed to address this issue, and will be discussed in the future research section.
- Being exploratory in nature, the findings were descriptive for the most part and not explanatory. Therefore, the study identifies the "what" about Six Sigma deployment and implementation, but does not explain "why".
- Although the proposed framework (roadmap) provides guidance for how to roll out a Six Sigma program, the success of implementing Six Sigma is dependent upon the skills of the implementers, especially when dealing with the culture and change management components of the framework.
- The framework may need to be adapted according to the size and resource availability of the firm

1.6 LAYOUT OF THE STUDY

Chapter 1

This chapter is an introduction to the mini-dissertation. The discussion in this chapter is devoted to issues such as the problem statement, objectives of the study, demarcation of the field of study, research methodology and limitations of the study.

Chapter 2

Six Sigma is considered one of the most popular quality methodologies. However, what is Six Sigma, why does it work, and how it works are questions

addressed in Chapter 2 which provides an overview of the Six Sigma methodology.

Chapter two contains a literature study on particular aspects of Six Sigma. This chapter will include definitions of Six Sigma, the methodology of Six Sigma, the need for Six Sigma, financial benefits of implementing Six Sigma, CSFs – and hurdles in the implementation of Six Sigma.

Chapter 3

This chapter contains the exploratory empirical study with specific findings on research conducted on the topic of Six Sigma implementation in South Africa.

Chapter 4

A framework roadmap is proposed that includes the activities, principles, tools, and important component factors that can be used to successfully implement Six Sigma. The goal is that the framework can be used by firms in South Africa interested in becoming familiar with the six-sigma philosophy as a means of strengthening their competitive position.

Chapter 5

This is the final chapter, where conclusions are reached and recommendations are made regarding the successful implementation of Six Sigma. In conclusion, steps to Six Sigma success is discussed as well as key considerations in selecting a Six Sigma partner (consultant).

1.7 CHAPTER SUMMARY

In chapter one, the problem from which the study evolved has been stated. In addition to this, the primary and secondary objectives, which the study aims to achieve, were defined. Furthermore, the method of research, and its limitations were described.

To be able to achieve the goals laid down in this chapter, it is essential to gain specific knowledge in the field of Six Sigma. Chapter two contains specific literature on Six Sigma.

CHAPTER TWO: SIX SIGMA FUNDAMENTALS

2.1 INTRODUCTION

Rathey (2004) quotes, Jack Welch of GE said: "Six Sigma will be the biggest and, in the end, the most profitable undertaking in our history."

Long (2004) also suggests that, one of the most dynamic processes in the field of quality control over the last thirty years has been Six Sigma as pioneered by Motorola.

Antony (2006) further argues that Six Sigma has been recognised as the most powerful management strategy that utilizes statistical and non-statistical tools and techniques to maximise a firm's return on investment (ROI) through the elimination of defects in all processes: manufacturing, service and/or transactional.

One of the aspects that distinguish Six Sigma from other approaches is a clear focus on obtaining bottom-line results in a relatively short three to six-month period of time. This has enabled Six Sigma to obtain strong support from top management of many firms (Levine, Stephan, Krehbiel & Berenson, 2005: 755).

Keller (2003) suggests that most firms today operate between Three and Four Sigma, where the cost of quality is 15 to 25 percent of revenue. Considering that 25 percent of revenue is wasted in a Three Sigma firm, it is clear there are tremendous opportunities for advancement to a Six Sigma level. A properly designed and deployed Six Sigma program will provide financial benefits that quickly overwhelm the costs.

The Six Sigma concept in South Africa is still in its beginning phases. Not many firms are familiar with Six Sigma and how to implement it. Critical success factors determine the successful application of Six Sigma in any firm. One of the objectives of this study was to present the key ingredients, which are essential for Six Sigma implementation. The purpose of this dissertation is also to review the basic concepts of Six Sigma, its benefits, and successful approaches for implementation. It also provides information, based on a literature review, on the

financial benefits of Six Sigma implementation. Six Sigma will be explained firstly by providing a short, historical background of where it comes from and how it evolved. This will be followed by defining Six Sigma and provide business definitions and theoretical (statistical) definitions of Six Sigma. Once defined, the methodology of Six Sigma followed by the philosophy of Six Sigma will be explained.

Financial benefits of implementing Six Sigma will be presented. Finally the critical success factors (CSFs) for Six Sigma implementation will be identified.

But first of all, why should any firm consider Six Sigma?

2.2 THE ORIGIN OF SIX SIGMA

2.2.1 Historical development

Török (2007: 33) discusses the historical development of Six Sigma, providing a framework from its initialisation (1920s), how it has developed and the strength gaining thereof. Török categorises the development process into the following:

- The Foundation years;
- Embellishment period;
- The Breakthrough stage; and
- The Perfect Storm period.

These four categories will be discussed in the next sections.

- **The Foundation Years: 1920-1940**

Despite earlier developments in management theory, the first true thought leaders of process oriented quality management appeared in the decades after World War I. The three most important names in quality in the United States at the time were Deming, Juran and Walter Shewhart.

Shewhart and Juran were both working at Bell Telephone Laboratories to achieve quality and uniformity in manufacturing. It was there, in the 1920s, that Shewhart developed the first control charts, marking the first application of statistics to manage

process variability and establishing what became known as statistical process control (SPC) (Török, 2007: 33).

- **The Embellishment Period: 1950-1970**

In the 1950s, both Juran and Deming gave lectures and seminars in Japan about managing quality and throughout the following decades both men developed close relationships with industrial leaders there. From them, the Japanese learned two key things - the application of statistical methods to measure and control process variability, and the responsibility of management for quality.

Taking what they learned, people such as Taiichi Ohno (Toyota Production System), Kaoru Ishikawa (fishbone diagram, statistical thinking on the shop floor), Genichi Taguchi (loss function, robust designs in design of experiments, or DOE), as well as Yoji Akao and Shigeru Mizuno (quality function deployment, or QFD) and Masaaki Imai (Kaizen) went on to develop new tools and methodologies to support quality.

Török (2007: 33) uses the Toyota Production System as a good example of all the above. During this 30-year period, Toyota became skilled at running manufacturing operations with minimal waste and inventory, and maximal right-the-first-time production quality. The ability of Toyota and other manufacturers to produce top-quality cars at low cost became the envy of the automobile industry worldwide and was a major catalyst, triggering the next historical phase of quality.

- **The Breakthrough Stage : 1980s**

Török (2007: 33) argues that one event is considered a major turning point in the awareness of American industry regarding Japanese quality, namely the return of Deming (from Japan) to the U.S.A. This created a surge in demand for his teachings, as well as his time. In particular, the Ford Motor Co., keen to catch up with the Japanese, developed a long and close relationship with the quality expert.

Török (2007: 33) describes two more developments which had a profound effect on quality and process awareness - the expansion of international financial markets

(because of the growth in private pensions and funding of new technology) and the expanding consulting industry. The combined forces rekindled the interest in quality as a way of creating shareholder value and led to consulting products to help attain it.

Various methodologies in the 1980s helped Western firms address the success factors of quality and competitiveness. Including Total Quality Management (TQM), Lean production, and the Japanese consultant Masaaki Imai's Kaizen, all based on varying combinations of Juran/ Deming's fundamentals and the Japanese experience in applying them. It was around this time, at Motorola, that Six Sigma had its beginnings as a tool to manage production variation using rigorous statistical analysis.

Despite the developments, Török (2007: 33) also makes mention of the disappointments during this period. Török suggests that although the learning during this period was great, so, unfortunately, were some of the disappointments. Despite all the enthusiasm for the rediscovery of quality by a new generation of leadership, the strong connection between process and business performance did not occur broadly. Quality programs remained largely the isolated responsibility of "traditional" quality departments that too often suffered from insufficient management support.

- **The Perfect Storm Period: 1990s**

Török (2007: 33) argues that the stirrings of change in the 1980s set the scene for the coming storm of the 1990s. As new communications technologies took root, this period was marked by accelerating globalisation and emphasis on process quality for gaining and maintaining a competitive edge. Török cites that at Motorola and Allied Signal (since changed to Honeywell), financial accountability was added to the in-depth statistical approach of Six Sigma, turning it into a strategic framework that made the connection between process results and the bottom line. By mid-decade, it caught the attention of Jack Welch, CEO at GE, who then proceeded to create a vision for his firm based on the full implications of Six Sigma. GE made Six Sigma the firm's global strategic platform. This very visible example turned the tempest of

quality into a major storm, catching the attention of financial markets and the imagination of Welch's counterparts around the world.

Török (2007: 33) concludes, suggesting that now that Western management has finally understood the link between superior process quality and the bottom line, the pace of learning keeps accelerating. Far from slowing down, Six Sigma appears to be gaining strength on its path.

Understanding the origin of Six Sigma and how it has evolved, it is now important to define Six Sigma and explain its modern day philosophy.

2.3 SIX SIGMA DEFINITIONS AND LEVELS

2.3.1 Business definition

Jacowski (2006) defines Six Sigma as a strategic approach that works across all industries, firm functions, processes, and products. Six Sigma has both management and technical components. On the management side it focuses on getting the right process metrics and goals, the right projects and right people to work on the projects and use of management systems to successfully complete the projects and sustain the gains over time. On the technical side the focus is on enhancing process performance (improving the average level of performance and reducing variation) using process data, statistical thinking and methods, and a disciplined and focused process improvement methodology which has four key stages: measure, analyse, improve and control. The statistical and other tools (the tools are not all statistical) are linked and sequenced in a unique way that is both easy to use and effective. The approach focuses on the identification of the key process drivers (variables with the largest effects) and relies on software packages for the statistical calculations.

Das Sarma (2007) confirms this strategic approach, arguing that Six Sigma is a management system/business strategy which has delivered huge business benefits to many firms across the globe, cutting across all industry boundaries. Snee (2001) also indicates that Six Sigma is focused on improving process performance in such a way that the bottom line is also improved. Six Sigma utilizes the project-by-project approach to improvement in which the projects are linked to

business priorities; those issues that are important to the success of the firm and of keen interest to management.

A survey conducted by the Aberdeen Group (2006), reveals the financial aspect of Six Sigma is included in stating that Six Sigma is an integrated, disciplined approach for reducing defects and producing measurable financial results.

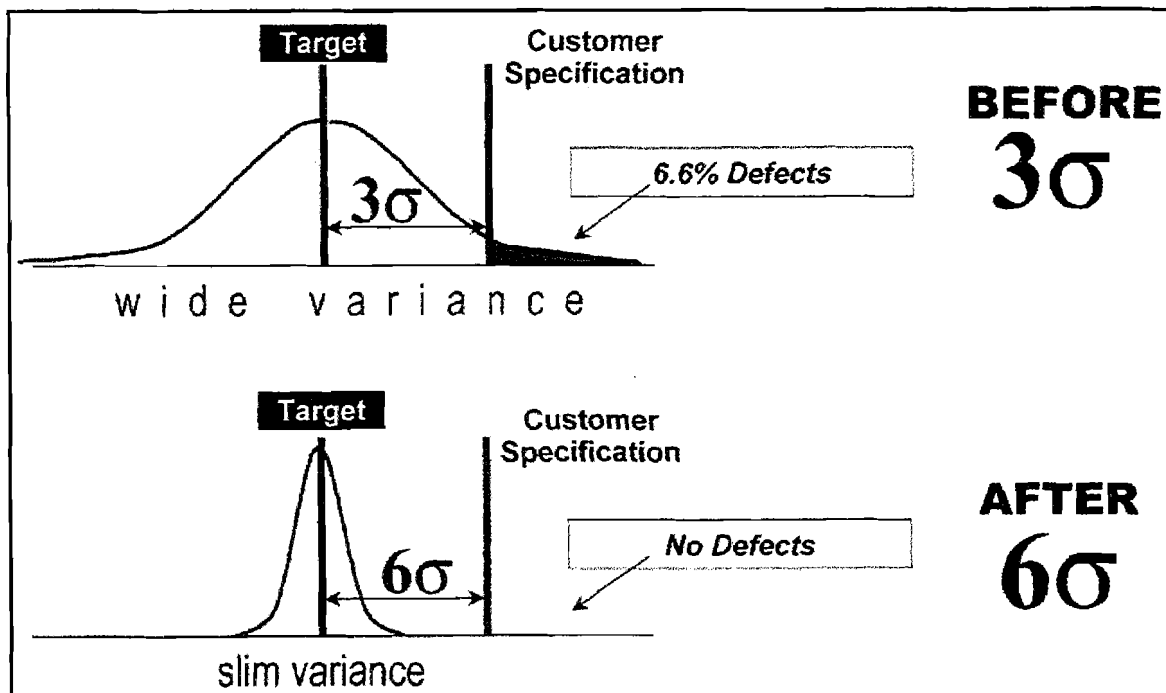
Neusscheler-Fritsch and Norris (2001) include the shareholder in their definition, arguing that Six Sigma is about delivering value to the shareholder. It is all about driving results: creating, preserving and realising value. In this way, it links the customer to the shareholder.

2.3.2 Statistical definition

Leblanc, McLaughlin, Freedman, Sager and Weissman (2004: 19) define Six Sigma as follows: Sigma is a Greek letter used to describe the amount of variation in a process or procedure. Traditional, continuous quality improvement efforts focus on improving average scores. A Six Sigma approach focuses not only on consistently achieving high average scores, but also on minimising the variation in the process. In other words, a Six Sigma approach can make good processes and procedures even better. As shown in Figure 2.1, processes which obtained high sigma levels have less variation and fewer defects, and are tightly centred in customer specifications or targets. A process performing at Six Sigma has fewer than 4 defects per million opportunities. In other words, there is virtually no deviation from desired performance. In contrast, a process performing at a Three Sigma level has 67,000 variations from desired performance.

Table 2.1 depicts how sigma levels relate to part per million (ppm) levels.

Figure 2.1: Processes with high versus low sigma values



(Source: Adapted from Leblanc, McLaughlin, Freedman, Sager and Weissman, 2004: 20).

Revelle (2004: 38) classifies Six Sigma performance in different sigma (σ) levels.

Table 2.1: Sigma level: PPM transformation

σ Level	Process Centred	Process Shift = $\pm 1.5s$
0.5	617,075 ppm	841,345 ppm
1	317,311	691,462
1.5	133,614	500,000
2	45,500	308,538
2.5	12,419	158,655
3	2,700	66,807
3.5	465	22,750
4	63	6,210
4.5	7	1,350
5	57 ppb	233
5.5	38	32
6	2	3.4
6.5	0.1	0.3
7	0.001	0.02

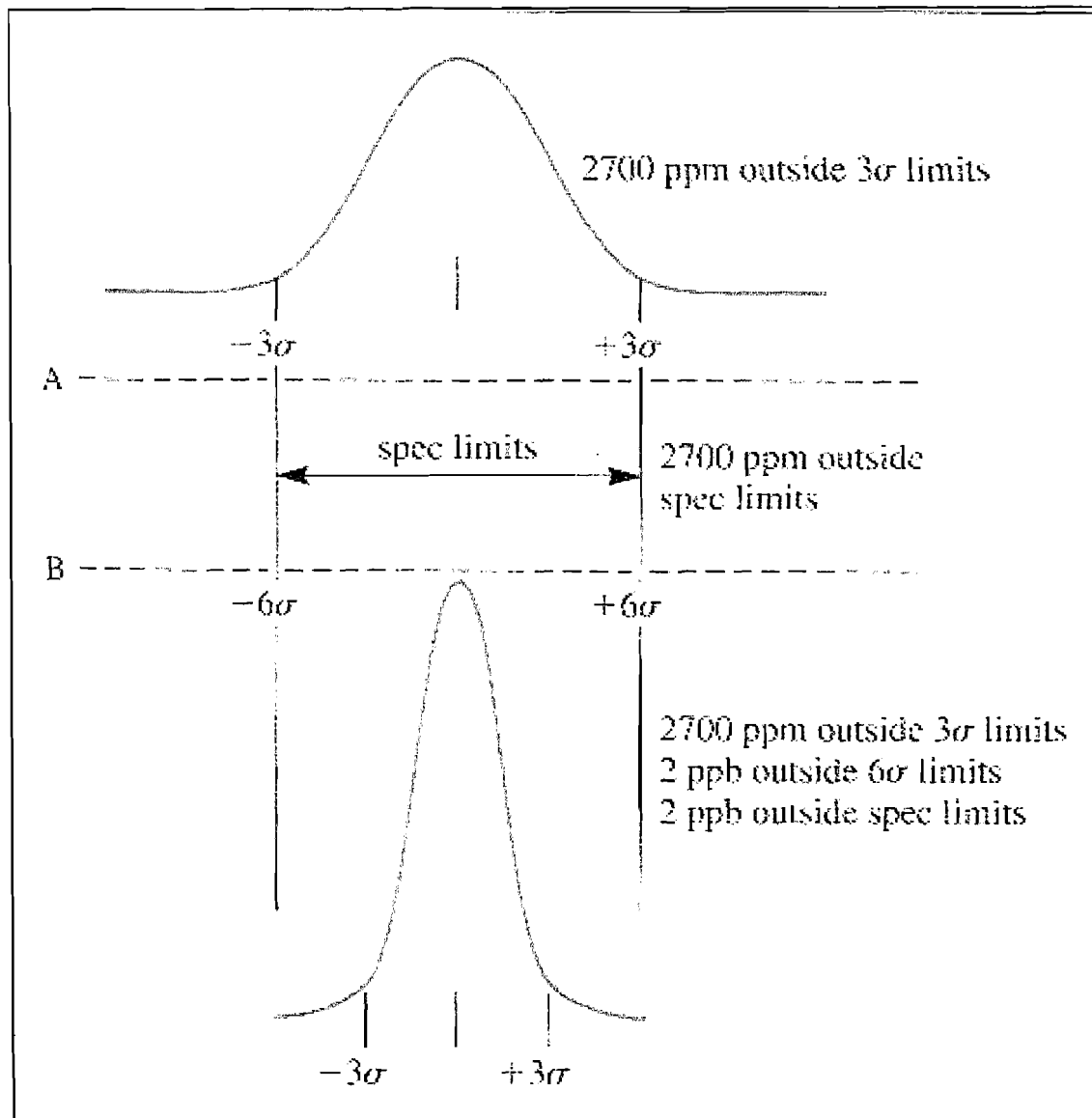
(Source: Adapted from ReVelle, 2004: 41 Journal of the American Society of Safety Engineers, October 2004)

A process in a cardiac catheterization laboratory is used to illustrate the statistical approach of Six Sigma. Six Sigma is based on the philosophy that every process can be described in terms of a mathematical equation of $Y = f(x_1, x_2, x_3, \text{etc.})$, where the outcome or Y is dependent upon other factors—the x 's. For example, on-time case starts in a cardiac catheterization laboratory (Y) are dependent upon the availability of staff (x_1), the availability and timeliness of the physician, (x_2 and x_3), patient availability and readiness (x_4 and x_5), and equipment/room availability (x_6). The statistical rigour of Six Sigma assists the team in identifying and addressing those vital few x variables that affect the outcome versus those factors that have minimum to no impact on the desired outcome.

2.3.3 Six Sigma Levels (Two-, Three-, Four-, Five-, or Six Sigma)

Chase, Jacobs and Aquilano (2004: 279) compare Three Sigma and Six Sigma distributions. Suppose that the outputs of a process are normally distributed as shown above line A in Figure 2.2. By the definition of $\pm 3\sigma$ (σ is the standard deviation), 99.73 percent of the outputs are within $\pm 3\sigma$ of the mean and, therefore, 0.27 percent are outside $\pm 3\sigma$ of the mean. Thus, if the specification limits of the product are set equal to $\pm 3\sigma$ for the process, one could expect 0.27 percent of the outputs to be out of specification. That is, one could expect 2.7 units per thousand or 2700 units or part per million (ppm) to be out of specification. Suppose one decides that a defect rate of 2700 ppm is too high. If the specification limits are kept at the same level and the process is improved so the output variation is much less, the probability of producing a unit out of specification will go down. This is shown below line B in Figure 2.2. In particular, suppose the process is improved to the point where the interval of natural variation ($\pm 3\sigma$) of the process is half of the interval of the specifications' limits (which then, by definition, will be $\pm 6\sigma$ for the process outputs). Then, the probability of producing a unit outside the $\pm 3\sigma$ interval remains 0.0027 (by definition of $\pm 3\sigma$), but the probability of having a part produced out of the specification interval is an order magnitude less – about two parts per billion (by the definition of $\pm 6\sigma$).

Figure 2.2: Comparison of Three Sigma and Six Sigma distributions



(Source: Adapted from Chase, Jacobs & Aquilano, 2004: 279).

Antony & Kumar (2005: 865) explains the financial benefit of improving from a Three Sigma level to a Four Sigma level. For instance, if a customer-order fulfilment process is operating at Three Sigma quality level (i.e. 66 800 defects per million opportunities) and the firm improves the level to Four Sigma quality level (i.e. 6 210 defects per million opportunities), this would realise a 10-fold improvement in operating performance. Assume each error or mistake costs, on average, \$5 to fix, the resulting savings would be in the range of \$300 000.

Antony and Banuelas (2001: 119) conclude that Six Sigma can be defined in both statistical and business terms. In business terms, Six Sigma is a business improvement strategy used to improve profitability, eliminate waste, to reduce quality costs and improve the effectiveness and efficiency of all operations that meet or even exceed customers' needs and expectations.

In statistical terms, Six Sigma is a term that refers to 3.4 defects per million opportunities (DPMO), where sigma is a term used to represent the variation about the process average. One key to the success of the Six Sigma program is the step-by-step approach or road map using Define-Measure-Analyse-Improve-Control (DMAIC) methodology (Antony & Banuelas, 2002).

2.4 WHY FIRMS SHOULD CONSIDER THE IMPLEMENTATION OF SIX SIGMA

This section will discuss why firms should consider the adoption of Six Sigma as a quality improvement strategy and identify the driving forces justifying a quality methodology like Six Sigma.

Thevnin (2004: 195) provides some of the driving forces, arguing that the competitive business environment has created a high degree of complexity, which caused a paradigm shift in quality and customer satisfaction. As a result, many firms, like Allied Signals, Motorola, and GE, tapped into a quality concept of some sort to help them stay ahead of the curve in meeting both internal and external customers' expectations. The concepts range from total quality management (TQM), continuous quality improvement (CQI), to the new evolutionary tool appearing in the mid 1980s known as the Six Sigma.

In scanning and assessing the business environment in which a firm operated, most firms realised that they would not be able to achieve competitive superiority if they did not become quality conscious. So, the need to adopt a quality concept and chart their business strategy in that direction became paramount for their core competence, and such deployment ever since has become exponentially more

compelling as the business environment gets more sophisticated. Basically, a quality concept to help better the firm's position in the market environment was seen as a prerequisite to having a competitive advantage. In addition, it helps command a lasting and sustaining growth, which in the long run helps any firm win a unique image in the industry environment.

Most firms, particularly those with tangible products, became hard pressed to find the right concept to help them achieve operational efficiency. Six Sigma in the 1980s became the quality concept of preference and some of the noted firms that adopted it and experienced a change in their operational efficiency were Motorola, Scott Paper, Allied Signals and GE (Thevnin, 2004: 195).

Ferguson (2007) explains that as customer expectations continue to rise and the sophistication of products and services increases, there is simply no room for operational error. The challenge for business today is to manage increasingly complex processes at lower overall cost, whilst at the same time improving customer service in an ever more competitive marketplace.

A survey conducted by the Aberdeen Group (2006) argues, whether driving Six Sigma programs or other quality initiatives, it is clear that the key business drivers revolve primarily around the bottom line, although in striving for competitive advantage, many also seek to impact the top line as well. While quality metrics, including defect rates, may appear to take a back seat to producing financial results, most quality programs are built around the principle that assumes striving for zero defects can reduce absolute product costs by as much as 20 to 30 percent.

Das Sarma (2007) considers why firms take up process improvement initiatives. Das Sarma argues that the reasons fall into the following three broad categories:
Due to requirement from customer: Many clients demand that their vendors should follow a quality model like International Organization of Standardization (ISO). Thus, this becomes the minimum requirement (hygiene factors) to get business from these clients.

To establish parity with competition: A smaller number of firms follow process improvement models because it is fashionable to do so; sometimes these firms are under competitive pressure. Thus their main objective for starting process improvement activities is to be ahead of their competitors so that they are viewed in a good light by their clients.

To improve organizational business performance: Too few firms take up process improvement purely to improve actual business performance. And similarly, too few CEOs truly think that quality improvement can lead to bottom line gain and thus it makes sense to invest in quality.

2.4.1 Competitive advantages of Six Sigma

CEOs and boards of directors are under continual increase in pressures to maintain a competitive edge in everything their firms do and to achieve complete customer satisfaction and ultimately shareholder satisfaction.

Wessel and Burcher (2004: 264) explain that quality management (QM) in general deals with permanently redirecting a firm's macro and micro operations towards the needs of internal and external customers. To maintain and extend competitive advantages in all dimensions and markets, firms shift increasingly from defining quality as a task that can be run by a quality department, to seeing it as the overall long-term umbrella objective of their business. In contrast, Six Sigma strives for a complete and profitable fulfillment of customer requirements. By only performing projects which support the core firm value drivers, Six Sigma explicitly considers a second main receiver of a firm's performance – the capital provider. Therefore, Six Sigma is characterized as a profit centre, not a cost centre, which has a major impact on the QM approach, while still based in the fundamental methods and tools of traditional QM.

Thevnin (2004: 195) explains that the significant competitive advantage that can be obtained from implementing Six Sigma is by way of the three basic resources: customer, process, and employee. The strengths, weaknesses, and the opportunities of these resources, as stimulated by the Six Sigma concept in some

way or another, tend to enrich organizational culture and view on quality and improve its position and strength in the market in which it operates.

The blending of the Six Sigma concept into the firm's culture could result in unique acknowledgement of some of the tangible factors that could give the firm competitive edge and superiority. It will also enable the firm to be cognisant of some of the intangible factors that are intrinsic, thus creating unique value to the firm that is irreplaceable by others. Six Sigma alone as a concept does not guarantee success; rather, it is the way firms adopt it and channel it into the organizational culture that helps achieve successful results.

2.5 SIX SIGMA'S BELT SYSTEM

Rowlands (2003: 18) defines the belt system used in Six Sigma. The Six Sigma training is based on a hierarchy of trained personnel classed as champion, master black belt, black belt, green belt and more recently, some firms have introduced a yellow belt, with each trained to a different level of competence. Typically, the training for a black belt would be based on a 20-day program interspersed with hands-on application at the firm.

In general terms the **Six Sigma champion** is the quality leader whose key role is the implementation and deployment of the Six Sigma program which includes the mentoring of master black belts and black belts. The role of the champion is therefore to look at the strategic issue and to see how the Six Sigma program and project fit into the firm's strategic plan. The role of the Six Sigma champion is central to the successful integration of Six Sigma into the business. Without the champion, Six Sigma becomes a mere bolt-on tool concentrating on individual projects which may bring about short-term financial success but may not be the priority for strategic improvement and long-term success.

The **master black belt** is normally someone who is a full-time Six Sigma practitioner and has completed a number of Six Sigma projects. The master black belt provides mentoring support to the black belts as well as providing strategic help to the champion. Depending on the size of the firm it may not have any

master black belts in which case the link with the champion rests with the black belts.

The **black belt** is a specialist practitioner trained in the use of advanced Six Sigma tools and problem-solving techniques. Black belts lead improvement projects and are often used to train green belts. The black belt is also a full-time post.

A **green belt** is someone trained in the use of Six Sigma tools but not to the same level as a black belt and only spends part of their time on Six Sigma projects. Typically, this would be 10-15 percent of their time although this will vary from firm to firm. The green belt's training is concentrated on problem solving and descriptive data analysis with less emphasis on advanced statistical methods and strategic issues which the black and master black belts would follow (Rowlands, 2003: 18).

Long (2004) defines a **yellow belt** as the starter level of Six Sigma. When an employee goes through yellow belt training they are taught the essentials of Six Sigma and discover how the process works. Yellow belt training normally takes one week to complete. Upon completion of yellow belt training, the employee can serve as an organizational leader in simple projects or support green and black belts in implementation of more complex projects.

2.6 SIX SIGMA METHODOLOGY

The first step in the Six Sigma DMAIC process is project selection. Only projects aligned with critical business issues and initiatives warrant the time, effort, and energy required to achieve Six Sigma performance (LeBlanc *et al.*, 2004: 19).

Rudisilli and Clary (2005: 21) comprehensively summarize the Six Sigma methodology, providing a brief explanation of the DMAIC approach. A common thread through all Six Sigma projects is the emphasis on data. Phrases such as "We feel that ..." or "We suspect that ..." aren't allowed. Instead, phrases such as "The data show that ..." and "Statistical analysis of the data supports that ..." replace them. This emphasis on data and measurement led to the methodology that has made Six Sigma so successful – the Define-Measure-Analyse-Improve-

Control (DMAIC) approach to process improvement. Each project follows this approach from beginning to end, regardless of whether it involves a manufacturing process, an administrative process, or a support process:

2.6.1 The Define Phase

In the Define phase, a team clearly identifies the suppliers, process inputs, process activities, process outputs and customers; establishes baselines and benchmarks; and sets and agrees upon goals and measures of success.

2.6.2 The Measurement Phase

During the Measurement phase, the team studies and evaluates relevant measurement systems to determine if they are capable of measuring key input variables (raw material characteristics and process conditions such as temperatures, speeds, pressures and flow rates) and output characteristics (product dimensions, customer-defined specifications, and product performance) with the desired precision and accuracy. If they aren't, then the team will work to improve the related measurement systems before proceeding with the project.

2.6.3 The Analysis Phase

During the Analysis phase, the team performs graphical and statistical analyses on historical and newly-obtained data to develop preliminary hypotheses for improvement. The team identifies the root causes of problems and the enablers of poor performance that need to be corrected.

2.6.4 The Improve Phase

In the Improve phase, the team designs and conducts experiments to find the optimal conditions needed to operate the process. Improvement requires change, and the correct changes are determined through statistically-designed

experiments where process inputs or system components are varied and the resulting effects on process outputs (related to quality, cost and customer requirements) are observed and measured. If the results are favourable, process conditions are changed to these optimal levels.

The team maintains these optimal conditions during the Control phase where audits and control systems sustain the improvements. No project is deemed completed until sufficient time has passed and evidence gathered to verify that the desired results have been obtained and maintained.

2.7 SIX SIGMA PHILOSOPHY

Revelle (2004: 38) argues that, the philosophy of Six Sigma is to employ a financially focused, highly structured approach to Process Improvement decision making using current, valid performance metrics. Revelle links Six Sigma and strategy by defining a breakthrough strategy as a thoroughly researched, well-planned series of interrelated steps designed to guide a firm to a much higher level of achievement. The Six Sigma strategy is a totally defined, carefully executed methodology for characterizing, then optimising any transactional (business) or industrial process.

In a research brief done by the Aberdeen Group, Jutras (2006a) links Six Sigma as a philosophy to customer satisfaction. Six Sigma is first a philosophy that focuses attention on those criteria that the *customer really cares about*. The philosophy strives for breakthrough improvements, using data-driven metrics to control inputs and processes to yield a predictable product.

Having defined and explained Six Sigma and its methodology, the question arises what should actually be measured in a process (manufacturing – or service process).

2.8 SIX SIGMA MEASUREMENT

The DPMO (Defects per million opportunities) metric can be applied to any product, process or service, since the application thereof is generic. Using an

invoice process as an example, this is explained by a simple calculation method for DPMO.

If there are 9 defects among 150 invoices, and there are 8 opportunities for errors for every invoice, what is the DPMO?

$$\text{dpu} = \text{no. of defects} / \text{total no. of product units} = 9/150 = 0.06 \text{ dpu}$$

$$\begin{aligned} \text{dpo} &= \text{no. of defects} / (\text{no. of units} \times \text{no. of defect opportunities per unit}) \\ &= 9/(150 \times 8) = 0.0075 \text{ dpo} \end{aligned}$$

$$\text{dpmo} = \text{dpo} \times 1,000,000 = 0.0075 \times 1,000,000 = 7,500 \text{ dpmo}$$

(Six Sigma Tutorial, 2000-2004).

Jutras (2006c) argues that, in general, those which employed the more stringent metrics of DPMO and PPM achieved more impressive results. While PPM, Rolled Throughput Yield and First Pass Yield are generally associated with manufacturing firms, DPMO can be used universally, regardless of industry, since it measures defects produced in a business process. As far as Six Sigma is concerned, a process is a process and a defect is a defect, whether assembling or fabricating parts or processing a customer's order. A survey conducted by the Aberdeen Group (2006) strongly recommended the use of this metric regardless of industry or firm size. Aberdeen found only 20 percent of mid-size firms employing this quality standard.

Jutras (2006b) argues that those firms that measure PPM and DPMO achieved better performance than those that simply measure defect rates in terms of "percentage good" or "percentage defective." In fact, those who measure DPMO are very close to Five Sigma performance. Jutras emphasizes that those who measure DPMO, achieve a higher level of overall quality. As the old saying goes, "what gets measured gets managed." By aspiring to this level of quality and attention and monitoring progress, results are achieved.

Six Sigma relies heavily on having accurate and accessible data, oftentimes in huge volumes. Without the proper means to analyse this data, the subsequent steps of the DMAIC (Define-Measure-Analyse-Improve-Control) model are crippled. Technology is a necessary enabler of this process and those who invest in the proper tools perform better.

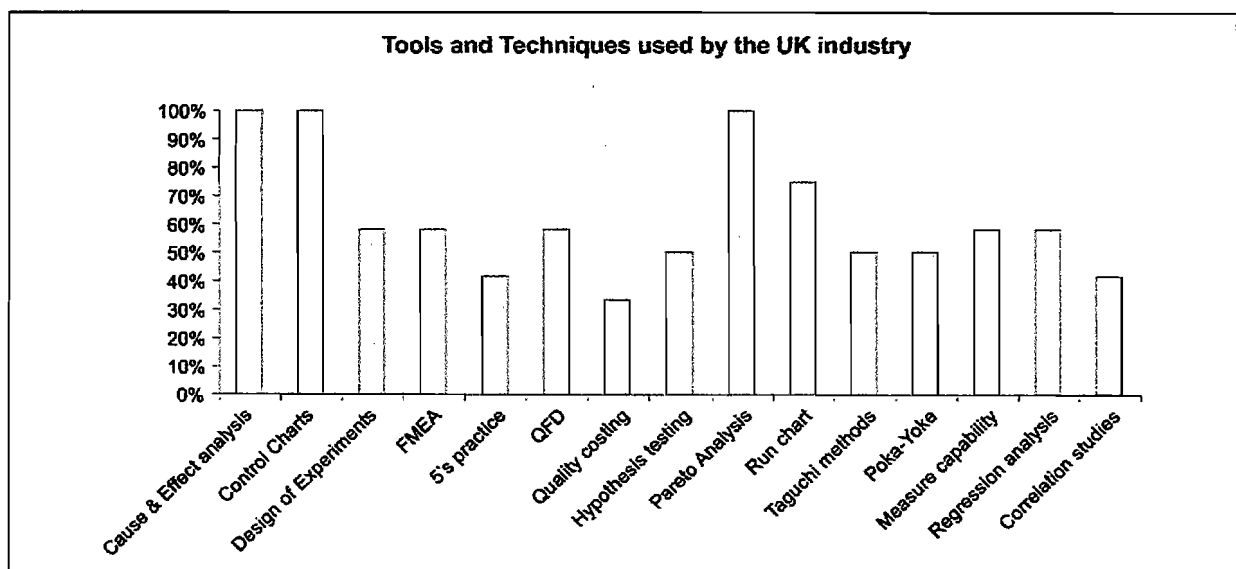
The following two sections will discuss some of the most common tools and techniques employed by the firms which have been practising Six Sigma.

2.9 SIX SIGMA TOOLS

A survey conducted by Antony and Banuelas (2002) reveals that the most common metrics used in firms practising Six Sigma principles include process capability indices, defect rate, costs of poor quality (COPQ), percentage of scrap, first time yield (FTY) and number of customer complaints. In addition to the metrics, the survey also looked at the most common tools and techniques employed by the firms which have been practising Six Sigma. The results are shown in Figure 2.3.

The most commonly used tools for data accumulation and interpretation include cause and effect analysis, Pareto analysis, control charts and run charts. It was found that many firms are not using more powerful techniques such as design of experiments, Taguchi methods, quality function deployment, failure mode effect and criticality analysis, 5-S practice, Poka-Yoke and statistical process control. In other words, the more powerful techniques are less commonly used in these firms.

Figure 2.3: Tools and techniques in firms practising Six Sigma



(Source: Adapted from Antony and Banuelas, 2002: 20).

A survey conducted by the Aberdeen Group (2006) argues that the landscape of technology vendors that offer a variety of desktop and enterprise level tools is crowded. Minitab is probably the best known of these products, particularly in Six Sigma circles, since many Six Sigma training programs utilise this desktop tool.

2.10 FINANCIAL BENEFITS, IMPLICATIONS AND COSTS

2.10.1 Savings and benefits

McCarty (2004) argues that the Six Sigma methodology can assist in lowering costs, improve cycle time, increase client satisfaction and secure new, profitable business. When consulting literature (primary and secondary sources) there are very limited information available regarding the financial benefits firms quote because of Six Sigma implementation.

Harbert (2006) confirms that, because they consider it such a competitive advantage, most firms won't say exactly how much they've spent or saved, making any return-on-investment calculations difficult. Xerox uses an internal measure called "economic profit", which is project value minus cost, says Bob Shea, communications manager for corporate Lean Six Sigma. Those internal figures (which Xerox doesn't release) are then rolled into the firm's overall financial numbers. Soletron also declines to cite numbers, other than to point to its bottom line as proof of Lean Six's benefits. Although many firms are hesitant to reveal exact figures for their Return on Investment or cost saving because of Six Sigma, a significant representation of quoted financial benefits were obtained from various industries.

Savings fall into the three categories to which Xerox refers. Type 1 is money savings, which are directly measurable. Type 2 is cost-avoidance savings-expenses the firm did not incur, because of fewer process steps and/or increased productivity. Type 3, the most difficult to measure, is growth in revenue that results from process improvement such as shorter lead times.

Although firms tend to shield overall ROI figures, most of them can easily point to specific, dramatic improvements in manufacturing operations. For example,

Celestica cites a string of improvements at its Monterrey, Mexico, plant. Over the course of 18 months, workers reduced equipment setup time by 85 percent, shortened time between receiving an order and shipping it by 71 percent, reduced floor space used by 34 percent, reduced consumables by 25 percent, reduced scrap by 66 percent and reduced the investment in surface-mount technology (SMT) lines by 49 percent (Harbert, 2006).

Long (2004) states Motorola University claims that the return on investment for properly implemented Six Sigma projects ranges between 10:1 and 50:1. Few firms would not be interested in learning more about a process that can offer that level of return on investment.

Jutras (2006b) in a survey conducted by the Aberdeen Group, which they presented in The Lean Six Sigma Benchmark Report (2006), stated that in all cases, significant cost savings can be derived from quality efforts. Over half of the respondents realised reduced costs from eliminating non-value added work (53 percent), a full 50 percent achieved dramatic reductions in cycle time and costs, and 40 percent reduced rework costs. In addition, 45 percent gained intangible value from improved customer satisfaction.

Marx (2007: 28), in a survey, argues research indicates that the Fortune 500 firms with the largest revenues are more likely to have a Six Sigma initiative as illustrated by table 2.2:

Table 2.2: Six Sigma firms by rank in the Fortune 500

Rank	Number Using Six Sigma	Percent
Top 100	82	82,0
Top 200	140	70,0
Top 300	191	63.7
Top 400	239	59,8
All 500	266	53 2

(Source: Adapted from Marx, 2007: 28).

82 percent of the top 100 firms use the methodology, whereas only 27 percent of the bottom 100 firms use it. Of the 53 percent of the firms that practice Six Sigma, their revenues represent nearly 75 percent of the aggregate 500 revenues.

Marx (2007) also argues that according to iSixSigma research, firms with a corporate Six Sigma deployment save an average of about 2 percent of total revenue each year, see Table 2.3.

Table 2.3: Six Sigma as a percentage of annual revenue

Firm	Year(s)	Savings
3M	2002-2004	2.4%
Allied Signal	1998	3.3%
Countrywide Financial Corp.	2002	1.6%
Cummins	2000-2003	2.7%
Dell	2000-2003	1.5%
Dow	1998-2002	1.7%
DuPont	1998-2002	3.1%
Ford	2000-2002	2.3%
General Electric	1996-1999	1.2%
Honeywell	1998-2000	2.4%
IDX	2002-2004	2.5%
ITT Industries	2001	2.9%
JP Morgan Chase	2001-2003	0.4%
Motorola	1996-2001	4.5%
Raytheon	1999-2005	3.5%
Seagate	1998-2002	2.4%
Whirlpool	1997-1999	0.8%
WR Grace	2000-2001	18.0%

(Source: Adapted from Marx, 2007: 28).

Marx (2007: 28) estimates that Six Sigma has saved Fortune 500 firms approximately \$427 billion between January 1987 and December 2006.

DeFeo (2000: 25) provides examples of Six Sigma's proven results:

An international food firm had its first profitable year after six years of marginal profits. Continued Six-Sigma efforts helped it achieve an additional \$10 million in profits by identifying and implementing processes to increase revenues and reduce costs further.

An international pharmaceuticals firm completed a cost-of-quality study that identified 22 percent more waste than did traditional accounting procedures. The firm was able to increase profits dramatically by reducing waste and cycle time and improving customer satisfaction.

An international airline facing a decreasing share in its hub market conducted an analysis of its customers' buying behaviours and uncovered weaknesses not found in the airline's extensive customer surveys. Critical service and operational improvements were identified in the frequent-flyer program and their relationship with a partner airline. The result: \$79 million in savings.

A medical-device manufacturer sought to improve its quality system and became certified in an industry standard within a short time. The 80-year-old firm, a leader in its industry, accomplished its goal within 15 months and was certified on the first attempt.

An internationally recognized aerospace firm in an FAA-regulated industry achieved the same result as the medical-device firm in only 14 months.

2.10.2 Savings and Cost

- **Savings**

Waxer (2002) confirms the percentage savings for certain firms provided in table 2.3 above. Table 2.4 identifies by firm, the yearly revenues, the Six Sigma costs (investment) per year, where available, and the financial benefits (savings).

Table 2.4: Six Sigma and savings by firm

Six Sigma Cost And Savings By Firm					
Year	Revenue (\$B)	Invested (\$B)	% Revenue Invested	Savings (\$B)	% Revenue Savings
Motorola					
1986-2001	356.9(e)	ND	-	16	4.5
Allied Signal					
1998	15.1	ND	-	0.5	3.3
GE					
1996	79.2	0.2	0.3	0.2	0.2
1997	90.8	0.4	0.4	1	1.1
1998	100.5	0.5	0.4	1.3	1.2
1999	111.6	0.6	0.5	2	1.8
1996-1999	382.1	1.6	0.4	4.4	1.2
Honeywell					
1998	23.6	ND	-	0.5	2.2
1999	23.7	ND	-	0.6	2.5
2000	25.0	ND	-	0.7	2.6
1998-2000	72.3	ND	-	1.8	2.4
Ford					
2000-2002	43.9	ND	-	1	2.3
Key: \$B = \$ Billions, United States (e) = Estimated, Yearly Revenue 1986-1992 Could Not Be Found ND = Not Disclosed Note: Numbers Are Rounded To The Nearest Tenth					

(Source: Adapted from Waxer, 2002).

Although the complete picture of investment and savings by year is not present, Six Sigma savings can clearly be significant to a firm. The savings as a percentage of revenue vary from 1.2 percent to 4.5 percent. And what one can see from the GE deployment is that a firm shouldn't expect more than a breakeven the first year of implementation. Six Sigma is not a "get rich quick" methodology.

Air Academy Associates, a consulting and training firm, lists examples of Six Sigma projects and cost savings from a variety of industries (See Appendix 1).

Dusharme (2001) provides a table, compiled from a survey conducted, listing Six Sigma results (benefits) ranked by firm size (See Appendix 2).

- **Costs**

Waxer (2002) suggests, many people say that it takes money to make money. In the world of Six Sigma quality, the saying also holds true: it takes money to save money using the Six Sigma quality methodology. One can't expect to significantly reduce costs and increase sales using Six Sigma without investing in training, organizational infrastructure and culture evolution. If one wants to produce a culture shift within your firm, a shift that causes every employee to think about how their actions impact the customer and to communicate within the business using a consistent language, it's going to require a resource commitment. It takes money to save money.

Dusharme (2003) in a Six Sigma survey revealed that, not surprisingly, both the time set aside for training and the financial commitment to training and implementation are substantial. However, the vast majority of respondents report that it's time and money well spent.

Although evidence indicates an almost guaranteed return on investment, the start-up costs may be beyond the reach of small firms. Dusharme's (2003) survey corroborates that possibility. About 250 of the 935 respondents who have implemented Six Sigma shared how much their firm spends on the program per year (See Table 2.5). This includes training, consulting and the salaries of full-time Six Sigma employees.

Dusharme (2003) broke the responses down into two sets: one for stand-alone businesses - those not part of a larger firm - and one for those that are part of a larger firm. The average yearly cost for stand alone businesses amounts to \$75,000 per year. This figure could be smaller if you subtract the two or three firms that spent considerably more on Six Sigma than the others. Although this might be a reasonable figure for firms with several hundred employees, this amount could be too much smaller firms to consider Six Sigma implementation. Because training costs are based on the number of participants and Six Sigma

generally requires a percentage of employees to be directly involved, there's a direct correlation between the number of employees and the cost of implementation. Based on Dusharme's survey, for firms with 100 to 50,000 employees, the cost of Six Sigma implementation is on average \$200 per employee.

Many consultants are developing training materials or off-site courses that are more cost-effective for small – and medium sized firms. In addition, some small – and medium sized firms are implementing Six Sigma without using a full-time Six Sigma practitioner - one of the major ongoing costs for implementation. (Dusharme, 2003)

Table 2.5: Yearly cost of Six Sigma implementation based on firm size

Yearly Cost of Six Sigma Implementation Based on Firm Size							
Stand-Alone Business			Part of Larger Firm				
No. Employees	No. of Cos.	Avg. Cost	No. Employees	No. of Cos.	Avg. Cost	Avg. No. Emp.	Cost/Emp
1-50	4	\$22,750.00	1-100	5	\$32,340.00	54	\$598.89
5-100	8	\$60,650.00	101-500	20	\$120,055.25	321	\$374.00
101-250	6	\$124,166.00	501-1,000	21	\$121,190.48	733	\$165.33
251-500	7	\$39,285.00	1,001-2,500	27	\$451,925.93	1,798	\$251.35
501-1,000	3	\$166,667.00	2,501-5,000	38	\$681,447.37	3,960	\$172.08
			5,001-10,000	27	\$944,118.52	8,125	\$116.20
			10,001-25,000	21	\$3,075,476.19	16,747	\$183.64
			25,001-50,000	35	\$5,317,142.86	39,228	\$135.54
			50,001-100,000	20	\$2,073,250.00	74,250	\$27.92
			>100,000	15	\$6,825,473.21	217,142	\$31.43

These numbers are based on the roughly 250 respondents who provided cost data.

(Source: Adapted from Dusharme, 2003)

- **Cost of poor quality**

Waxer (2002) cites a quote from General Electric's (GE) 1996 annual report stating, "It has been estimated that less than Six Sigma quality, i.e., the three-to-four Sigma levels that are average for most U.S. firms, can cost a firm as much as 10-15 percent of its revenues. For GE, that would mean \$8-12 billion." With GE's 2001 revenue of \$111.6 billion, this would translate into \$11.2-16.7 billion of savings. A 1.2-4.5 percent of revenue is significant and should require the attention of any CEO or CFO. For a \$30 million a year firm, that can translate into between \$360,000 and \$1,350,000 in bottom-line-impacting savings per year.

It is generally possible to calibrate the "cost of quality" or - more accurately - the "cost of poor quality" (COPQ) with the sigma level at which processes perform. Six Sigma performance levels are generally considered to be world class with the COPQ being less than one percent of sales. By contrast, sigma levels of three, four, and five produce DPMO rates of 66 807, 6 210, and 233, and corresponding COPQ ranges of 25-40 percent, 15-25 percent, and 5-15 percent. These numbers substantiate the importance of reducing process variation across all key primary and support processes in a firm, as well as variation of that obtained from suppliers (Klefsjö, Wiklund & Edgeman, 2001: 31).

2.11 CRITICAL SUCCESS FACTORS (CSFs)

Several critical success factors have been identified in the literature, which can be summarized as follows;

2.11.1 Management commitment

Thevnin (2004: 195) argues that the success of Six Sigma in a firm depends on the management leadership style and how it is blended into the firm's management strategy. For Six Sigma to work well, implementation must be with the impetus of top management. Top management should be dedicatedly involved from the onset of the program. They should understand clearly the requirements for its success. It must also

be part of the vision of the firm with resources and human capital dedicated for its ensured success.

Nonthaleerak and Hendry (2008: 279) in an empirical study, verifies that they found differences between the two sites in the progress of their Six Sigma programs, concluding that the operation with lower progress suffered from a lack of management buy-in.

Motwani, Kumar and Antony (2004: 273) illustrate how Dow Chemicals' management was committed to making Six Sigma a top priority within their business environment. The firm established a six-sigma resource commitment. This commitment calls for three percent of all employees to be six-sigma black belts. For example, employee compensation plans are tied to six-sigma results

Byrne (2003: 43) suggests the first step to assure a high likelihood of success with Six Sigma deployments, is that the top leaders—including the CEO—must become highly visible and vigorous champions of Six Sigma. This means they must clearly and consistently communicate to the firm all the ways in which Six Sigma methods and approaches can help the firm eliminate waste, cut costs, reduce defects in business processes, and improve efficiency and productivity.

They must clearly communicate new work expectations to people and demand compliance with specific Six Sigma financial targets even as they empathize with the challenging demands that they are placing on employees.

Top leaders must also work to eliminate organizational obstacles to success and to be credible leaders of Six Sigma initiatives they must demonstrate a firm grasp of the methodology themselves.

Oke (2007: 109) explains that top management commitment is a key success factor in the implementation of Six Sigma and such commitment manifests in top management's regular attendance at meetings, encouraging team members to be committed to work, and emphasizing the need for goal achievement in employees' tight schedules.

There should be established rules and policies relating to availability for Six Sigma project team meetings, and these should be enforced by the management.

2.11.2 Strategic alignment

DeFeo (1999: 8) argues that, before implementing a Six Sigma process, management must have a basic strategy in place that establishes three things;

A vision of where the firm is going- clearly stated and communicated to every employee at all levels in language they will understand.

Clear definitions of a small number of key objectives that must be achieved, if the firm is to realise its vision. Communication of these objectives throughout the entire firm so that each person knows how his or her performance helps achieve those objectives, this alignment is critical.

Coronado and Antony (2002: 92) confirms that Six Sigma cannot be treated as yet another stand-alone activity. Since the goal of every firm is to make profits now and in the future, Six Sigma makes processes profitable while attacking variability in business processes. In every single project, the link between the project and the business strategy should be identified. It should also demonstrate in money figures, the benefit of the project in financial terms and in which way it will help the business strategy.

2.11.3 Training and Personnel

Gale (2003) suggests that Six Sigma differs from other quality programs because it creates specialized positions in the firm instead of putting additional tasks on already overburdened executives. Those chosen to be "black belts." or Six Sigma specialists, are removed from their jobs and assigned solely to the role of Six Sigma project leader. Through an intensive, typically four-week training program, these experts learn the statistical fact-based approach to identifying Six Sigma projects, eliminating the waste and, most important, measuring their impact.

Rowlands (2003) argues that the key to the success of the Six Sigma process is the effective deployment of people. Each firm should define its own structure and profiles of various roles. In this way the roles will be based around the needs of the specific firm and not as defined by Motorola or others who have successfully used the Six Sigma approach. The problem with this is that which works for Motorola may not

work for other firms in different sectors and therefore, an individualised training structure is needed.

Well-planned and implemented training courses, which will first be handled by outside experts and then by in-house experts, should be carried out for the various categories of employees. Courses designed for beginners, intermediate, and advanced employees in Six Sigma knowledge are essential. The aim of training is to develop a knowledge organization. (Oke, 2007: 109)

Several firms have corporate Six Sigma training web sites accessible to every employee to enable self-learning. (Nonthaleerak and Hendry, 2008: 279)

Byrne (2003: 43) argues that choosing the right people to be Black Belts is essential to success. As project team leaders, these individuals need both hard (analytical/statistical) and soft (leadership/people) skills. Typically, Black Belt candidates should possess;

- A clear understanding of their firm's business strategies and objectives
- A strong process orientation
- A solid knowledge of and ability to apply statistical/analytical tools and techniques
- Strong facilitation, teaching, and team-building skills
- Change management skills and experience
- Cross-functional business and work experience

In addition Lee (2002) shows that Six Sigma training program is a significant factor in the success of Six Sigma implementation, suggesting that statistical software training, statistical tools training, problem-solving training and project management training are equally important to the success of Six Sigma.

2.11.4 Communication strategy

Gale (2003) argues that a firm should create and implement a communication strategy that will keep the entire firm informed about Six Sigma achievements.

Motwani, Kumar and Antony (2004: 273) illustrates how Dow Chemicals has implemented Global Workstations which established a communications pipeline that allowed all employees around the world to share a common computer system, thereby accelerating the pace and quality of communications.

In an empirical study Nonthaleerak and Hendry (2008: 279) illustrates how a firm employs different kinds of media and communication channels to educate operators on the shop floor, including posters, songs and online sound. One firm uses e-mail to issue Six Sigma articles to all staff on a regular basis to increase employee's awareness.

It is important to establish a communication program that can describe what should be communicated by whom and how often. It would help firms to propagate their business strategy, customer requirements and work team. After implementation of Six Sigma projects, it is best to publish results, but these should not be restricted to success stories but also admit and communicate setbacks. It will help other projects in the pipeline to avoid the same mistakes and learn from mistakes. (Coronado and Antony, 2002: 92)

2.11.5 Organizational structure

Gale (2003) argues that most critically, the human resources team should be on board from the beginning to build an infrastructure that will support a Six Sigma rollout.

There needs to be a good accountability structure. The Six Sigma reporting structure should be the same as a functional reporting structure. An indirect and complex type of reporting structure creates a risk that there will be inadequate management involvement and a lack of accountability on project success.

Assigning a full-time black belt or part-time black belt has been identified as being another CSF. Evidence from some firms suggest that the part-time black belt struggled to allocate time appropriately between the Six Sigma project and other work commitments; had low motivation to complete the Six Sigma project and the scope of the projects was limited due to time constraints. A full time black belt has the capability to handle a cross-functional, large-scale and complicated project with a

high potential to have a significant impact on organizational performance. There may however still be a cost disadvantage as clearly it is more costly in terms of salary, thus the most appropriate choice of black belt pattern may vary according to the size of the firm and hence the resources available. (Nonthaleerak and Hendry 2008: 279)

2.11.6 Technological tools

Antony, Antony and Kumar (2007: 294) indicate that, the successful implementation of Six Sigma requires systematic and disciplined applications of different tools and techniques. Although the tools and techniques used within the Six Sigma methodology are not new, the strength lies in the integration of these tools and techniques into the five stages of the methodology. It was observed from the research that many service firms are reaping benefits from the application of the simple tools of process improvement (e.g. process mapping, Pareto analysis, cause and effect analysis or root cause analysis, etc.).

Many techniques in the Six Sigma toolkit are directly applicable to software and are already in use in the software industry. For instance, "Voice of the Client" and "Quality Function Deployment" is useful for developing customer requirements (and is relevant measures). There are numerous charting/calculation techniques that can be used to scrutinize cost, schedule, and quality (project-level and personal-level) data as a project proceeds. And, for technical development, there are quantitative methods for risk analysis and concept/design selection. The strength of "Six Sigma" comes from consciously and methodically deploying these tools in a way that achieves (directly or indirectly) customer satisfaction. (Siviy, 2001)

Furterer (2004) lists the following tools, in the Six Sigma toolkit, that can be used to measure and improve quality:

- Affinity Diagrams
- Analysis of Variance (ANOVA)
- Benchmarking
- Brainstorming

- Capability Analysis and Capability Indices (Cp and Cpk)
- Cause and Effect/Fishbone Diagrams
- Check sheets
- Scatter diagrams
- Design of Experiments, Taguchi Methods
- Evolutionary Operation (EVOP)
- Failure Mode and Effect Analysis (FMEA)
- Histograms
- Measurement system assessment (Gage R&R)
- Pareto Chart and 80/20 rule
- Process Mapping
- Process Performance Metrics (DPMO, DPU)
- Quality Function Deployment (QFD)
- Regression Analysis
- Response Surface Methodology (RSM)
- Run Charts
- Statistical Process Control

2.11.7 Organizational culture (Change management)

Clark (2007) emphasizes, changed processes, changed skill sets, changed thinking and changed performance; Six Sigma is all about change. Passion, defined as "boundless enthusiasm", is the seed of change. With it, Six Sigma flourishes. Without it, project implementation is a constant struggle.

Change, even on a good day, is difficult. Resistance to change is natural. That is why Belts of all colours should be well versed in change management tools and techniques. A well thought out change plan can go a long way in building a cadre of passionate supporters for your proposed change. The change plan should address methods to create sponsorship, engage all stakeholders early in the process and effectively communicate to all parties involved.

Coronado and Antony (2002: 92) argue that Six Sigma is considered a breakthrough management strategy, because it involves adjustments to the firm's values and culture for its introduction.

Some firms that have succeeded in managing change have identified that the best way to tackle resistance to change is through increased and sustained communication, motivation and education. It is important as well to get as much practical feedback as possible from employees, plan the change through a detailed Six Sigma implementation milestone, delegate responsibilities when possible and empower people to make their own decisions.

2.11.8 Linking Six Sigma to the customer

Six Sigma should begin and end with the customer. Similar to the linkage with the business strategy, Six Sigma should also be linked to what is important to the customer. An important issue here is the identification of the critical-to-quality characteristics (CTQ).

CTQs or customer's "wants" are identified quantitatively in the starting phase of the Six Sigma methodology. It is when several tools and techniques (for example, quality function deployment) are applied in order to obtain data that describe customer expectations. (Coronado and Antony, 2002: 92)

2.11.9 Project management

Coronado and Antony (2002: 92) argues that another key ingredient in the implementation of Six Sigma is that project leaders must have some basic project management skills. Project managers, champions, black belts and green belts should consider the key elements of project management, time, cost and quality. Defining them will provide the team with the scope, aim and resources needed to deliver an improvement in the short time, at the lowest cost and meeting the requirements needed. To obtain this, they need to work in cross-functional teams in which facilitative leadership guides the team to contribute in reaching the business strategy by identifying customer requirements.

2.11.10 Project prioritizations and selection

As Six Sigma is a project driven methodology, it is essential to prioritise projects which provide maximum financial benefits to the firm.

Therefore every project should be selected so that it will help the firm improve competitive advantage, business profitability, process cycle-time, throughput yield, etc. When projects are selected, it is important to define their scope, limitations etc. showing what the team will be and will not be working on. Moreover, the project goals or objectives must reflect the critical quality requirements from customers.

Nonthaleerak and Hendry (2008: 279) in an empirical study, however suggest that the main issue regarding the project selection criteria is the over-emphasis on financial savings criteria. Some firms set financial savings as their first priority in project selection. Some of their managers suggested that this criterion sometimes limits the selection to cost reduction projects thereby losing the opportunity to select higher impact projects, such as product quality improvement projects. Some interviewees suggested that project selection criteria should carefully combine financial and non-financial criteria.

2.12 CHALLENGES FOR SIX SIGMA IMPLEMENTATION

A survey conducted by the Aberdeen Group (2006), reveals that adapting to the rigors of Six Sigma requires significant culture change for most firms and many find it a challenge. In fact, this was reported as the top challenge. Not all challenges are cultural though. With its roots in statistical engineering, Six Sigma methodologies, particularly in the analysis phase of DMAIC is indeed dependent on data, so the inability to collect data can present significant obstacles. And unless the data is "clean," the next phase of the DMAIC methodology – the Improve phase – can be derailed. Excessive time spent "scrubbing" the data can also present a barrier to achieving desired results. Automated data collection and Information Technology (IT) solutions can play a key role in resolving the data collection and – validation obstacles.

The process of implementing Six Sigma is a challenge for any firm. The implementation process introduces a huge time of adjustment which is one of the primary challenges of Six Sigma. Many of the Six Sigma organizational implementations that don't stick have to do with these firms not being fully committed to the process. In addition, many firms are faced with challenges regarding implementation of Six Sigma because they fail to assign metrics to all business functions. One of the necessities of Six Sigma is to quantify all business functions in order to improve on them. Even when it comes to support functions such as paperwork, quality of this function must be analysed quantitatively. Stating that peripheral business functions are good or bad is not precise enough. It is essential to determine how many errors are made per million attempts (Long, 2004).

2.13 HURDLES IN THE IMPLEMENTATION OF SIX SIGMA

Gijo and Rao (2005: 721) discuss the following hurdles faced by firms before, during and after implementation:

2.13.1 Lack of constancy of purpose

In a dynamic market scenario, customer needs and expectations are changing rapidly. Firms need to understand the current and future needs of their customers; meet the current customer requirements and strive to exceed their expectations. During this process, the management priorities or objectives are changing frequently and this is thereby leading to failure of Six Sigma implementation.

2.13.2 Foot in several boats

Many firms take up several quality initiatives simultaneously, namely Kaizen, Quality Circles, TQM, ISO-9000, QS-9000, and Six Sigma. In this case, however, the people within the firm are not able to devote their time and resources to the successful implementation of any one initiative. In other words, this is like 'a man on many boats'. Often, 'several initiatives at a time' create a lot of confusion in the concepts and methodologies and the initiatives are unable to integrate one with another.

2.13.3 Old wine in a new bottle

Successful implementation of Six Sigma requires knowledge and skill about the respective processes, in-depth knowledge of all the tools and techniques, namely Quality Function Deployment (QFD), descriptive and inferential statistics, design of experiments and the capability to convince and manage people.

The resources utilized might not have the abovementioned qualities. This may lead to closure of the projects with the usual quality circle style (problem–cause & effect diagram–solution) of solving a problem. As a result, people may not find any difference between the earlier methodologies and Six Sigma. People often call this ‘old wine in a new bottle’.

2.13.4 Improper project selection criteria

Firms try to implement a Six Sigma approach in anticipation of market penetration and organizational speed, while simultaneously reducing the cost of doing business. In other words, the projects must be selected in line with the firm’s goals and objectives. Some firms fail to have SMART (Specific, Measurable, Achievable, Relevant and Time-Bound) goals and objectives and few others might not be able to link their projects to their goals and objectives.

2.13.5 Lack of resources

Some firms are unable to spare their people in the mandatory training of Six Sigma methodology and the equipment for trials, such as pilot runs, due to the usual production pressures, like month-end and year-end pressures. At times, the project requires a lot of data gathering and analysis, requiring the availability of proper software and computational facilities. Inadequate training facilities, such as improper training halls, may also hamper the progress of successful implementation.

2.13.6 Lack of coordination between functions

Often, Six Sigma projects are cross-functional and require a large amount of coordination between different departments or functions. Lack of proper coordination may lead to improper selection of their Critical-to-Quality (CTQ) characteristics,

incorrect data, analysis and solutions. Further, this may lead to resistance to implement solutions.

2.13.7 Non-availability of data

Six Sigma is a data-driven approach and it is mandatory to support any conclusion by correct data gathering and its analysis. In some cases, the relevant data are hard to collect and may be expensive. Some processes, such as strategic planning and target setting, require more cycle time, therefore process cycling is very slow and the quantity of data may be small. The fear and frustration of people to collect data may also hamper the progress of a Six Sigma project.

2.13.8 Impatience to get results

To observe the effectiveness of any methodology requires time. Some firms are impatient to get the results, thereby losing faith and confidence in the methodology. This may lead to closure of the projects by short-cut methods, and the implementation may slow down or may even stop.

2.13.9 Selection of belts

Unlike the other approaches, the Six Sigma methodology assumes the human resources (belts) are assets to the firm. Unfortunately, these belts switch over their jobs so frequently because of the growing market demand. In a few cases, the job responsibility of the belts might change during the course of the projects, which may hamper the progress of a Six Sigma project. Too often, too much time is spend on the technical side of the change – what has to happen by when. The people side of the change is generally ignored – removing the resistance of people and systems vital to the accomplishment of work. This resistance may be due to the authoritative style of management, such as 'just do it'. In Six Sigma methodology, the belts should have the technical and managerial skills, the ability to understand and implement the tools, techniques and methodologies and be able to coach the team about the same. In other words, the belts should have a strong will to improve. Selection of these belts plays a vital role in successful Six Sigma implementation. (Gijo and Rao, 2005)

2.14 DIFFERENT APPLICATIONS FOR SIX SIGMA

Long (2004) argues that Six Sigma has been applied to unconventional business practices such as the percentage of properly filed paperwork, customer complaints, and even effectiveness of solvents used in restrooms.

The type of Six Sigma projects is unlimited. Rudisilli and Clary (2005) provide some examples of typical Six Sigma projects:

- Reducing scrap in a ball bearing manufacturing plant and capacitor assembly plant.
- Identifying and reducing unnecessary spare parts inventory for a paper cup plant.
- Reducing defects and product variation in a textile finishing plant, thus increasing the percentage of material that meets customer requirements.
- Reducing lead times for product development and scale-up in a pharmaceutical firm.
- Eliminating unnecessary product testing in a fibre plant.
- Reducing hospital billing errors.
- Reducing shipping errors in a dispatch plant.
- Increasing machine efficiency in a paper plant.
- Reducing the number of customer service and order-entry errors in a box plant.
- Streamlining the appropriation request process for new technology and equipment in an automotive plant.
- Reducing the waiting time for notification of bank loan approval.

Literally everything a firm does is a candidate for the Six Sigma process. Whether it is design, yield, communications, paperwork, training, production, inspection, testing, returns, recalls, rejects, response time, attitude or organizational structure—it is all of those and more. The disciplined processes used by Six Sigma also apply to senior-level functions, e.g. finance, law, health and engineering, but the procedural steps are specialized. (DeFeo, 1999: 8)

2.15 CONCLUSION

Six Sigma offers businesses an opportunity to shake off complacency and continue to compete in an increasingly demanding marketplace.

Since the implementation of Six Sigma in the US in the late eighties, it has gained a lot of momentum and has become a methodology considered by many firms to increase their competitive advantages. Six Sigma has been shown in the literature to be an effective program to help firms reduce costs, eliminate waste, reduce variation, and improve quality of products and services and improve customer satisfaction.

The financial impact of the different Six Sigma quality levels has been illustrated which indicates that if a firm improves its Six Sigma quality levels it will improve its operating performance.

The need for firms to implement Six Sigma can be justified for many reasons, these driving forces range from meeting customer expectations, continuous quality improvement, improved market position, operational efficiency and most importantly improved financial performance.

Significant cost savings can be derived from implementing Six Sigma and is quoted by many firms. The return on investment for properly implemented Six Sigma projects ranges between 10:1 and 50:1. Based on the figures quoted by many firms the savings as a percentage of revenue vary from 1.2 percent to 4.5 percent. However one cannot expect to significantly reduce costs and increase sales using Six Sigma without investing in training, organizational infrastructure and culture evolution.

Although the start-up cost for Six Sigma implementation is high, there are many ways of reducing these costs depending on the implementation period a firm has determined and the amount of resources assigned for implementation.

This chapter illustrated the critical success factors for the successful implementation of Six Sigma. All these factors are essential and therefore should be taken into account for optimising the financial return from Six Sigma projects in all firms. In order to achieve the full potential of six sigma applications, it is important to take these factors into consideration.

There are many challenges for Six Sigma implementation; the most important is staying committed to the process. Once implemented effectively, Six Sigma can be applied to many different applications, i.e. reducing scrap, reducing defects, reducing lead times or increasing machine efficiency.

The next stage of the research is to evaluate the status of Six Sigma implementation in South African firms. The next chapter will study these factors in manufacturing and service firms which would determine their priority of importance by comparing the ranking of the CSFs in South African firms. The knowledge gained through the literature and empirical study will form the basis to develop and propose a framework for successful Six Sigma implementation.

CHAPTER THREE: STATUS OF SIX SIGMA IMPLEMENTATION IN SOUTH AFRICA

3.1 INTRODUCTION

An empirical study was undertaken to determine the status of successful Six Sigma implementation in South African firms. The purpose of the empirical study was also to arrive at conclusions and recommendations when linking the theory in Chapter two with the results of the status of Six Sigma implementation in this chapter. The comparisons made between Chapter two and three will form the foundation for the development of a framework (roadmap) for successful Six Sigma implementation, presented in Chapter 4.

A questionnaire (Appendix 3) was developed to obtain specific information for Six Sigma implementation. Questions relating to the current status of Six Sigma, the number of trained Black Belts, project completion times, financial and other benefits, CSF (critical success factors) and barriers to implementation were formulated in the questionnaire.

3.2 QUESTIONNAIRE DESIGN

After the literature study, the survey questionnaire was developed to gather data as required for this study. The questionnaire developed in this study consists of four main sections. The first section was intended to determine the firm's profile, such as the type of industry and the size of the firm. The second section was intended to determine the firm's Six Sigma profile i.e. the status of – and how long Six Sigma has been implemented and the Black Belt status of the firm. The third section was intended to establish the financial costs and benefits of Six Sigma. The fourth section was intended to identify the critical success factors, benefits, the common Six Sigma tools and techniques employed by the participant firms and, the barriers to the implementation of Six Sigma.

3.3 SAMPLING METHOD AND PROCEDURE

During this survey there were two Six Sigma user group forums in South Africa. Each of these forums is facilitated by a respective Six Sigma consulting firm. Survey questionnaires were distributed via email and handed out at an annual symposium held by one of the consulting firms. The first consulting firm emailed the questionnaire to 17 of its participating firms. The response rate from the survey was 41.2 percent (i.e. a sample size of 7 firms). The second consulting firm's symposium was attended by 14 delegates of whom 9 responded to the survey. This represented a response rate of 64.3 percent. The total response rate from the survey was 51.6 percent which was considered as satisfactory to make valid conclusions. According to one of the Six Sigma consulting firms there are currently 45 Six Sigma firms in South Africa, thus the survey results represents 35.6 percent of the total population. The firms who participated in the survey are involved in both manufacturing and non-manufacturing operations. The majority of the respondents were Black Belts and managers, followed by technical specialists.

Interviews were held with two Black Belts using Section D (Six Sigma implementation) part of the questionnaire as basis for the interview.

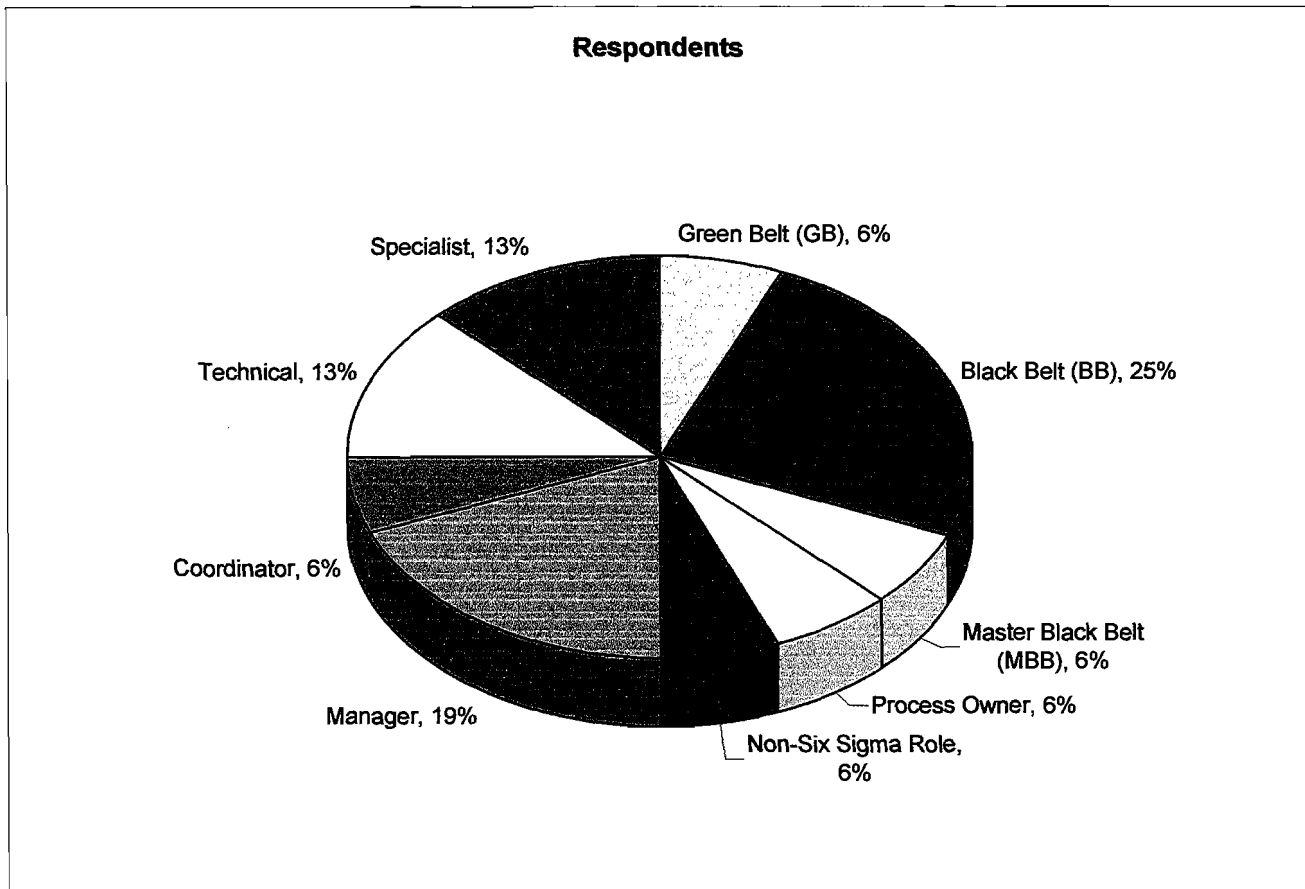
3.4 SURVEY RESULTS AND ANALYSIS

The results presented in this study are exploratory and are based primarily on descriptive statistics. The analysis of the first part of the questionnaire revealed the demographics of the firms i.e. the position occupied by the respondents, the areas of industries and the number of employees in the firm responded to the survey.

Diagram 3.1 provides information on the position held by the respondents. The largest proportion of the respondents was Black Belts (25 percent). The second largest proportion of respondents is represented by Managers (19 percent). This is followed by Technical and Specialists (13 percent each). Since the study is directed at implementation of Six Sigma programs, it is understandable that the majority of the respondents were Black Belts. Based on the distribution of the respondents the information provided in the survey can be considered accurate, since the majority of the respondents are trained in the

fundamentals of Six Sigma who have first-hand knowledge and expertise with the Six Sigma philosophy.

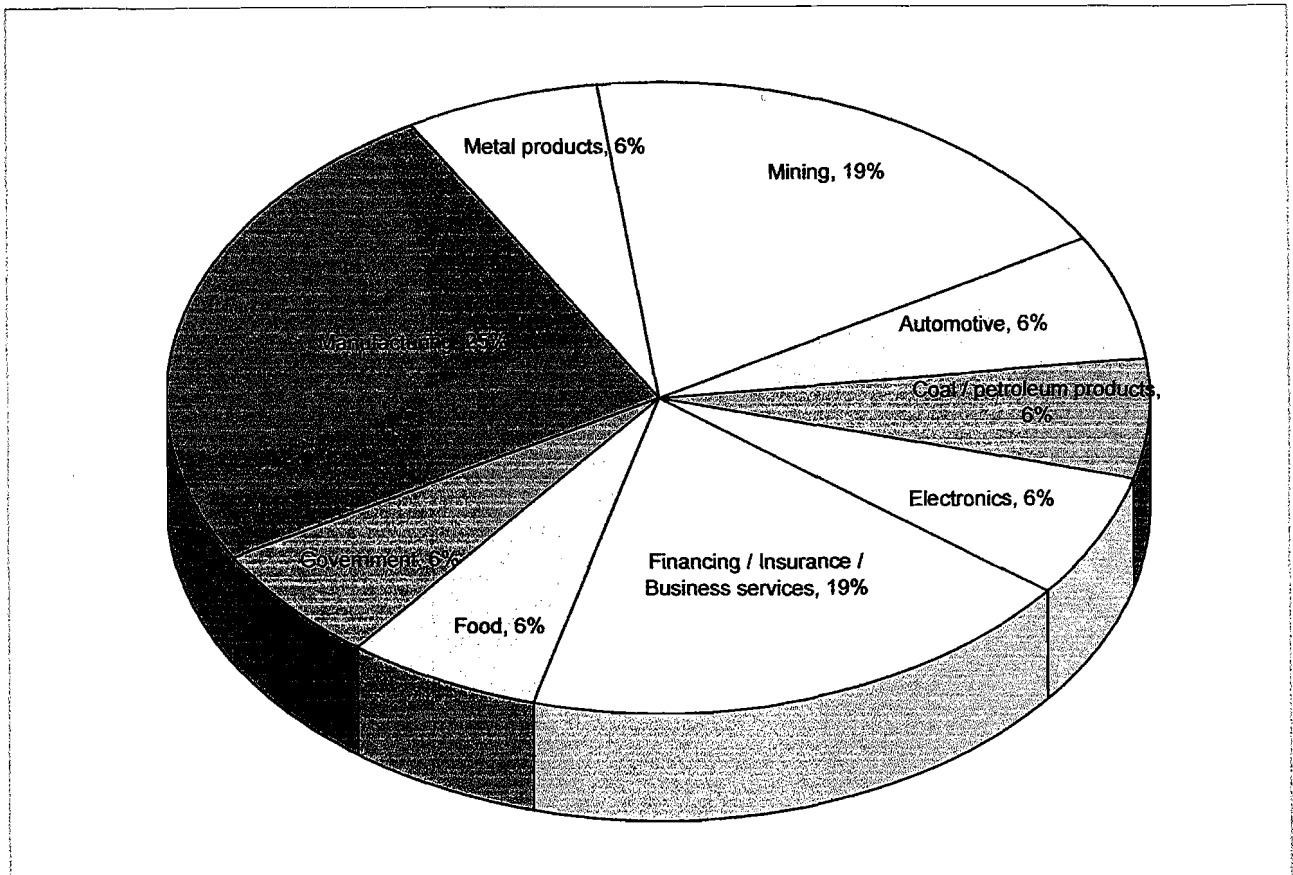
Diagram 3.1: Role of respondents



3.4.1 Areas of industry and number of employees

An outline of the kind of industries who participated in the study is outlined in diagram 3.2.

Diagram 3.2: Areas of participating industries



Considering the literature in chapter 2, Six Sigma was originally deployed by mainly manufacturing firms. Therefore the majority of respondents were from the manufacturing sector (25 percent). The percentage distribution of the size of the firms that participated in the study is shown in Table 3.1. It is noted that most firms who participated in the survey have in excess of 2500 employees (75 percent).

Table 3.1: Number of employees (Size of firm)

Number of employees	Percentage distribution
<250	0.0%
250-500	6.3%
500-1,000	12.5%
1,000-2,000	6.3%
2,500-5,000	50.0%
5,000-7,500	0.0%
7,500-10,000	12.5%
>10,000	12.5%

3.4.2 Status of Six Sigma deployment

The statuses of the deployment of Six Sigma in the firms are as follows;

Table 3.2: Status of Six Sigma deployment

Considering a deployment	13%
Deployment planned but not yet launched	6%
Partially deployed in one business unit	13%
Partially deployed in multiple business units	25%
Fully deployed in one business unit and partially in other areas	13%
Fully deployed throughout the firm	31%

From table 3.2 it is illustrated that Six Sigma is a relatively new concept in South Africa. Only 31 percent of the firms have fully deployed Six Sigma. It was observed that 57 percent of the firms have not fully deployed Six Sigma throughout their firms, and 38 percent of the firms have only partially deployed Six Sigma.

3.4.3 Status of Six Sigma vs. Six Sigma training and – projects.

The following rating was assigned to each firm according to its status of Six Sigma deployment;

Table 3.3: Rating assigned according to Six Sigma deployment

Considering a deployment	1
Deployment planned but not yet launched	2
Partially deployed in one business unit	3
Partially deployed in multiple business units	4
Fully deployed in one business unit and no other areas	5
Fully deployed in one business unit and partially in other areas	6
Fully deployed throughout the firm	7
Not specified	0

These ratings were plotted against each firm's number of trained Black Belts (BB), the amount of BB projects completed, how long the firm takes for BB project completion and how long the firm has used Six Sigma. See figure 3.1.

Figure 3.1: Six Sigma deployment rating and years, number of black belts and projects, and project completion times.

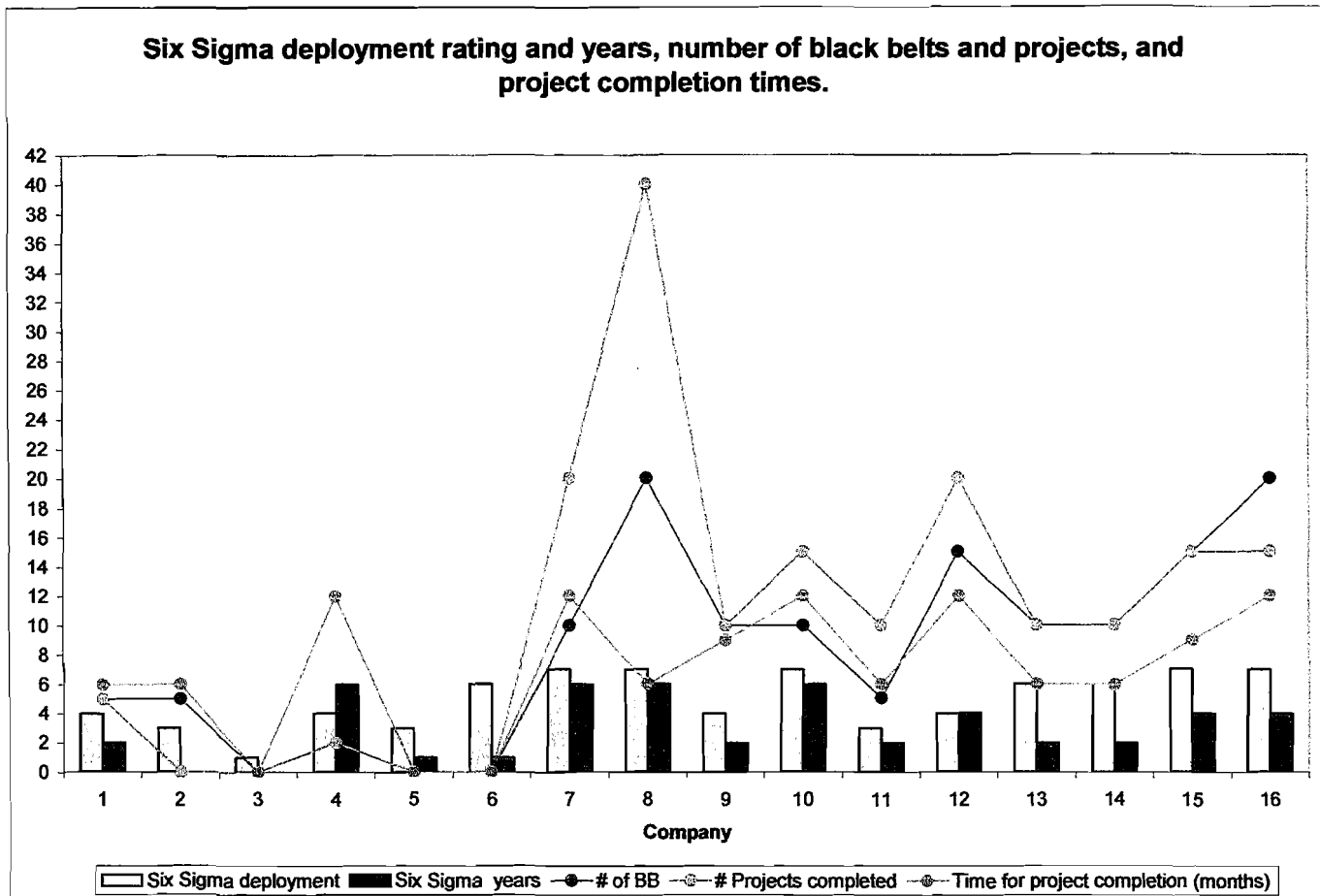
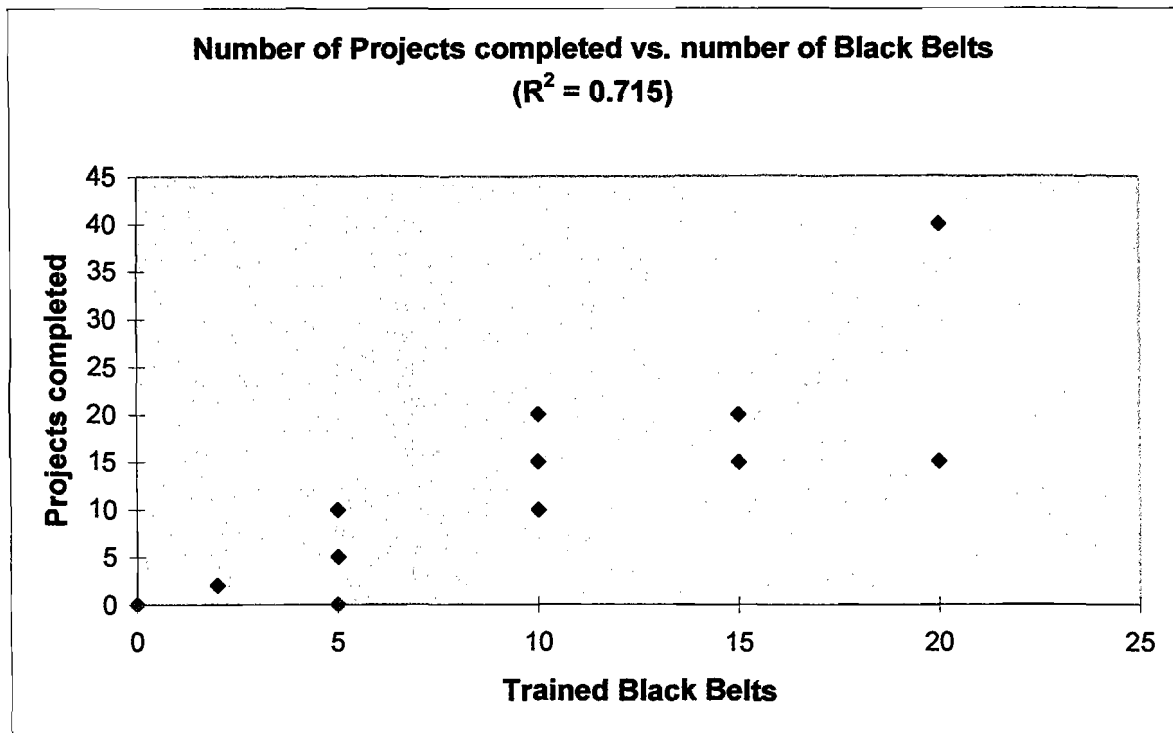


Figure 3.1 indicates that there is an upward trend for the amount of trained black belts vs. the amount of projects completed. Also see figure 3.2 which is a scatter plot of the number of projects completed as a function of the number of trained Black Belts which indicates a positive correlation. Figure 3.1 also indicates that as the Six Sigma deployment matures, more projects are completed.

Figure 3.2: Scatter plot of the number of projects completed as a function of the number of trained Black Belts



It was also noted that the highest number black belts were found in manufacturing, automotive and mining industries whereas the lowest number of black belts were found in the electronics industry.

From table 3.4 it was noted that 25 percent of the firms involved in the survey have been using Six Sigma for less than 1 year on average. Only 25 percent of the firms have been using Six Sigma for $\pm$ six years. This illustrates that Six Sigma deployment in South Africa is still in its infant stages compared to deployment in America (since 1986).

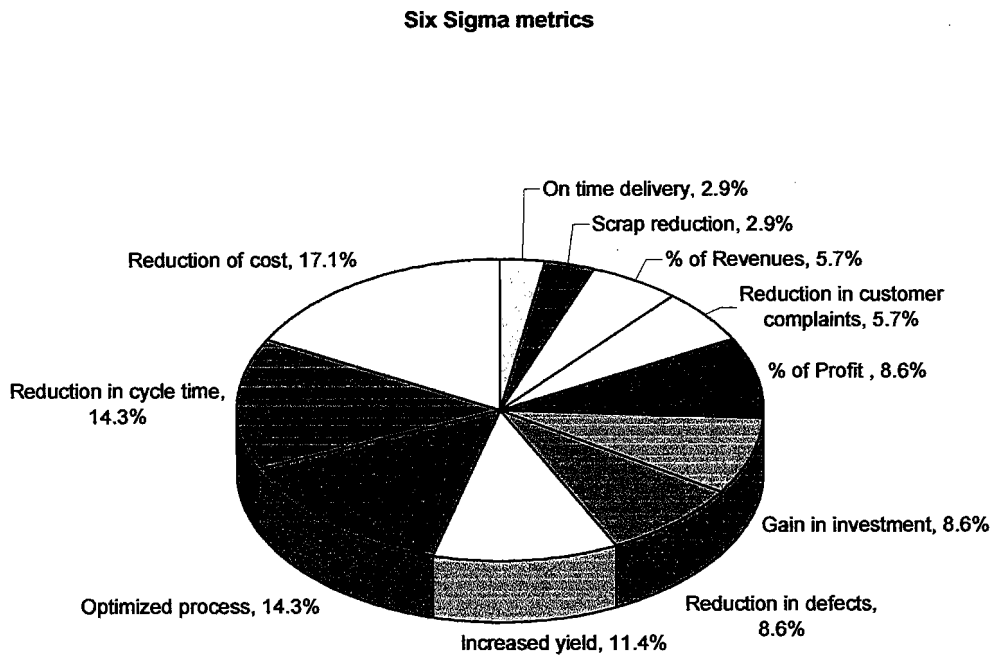
Table 3.4: Number of years using Six Sigma

Years utilizing Six Sigma	Percent
0-1	25.0%
2	31.3%
4	18.8%
6	25.0%

3.4.4 Six Sigma metrics.

A metric is a specification or attribute against which the outputs of a process are compared and declared acceptable or unacceptable. (Antony & Kumar, 2005). Diagram 3.3 presents the key metrics of Six Sigma and their percentages that were commonly used by the firms that participated in this survey. The results of the study revealed that the most commonly used Six Sigma metrics were the reduction of cost. The least commonly used metrics were on time delivery and scrap reduction.

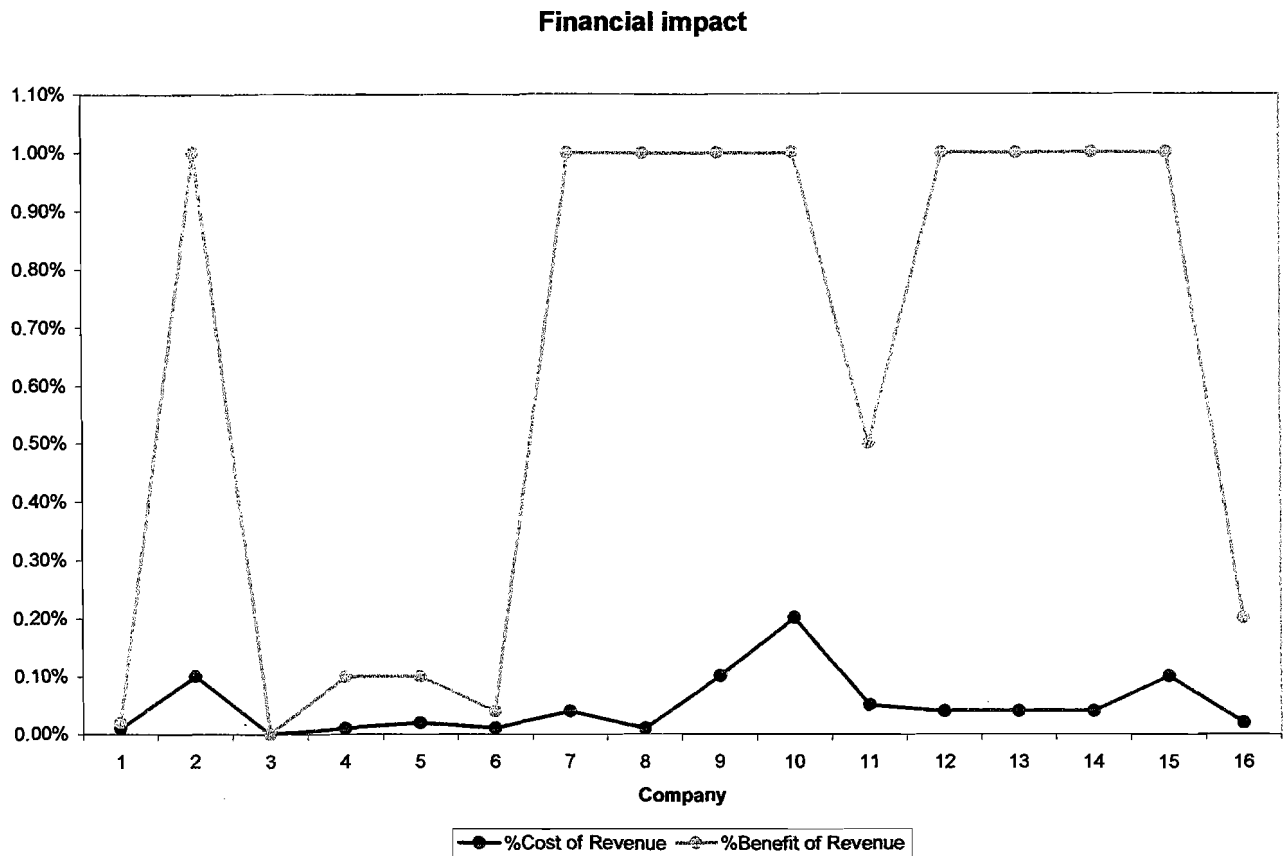
Diagram 3.3: Six Sigma metrics



3.4.5 Financial results

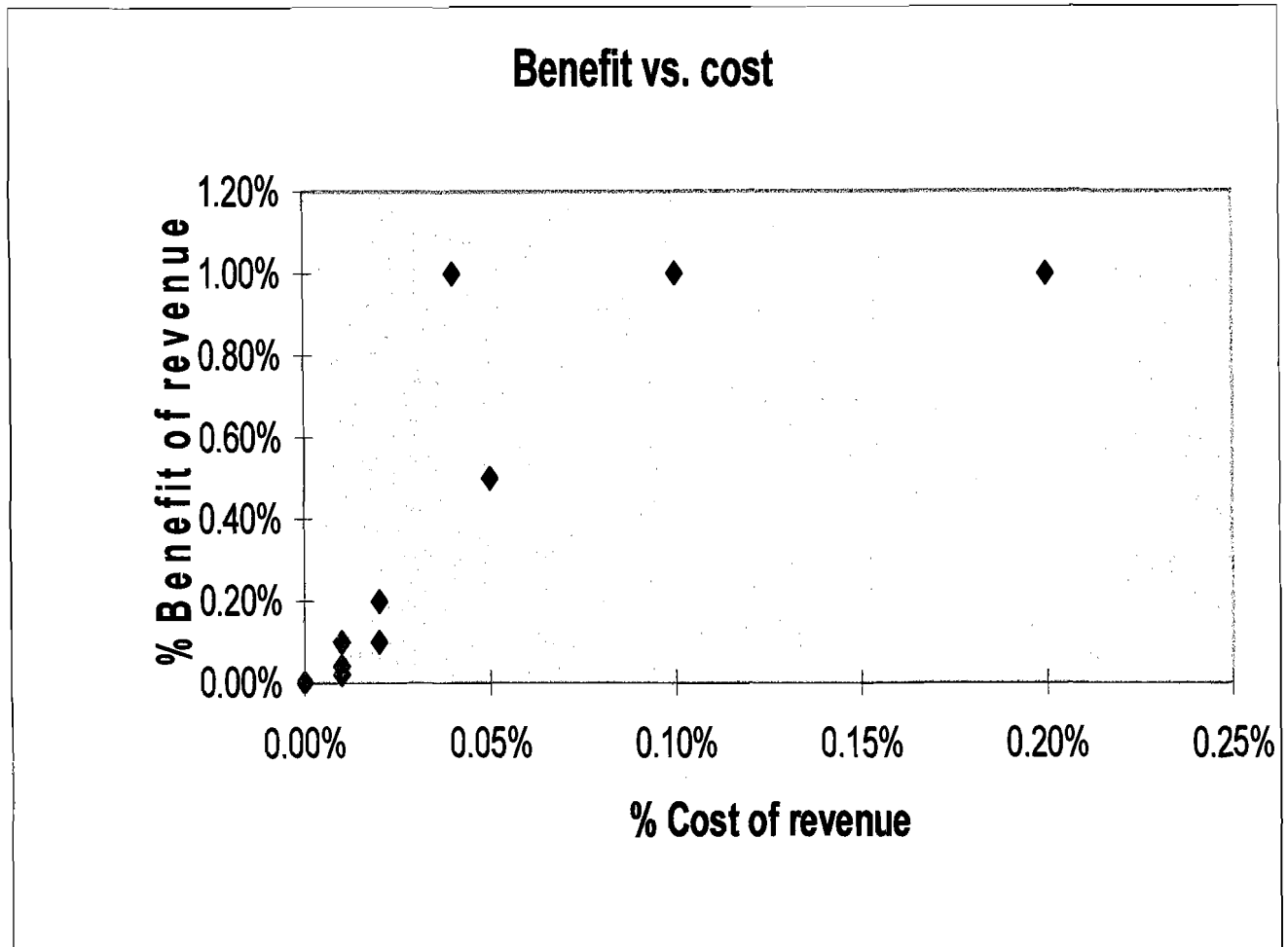
The survey questionnaire attempted to gather the cost of a firm's Six Sigma implementation and its financial benefit obtained from Six Sigma. Each of the aforementioned parameters was expressed as a percentage of each firm's revenue and is displayed in figure 3.3.

Figure 3.3: Financial results



The results indicate that the capital expenditure on Six Sigma correlates the financial benefit obtained from Six Sigma, indicating that the more capital is invested in Six Sigma the greater the financial gain, see figure 3.4 which is a scatter plot of financial benefit vs. the cost of implementing Six Sigma.

Figure 3.4: Scatter plot of financial benefit vs. cost of implementing Six Sigma



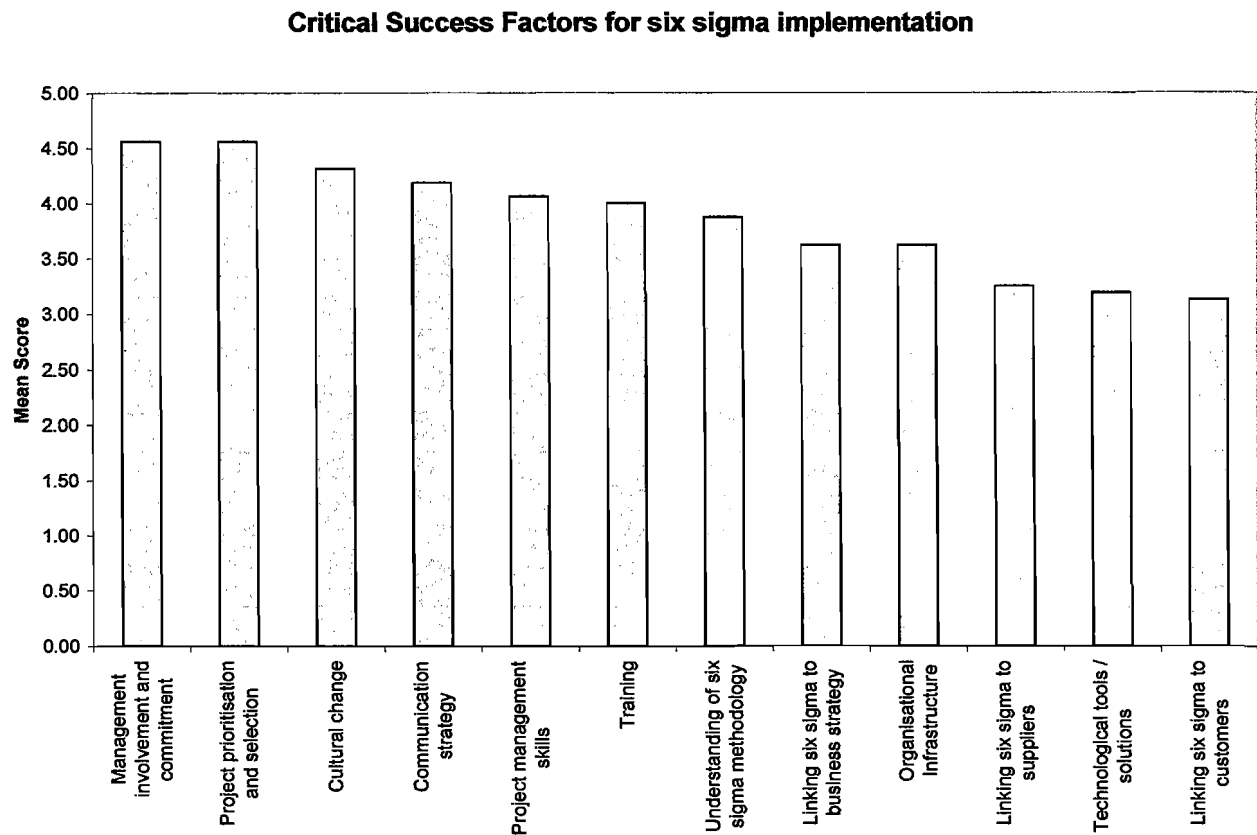
3.4.6 Critical success factors for Six Sigma implementation

The critical success factors represent the key ingredients without which Six Sigma stands limited chance of success. The respondents were asked to rate each CSF on a scale of 1 to 5 (1 = least important, 2 =less important, 3 = important, 4 =very important and 5 = crucial). The CSFs used in this survey study were derived from existing literature of Six Sigma (see Chapter 2). The aim was to determine the CSFs that the participating firms' felt to be important and make a comparative study with the CSFs identified from the literature study. The 12 CSFs identified from the literature were:

- Management involvement and commitment
- Organizational Infrastructure
- Cultural change
- Training
- Linking Six Sigma to customers
- Linking Six Sigma to business strategy
- Technological tools / solutions
- Linking Six Sigma to suppliers
- Understanding of Six Sigma methodology
- Project management skills
- Project prioritisation and selection
- Communication strategy

Figure 3.5 illustrates the CSFs for the successful implementation of Six Sigma within South African firms, showing the mean scores of each critical success factor. Figure 3.5 indicates the priority of importance of the critical success factors for the successful implementation of Six Sigma namely; management involvement and commitment, project prioritization and selection, cultural change, communication strategy, project management skills and training.

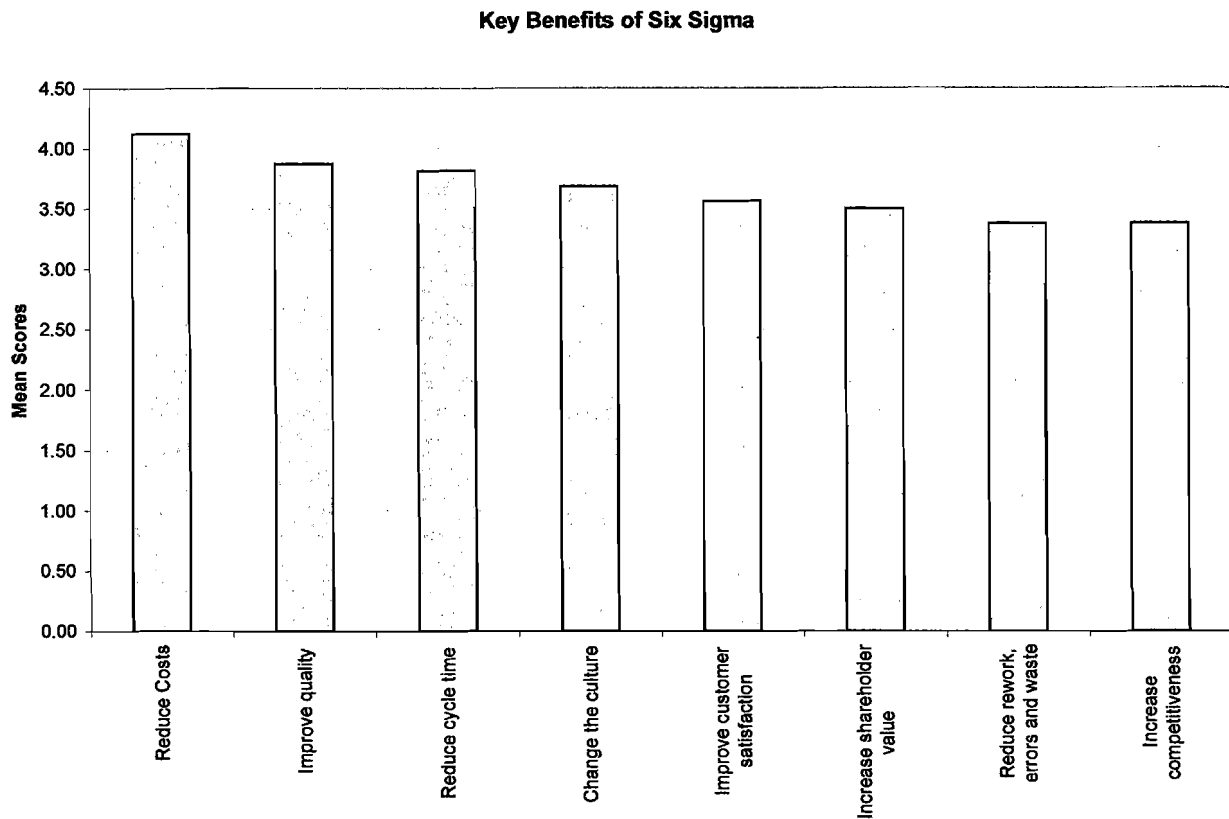
Figure 3.5: Critical Success Factors for Six Sigma implementation



3.4.7 Key Benefits of Six Sigma implementation.

The participating firms were asked to rate the benefits that Six Sigma had brought to their firms since implementation, on a Likert scale of 1 to 5, where 1 = no benefit, 2 = weak benefit, 3 = moderate benefit, 4 = good benefit and 5 = excellent benefits from Six Sigma implementation. Figure 3.6 illustrates the key benefits gained from the implementation of Six Sigma in South African firms. The top 3 benefits experienced are reduction in cost, improved quality and reduction in cycle time.

Figure 3.6: Key Benefits of Six Sigma implementation



3.4.8 Six Sigma success measurements.

Table 3.5 presents the primary measure of success the firms use for their Six Sigma performance and their percentages that were commonly used by the firms that participated in this survey.

Table 3.5: Success measurement for Six Sigma

Primary success measurement	Percentage used
Cost Saving	45.5%
Customer satisfaction	27.3%
Top line revenue growth	13.6%
Number of trained employees	9.1%
Employee attitude change	4.5%

The result of the survey revealed that the most commonly used measure of success by the participating firms were cost saving. This supports the finding of the most popular metrics used for Six Sigma success namely reduction of costs. (see diagram 3.3).

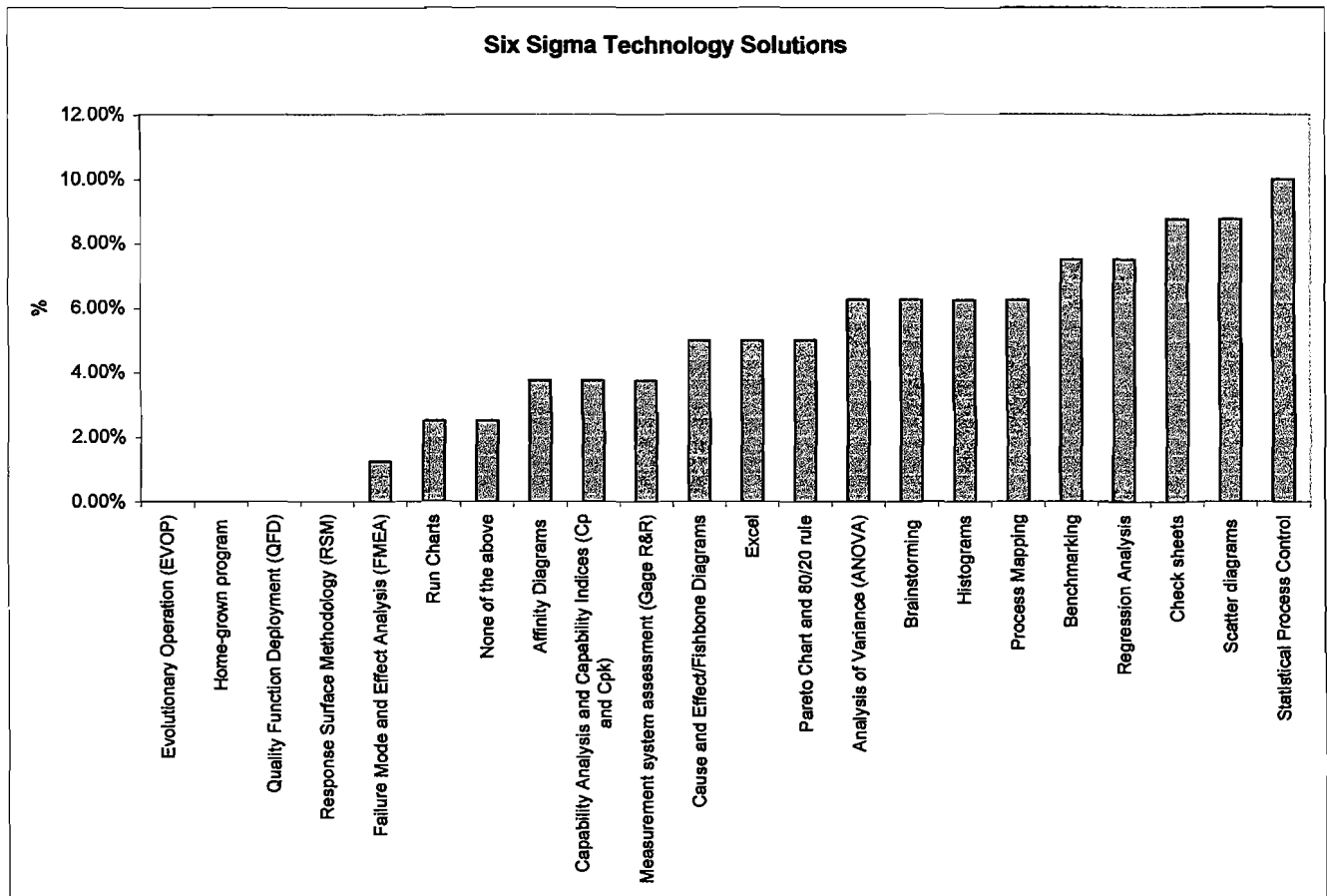
3.4.9 Technology solutions (tools)

From the literature study the following technology solutions (tools) were listed as possibilities to firms;

- Affinity Diagrams
- Analysis of Variance (ANOVA)
- Benchmarking
- Brainstorming
- Capability Analysis and Capability Indices (Cp and Cpk)
- Cause and Effect/Fishbone Diagrams
- Check sheets
- Excel
- Evolutionary Operation (EVOP)
- Failure Mode and Effect Analysis (FMEA)
- Histograms
- Home-grown program
- Measurement system assessment (Gage R&R)
- Pareto Chart and 80/20 rule
- Process Mapping
- Quality Function Deployment (QFD)
- Regression Analysis
- Response Surface Methodology (RSM)
- Run Charts
- Scatter diagrams
- Statistical Process Control

Figure 3.7 presents the technology solutions (tools) most commonly used.

Figure 3.7: Six Sigma Technology Solutions

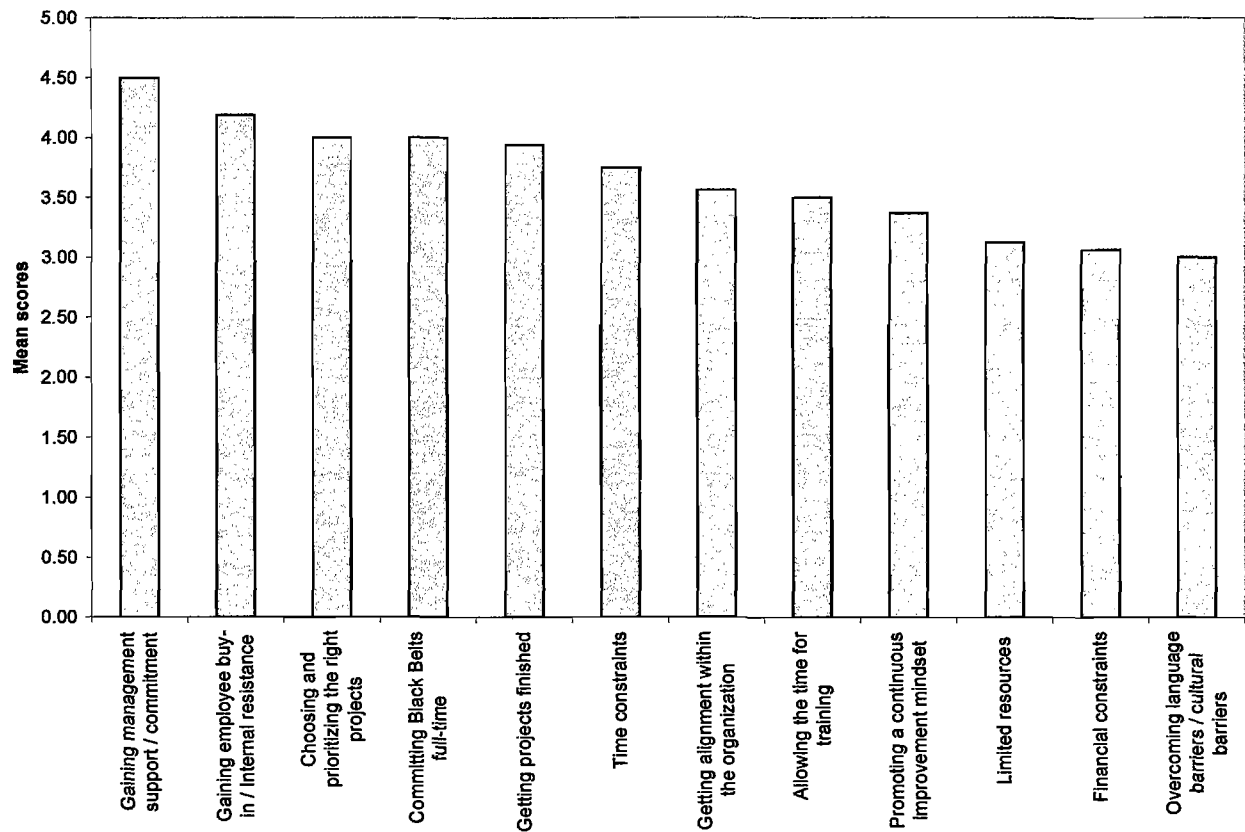


The most commonly used technology solutions were statistical process control (10%) and scatter diagrams (8.75%) which is basic statistical evaluation tools.

3.4.10 Barriers to Six Sigma implementation

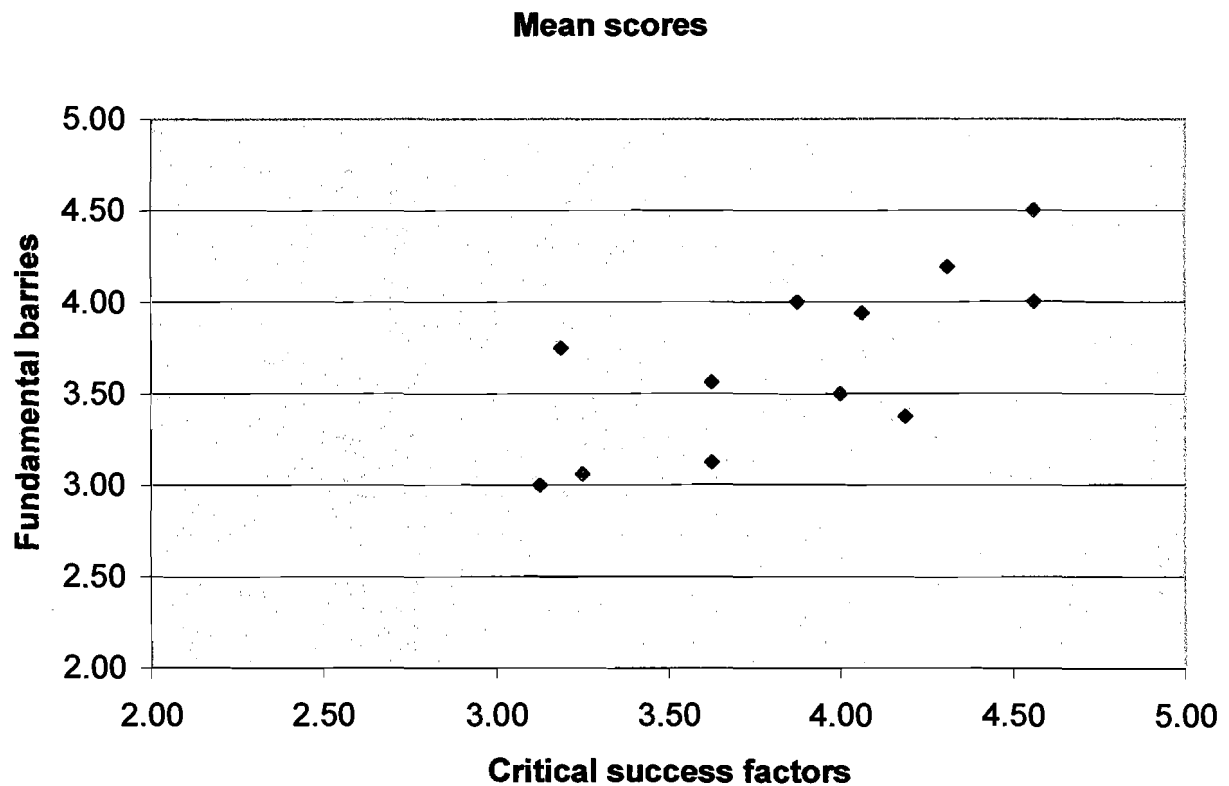
The participating firms were asked to rate the fundamental barriers to the implementation of Six Sigma, on a Likert scale of 1 to 5, where 1 = very weak barrier, 2 = weak barrier, 3 = moderate barrier, 4 = strong barrier and 5 = very strong barrier. Figure 3.8 illustrates the mean scores of each of these barriers obtained. The top three barriers are gaining management support/commitment (mean score 4.5), internal resistance (mean score 4.19) and choosing and prioritizing the right projects (mean score 4.00).

Figure 3.8: Fundamental barriers to Six Sigma implementation



The fundamental barriers and the critical success factors for Six Sigma were arranged in the same categories and a scatter plot of the mean scores for these categories was plotted (see figure 3.9). The trend for this figure indicates that there is a correlation between the fundamental barriers and the critical success factors. This correlation confirms the critical success factors identified, since the CSF if not addressed effectively will become barriers to successful Six Sigma implementation.

Figure 3.9: Scatter plot of fundamental barriers vs. critical success factors



3.5 CONCLUSION

The survey respondents were well represented and only 6 percent of the respondents were in non Six Sigma roles. The industries covered in the survey are also considered well represented, 25 percent from manufacturing, 19 percent from mining, and 19 percent from financial services.

Six Sigma deployments in South Africa are still in its infant stages. This is evident when considering that to date there are only 45 firms who have implemented Six Sigma. 75 percent of the respondents are larger firms (>2500 employees) who has implemented Six Sigma and only 31 percent of the respondents have fully deployed Six Sigma throughout their firms. The financial figures is also testimony of the beginning stages of Six Sigma deployment in South Africa; although all of the firms

have recovered their Six Sigma costs in terms of financial gains, the percentage benefit of revenue is still fairly small (0.62 percent on average) compared to figures quoted in the literature (2.5-3.5 percent).

Based on the survey results and given the need to train several employees, it is implied that a firm may take up to two to three years to realize the benefits of embracing Six Sigma.

The critical success factors' ratings received from the survey corresponded fairly well to those identified in literature, see table 3.6. Four of the top seven CSFs in the survey were also amongst the top seven CSFs identified in the literature. The corresponding CSFs were as follows;

Table 3.6: Critical success factors in literature vs. survey

Literature position	CSF	Survey position
3	Project management skills	5
4	Management commitment	1
6	Understanding six sigma methodology	7
7	Project selection & prioritisation	2

At this stage 45.5 percent of the respondents are using cost savings as the measure of their Six Sigma success, once Six Sigma has reached a more mature level in South Africa it is envisaged that other success metrics will become more popular.

From the results of the survey this chapter illustrates the critical success factors for the successful implementation of Six Sigma and Six Sigma projects. All these factors are essential and therefore should be taken into account for optimizing the financial return from Six Sigma projects in all firms.

The research – and literature results will be used to provide a framework roadmap for implementing Six Sigma successfully. The framework components that is important to consider when implementing Six Sigma will be presented in the following chapter.

CHAPTER FOUR: A FRAMEWORK FOR SUCCESSFUL SIX SIGMA IMPLEMENTATION

4.1 INTRODUCTION

Forward-looking firms are characterized by their willingness to invest resources and energy into activities that position them well for growth and increased profitability. In today's business world, investment of resources is only a small part of the formula for success. Success also relies heavily on fulfilling customer requirements quickly and accurately, reducing processing costs and differentiation among competitors.

Accomplishing all of these objectives simultaneously requires an organized approach at defining and prioritizing key strategic initiatives. A key to bringing these elements together into a recipe for success is in the selection of an appropriate management methodology, which provides a framework for defining and reaching key goals. Commitment among top management is crucial, and that commitment is demonstrated by continued dedication and adherence to the chosen methodology. (Henderson, 2006: 10).

Six Sigma can be very flexible and it is firms that have the ability to exploit this flexibility that achieve the most benefit from the approach. However, many firms like to have a fixed framework to work from. Again, Six Sigma does provide such a framework; however, the framework needs to be developed and personalised for each individual firm for them to achieve the greatest benefit (Rowlands, 2003).

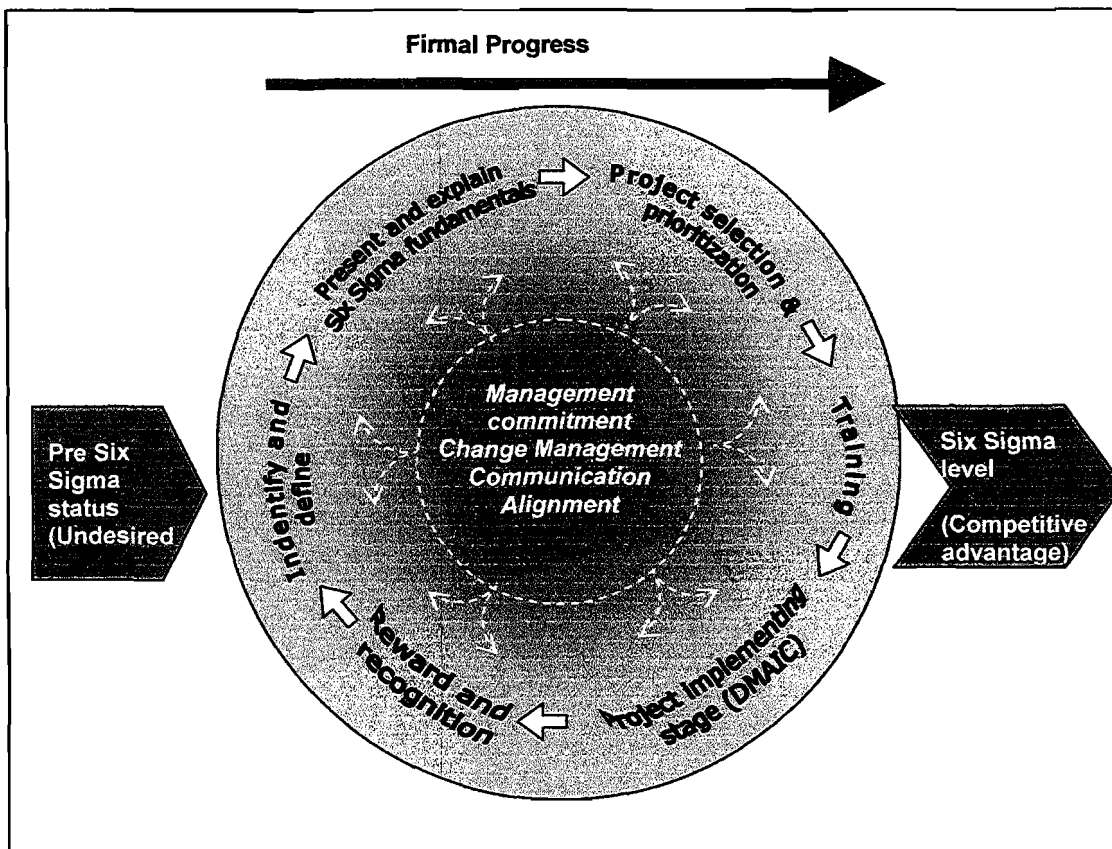
Six Sigma is a disciplined and quantitative approach involving setting up a system and process for the improvement of defined metrics in manufacturing, service, or financial processes. In this chapter a framework (roadmap) is presented that can be used to drive the overall process of selecting the right projects based on a firm's business goals and selecting and training the right people to obtain the desired results.

Combining the information gathered from the literature study (chapter 2), the survey results (chapter 3) and experience from Six Sigma projects the identified critical success factors for successful Six Sigma implementation are encompassed and designed into the proposed framework.

4.2 SIX SIGMA FRAMEWORK

The objective is to develop a rigorous framework that is suitable to a wide range of firms and that can provide adequate direction or guidance for Six Sigma implementation. The framework is designed to be applied in the implementation (deployment) of Six Sigma and can also be applied to new Six Sigma projects in a Six Sigma firm. A proposed framework (roadmap) for successful Six Sigma implementation is presented in figure 4.1. The framework consists of six interlinking components which is dependent on four core elements. The continuous loop of the interlinking components represents the process of continuous improvement, a Six Sigma philosophy. The first component (first step) required for successful implementation of Six Sigma is the - identify and define phase. This is followed by a sensitizing/awareness exercise which entails presenting and explaining the Six Sigma fundamentals to all employees. Once completed, projects can be selected and prioritized according to a defined criterion. Based on the scope and impact of these projects specific training is provided to identified individuals and groups. Equipped with the required knowledge and skills the project implementing phase can commence utilizing the Six Sigma methodology (DMAIC). After deployment or completion of Six Sigma projects the successes must be celebrated by applying a well defined reward and recognition system. On completion of these six steps a firm will have progressed from an initial undesired state to a Six Sigma level which provides them with a competitive advantage. This continuous process is however dependent on core elements i.e. management commitment, change management, a communication strategy and alignment. These core elements are crucial to the successful implementation of Six Sigma and are present during every step of the process. The degree of contribution of each core element to each step of the process will depend on the changing macro – and micro environment of the firm. E.g. if there is a sudden change in the firms' markets, re-alignment of the project goals will be the predominant element.

Figure 4.1: A framework for successful deployment of Six Sigma or successful completion of Six Sigma projects.



4.2.1 Core elements of the framework

4.2.1.1 Management commitment

Top management's commitment is probably the most crucial element for Six Sigma deployment and projects. Top management must recognize that they should play an active role in the Six Sigma implementation, because their involvement and support are essential to the successful implementation.

Top management dictates the firm's rules, they provide the required resources and can eliminate the barriers to success. Management's commitment should be visible throughout the firm; this will also facilitate the change management process.

Top management should drive the use of Six Sigma as a standard problem solving methodology.

DeFeo (2000: 25) confirms the leadership role in the effective deployment of Six Sigma arguing that, like most change initiatives, a Six-Sigma program requires unwavering and consistent ownership and leadership by top management, especially the CEO. Many quality programs have failed or been abandoned, wasting valuable resources in people and funds, because that commitment was missing.

CEO sponsorship confirms four critical elements:

- Resources for training and support will be provided.
- Provisions will be made for review and measurement of performance against goals.
- Achievements will be recognized and celebrated.
- Rewards and compensation will be linked to employee participation and progress.

4.2.1.2 Alignment

Alignment involves the alignment of the firms' strategic goals and its Six Sigma projects. It also entails the alignment of employees toward achieving these goals.

Coetsee (2002: 36) explains that alignment is created in the following way:

- To focus employees, to clarify expectations and to emphasize the principles guiding work behavior
- To involve employees in realizing a vision, transferring ownership, and informing them
- To enable employees to perform effectively and to unlock their potential
- When employees know what to do, how to do it and are able to do it trusting relationships are established
- When visions are realized

4.2.1.3 Change management

Six Sigma is all about change, thus in order to achieve the desired goals, the natural reaction to change should be managed. Any type of change will be met by varying degrees of resistance. Managing these resistances continuously is very important for

the success of Six Sigma. Getting the buy-in and keeping employees engaged is dependent on the successful application of a change management program.

Coetsee (2002: 198) explains that an important factor in the acceptance of change (thus in managing resistance) is the way in which changes are implemented. This includes how effectively and when (timing) details of the intended change are communicated, as well as how long the implementation take, what the expected results (outcomes) are, who is responsible for and involved in the change effort. An important first step is to create an atmosphere (climate) conducive to change. This can be done by creating dissatisfaction with the status quo. Once dissatisfaction with the present situation has been created, further resistance to change should be managed by reducing the fear for change, by providing emotional support, allowing employees to air and discuss their feelings and by allowing people to make mistakes (not repeating old mistakes, but making new ones) during the transitional period. Focusing on the beneficial results of the change will help to create this 'conducive to change climate'.

Employees are more positively responsive to change when they are kept informed. Employee, as important stakeholders, should be aware of and involved in all the facets of change, from the initial planning and diagnosis to the final implementation and evaluation. When employees are kept in the dark they become suspicious and resistant.

Change management includes establishing a learning culture which is required for continuous improvement.

4.2.1.4 Communication

A well defined communication strategy is essential to ensure effective communication regarding each activity during the Six Sigma process. When a firm implements Six Sigma the impact thereof should be communicated to every employee to ensure their engagement. All people differ with regard to their abilities, skills, backgrounds and knowledge which should be taken into consideration. The level of communication should be adjusted to the level of the receiver. It is not only important that top management provides communication at the beginning of the process, but constant communication throughout the process is essential. This will

improve 'buy in' and collaboration from the employees. Also important to help change the culture is to thoroughly and continuously communicate the status of the Six Sigma effort and projects. This communication can include formal project kick-off meetings where the mission, vision, and goals of the Six Sigma program and projects are discussed. At the beginning of the program and projects, it is critical to identify and communicate the mission, vision, values, goals, roles and responsibilities of the projects and project teams. Throughout the projects, it is important to provide continuous status of the projects through periodic status meetings and reports so that the firm is aware of the successes and learnings from the projects.

4.2.2 The Six Sigma cycle

4.2.2.1 Identify and Define

The Identify and Define phase is the foundation block (component) of any Six Sigma initiative and entails identifying and defining the current undesired status of the business. This phase is characterized by top management's commitment towards the implementation of the Six Sigma methodology throughout the business. By showing their commitment management must create an awareness and commitment to the need for improvements (changes). It can be facilitated by utilising tools i.e. baseline measurements, voice of the customer, voice of the business, key performance indicators, benchmarking etc.

The identified undesired status should set the scene for setting the firm's strategic goals.

4.2.2.2 Present and explain Six Sigma fundamentals

This component involves awareness training to all levels in the firm. This training should explain to the employee how Six Sigma can be utilized to move from the undesired status defined in the previous component. It can be established through i.e. Six Sigma workshops, information sessions etc. Thus, when an employee is incorporated in a Six Sigma project team he/she is already familiarized with the Six Sigma methodology. This is important since employee participation is crucial to its

success. This component should also include motivating the employees to align them with the firm's strategic goals.

Change management is a very important success factor for Six Sigma deployment. This component should therefore include creating a supportive climate where employee participation is established. Thorough and continuous communication regarding the statuses of Six Sigma projects helps to facilitate the change management process.

4.2.2.3 Project selection and prioritisation

This component involves the selection of the right projects for Six Sigma improvement. Top management should be responsible for, or alternatively appoint a selection committee for the selection of projects that are aligned with the firms' strategic goals. This involves defining the projects scope and committing the necessary required resources (financial – or human resources). They must also prioritize the projects according to a defined criteria i.e. high financial leverage -, quality improvement -, or waste reduction projects etc. The team should also regularly review the project progress and by doing this they will express their commitment towards the process. It is important that these functions are centralized to ensure consistency and avoid duplication. Included in this component is the instituting of a standard measurement system for Six Sigma success to be used throughout the firm.

4.2.2.4 Training

Based on the project selection the right people can be identified for the required training at different levels. Top management should implement a training strategy aligned with its strategic goals. It is important to provide training at all stages of Six Sigma deployment. The selection and training of black – and green belts are based on their process involvement and impact. Training should however not be limited to the black belt or green belt training but should include the following;

- change management training

- project management
- diversity management
- basic supply chain management
- specific training in the data gathering and – analysis tools utilized

These training criteria's should be categorized according to the different levels of the project member's involvement.

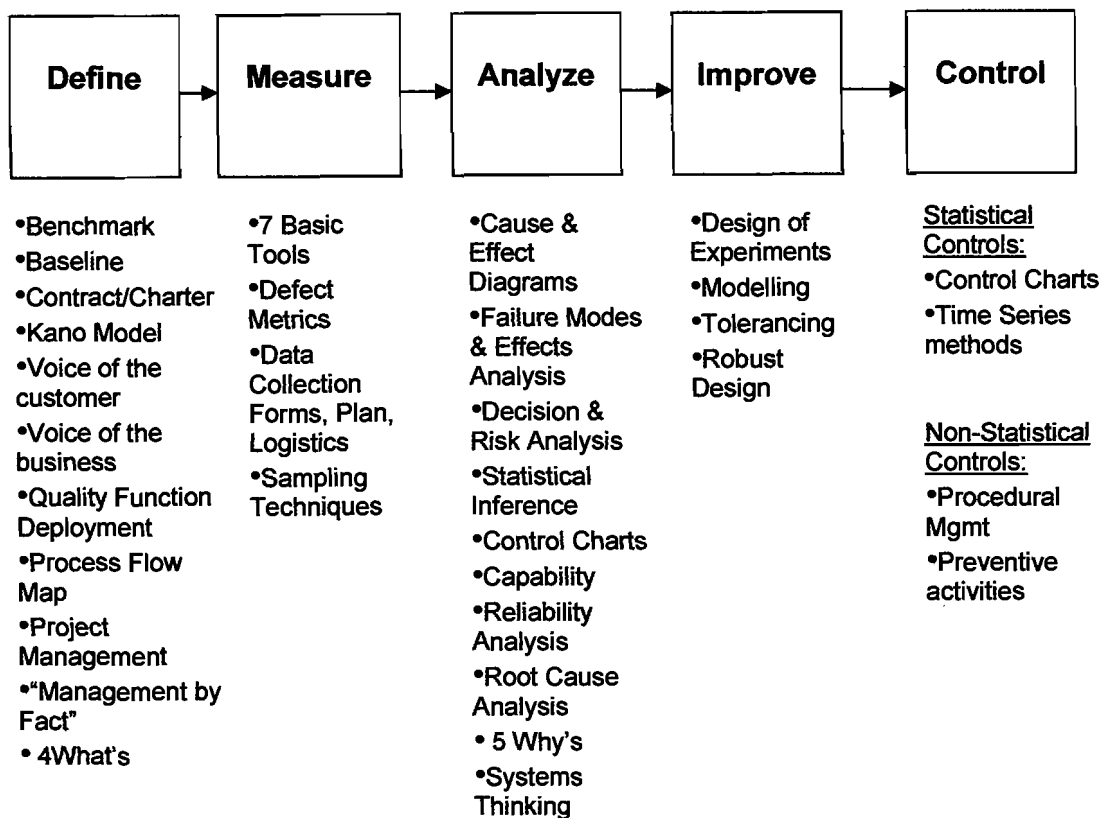
Top management should also be trained in the essentials of the Six Sigma methodology in order to be effective in their participation during the process.

4.2.2.5 Project implementing stage

This component contains the problem-solving road map (DMAIC) specific to the Six Sigma methodology, see figure 4.2

When a specific Six Sigma project is launched, the customer satisfaction goals have likely been established and decomposed into sub goals such as cycle time reduction, cost reduction, or defect reduction. Once an effort or project is defined, the team methodically proceeds through Measurement, Analysis, Improvement, and Control steps. A Six Sigma improvement team is responsible for identifying relevant metrics based on engineering principles and models. With data/information in hand, the team then proceeds to evaluate the data/information for trends, patterns, causal relationships and "root cause," etc. If needed, special experiments and modelling may be done to confirm hypothesized relationships or to understand the extent of leverage of factors; but many improvement projects may be accomplished with the most basic statistical and non-statistical tools. It is often necessary to iterate through the Measure-Analyze-Improve steps. When the target level of performance is achieved, control measures are then established to sustain performance. (Siviy, 2001).

Figure 4.2: DMAIC



(Source: Adapted from Sivi, 2001).

4.2.2.6 Reward and recognition

People have a need to know what they are getting in return for their efforts and what is in it for them. They expect their performance to be recognised and rewarded. Positive behaviour (effort) is reinforced by rewarding and recognising people and results in added performance. To strengthen the performance outcome relationship further, it is necessary to ensure that rewards and recognition are seen as significant. If a reward is not attractive it has far less value and will not contribute to a motivating climate. (Coetsee 2002: 153)

After the projects are completed, the projects' results are audited according the defined performance measurements (metrics). Processes and systems are

implemented to sustain these results and based on these new strategic goals for continuous improvement is established. To gain commitment ('buy-in') to the improved goals, top management is responsible to implement a well defined recognition/incentive system, since it is essential to sustain the Six Sigma initiative. The reward and recognition system must be designed to keep employees dedicated to the Six Sigma implementation. Based on the defined measurement system, successes should be celebrated and rewarded to maintain a level of employee motivation.

4.3 CONCLUSION

The proposed framework (roadmap) for the successful implementation of Six Sigma has been constructed by combining the most critical success factors (CSFs) for Six Sigma and elements of the Six Sigma methodology. Although there are other CSFs and elements, the ones identified in the framework should be regarded as the most crucial for successful Six Sigma implementation. The framework can however be modified to fit each firm's unique circumstances but the CSFs and elements identified should form the minimum requirement (basis) for Six Sigma implementation. The CSFs (core of framework) should be integrated with each step of the Six Sigma process. This will eliminate or address the following common stumbling blocks;

- Lack of support from management due to low level of understanding and buy-in.
- An organizational culture of 'we have always done it this way, why change?'
- Poor project selection
- A measurement culture of comparing past performances
- Roles and responsibilities not clearly defined.

Six Sigma implementation presents a multitude of challenges on various aspects within any firm. By utilising the proposed framework as a basis, it can meet some of these challenges. Thus the framework can ensure or assist in the following;

- Ensure a highly visible top down management commitment
- Goals and objectives that fit in with the firm's strategy

- Applicable training and education for everybody in the firm
- Responsibility and ownership to all participating employees
- A forum to communicate successes as well as failures, and creating a learning culture.
- A organization wide communication system to keep all departments up to date with developments and progress.
- Involving all levels of employees to ensure that Six Sigma becomes everyone's responsibility
- Keep track of results/ lessons learned
- Recognition events

CHAPTER FIVE: CONCLUSIONS and RECOMMENDATIONS

5.1 INTRODUCTION

Six Sigma is a powerful quality management tool and, when implemented and applied correctly can substantially impact on performances, processes, yields and ultimately improve a firm's return on investment (ROI) or reduce costs.

The aim of this chapter is to come to meaningful conclusions that will be based on the information gathered during the literature study, the survey study, the opinions of Six Sigma professionals and the integration of these results. The study offers the critical factors or elements to the success of Six Sigma implementation presented in a framework (roadmap). The framework components that are important to consider when implementing Six Sigma are: Commitment of top management, change management principles, effective communication and alignment of goals and resources. Considering these components, certain recommendations will be made in respect of successful Six Sigma implementation.

5.2 CONCLUSIONS

Six Sigma is a high performance system for executing business strategy. It is however a methodology that requires dedicated training, focus and participation (management and employees). Therefore to ensure its success it should form part of a firm's business strategy and practised as a management system. If Six Sigma is entrenched and part of a firm's activities it will ensure improvements and financial gains and, only then will it create a competitive advantage.

Six Sigma is a top-down solution to help firms, align their business strategy to critical improvement efforts, mobilize teams to attack high impact projects, accelerate improved business results and govern efforts to ensure improvements are sustained.

Antony and Kumar (2005) explains the link of Six Sigma and strategy, arguing that Six Sigma provides business leaders and executives with the strategy, methods, tools and techniques to change their firms.

When the Six Sigma philosophy is part of a firm's strategy it automatically links the tactical and the strategic issues of a firm. When the statistical techniques of Six Sigma are used in a systematic way, it will reduce variation and improve processes. These improvements will assist the firm to focus on customer-related requirements. This chain reaction of events will lead to enhanced marketplace performance and hence improved bottom-line financial results.

When implemented strategically, Six Sigma helps firms turn over working capital faster, reduce capital spending, make existing capacity available and new capacity unnecessary, and produce greater results from research and development investments. Not all firms need to cut defects as low as 3.4 parts per million in every process. Some may need to reach only Four or Five Sigma to meet their objectives (DeFeo, 2000: 25).

Six Sigma offers businesses an opportunity to shake off complacency and continue to compete in an increasingly demanding marketplace. With a successfully implemented Six Sigma initiative, one can expect to improve service, achieve product excellence and realise significant cost savings.

Six Sigma however won't work for firms not prepared to make the necessary investments. As in any improvement effort, the more one is ready to invest, the greater the potential return.

Jacowski (2006) states that Six Sigma will last as long as it significantly improves organizational performance, including putting dollars on the bottom line. Six Sigma will flourish in those firms where performance is significantly improved beyond that which can be obtained through other means.

David Kane, vice president for Cap Gemini Ernst & Young, stated: "We think it will increasingly become a basic requirement for doing business, similar to how ISO and other quality standards became core" (Van Arnum, 2003: 10).

The level of Six Sigma success in a firm requires that the methodology remains flexible. The level of success will be dependent on how the methodology is interpreted and how it is applied according to the individual firm's situation and needs. However, based on the results from the literature – and survey study there are certain critical success factors that need to be present in the implementation of

Six Sigma. The proposed framework (roadmap) for the successful implementation of Six Sigma has been constructed by combining the most critical success factors (CSFs) for Six Sigma and elements of the Six Sigma methodology. Although there are other CSFs and elements, the ones identified in the framework should be regarded as the most crucial for successful Six Sigma implementation

5.3 RECOMMENDATIONS

DeFeo (1999) argues that people, firms, industries, economies and nations will maintain leadership and a competitive edge only if they have a consistent mental attitude and a thirst for more effective ways to produce state-of-the-art products and services. The human element is finally taking advantage of an era of technological development to create a discipline based on the reality that higher levels of unbelievable quality at lower cost can be achieved to compete in a challenging global economy. Six Sigma is more than a road map for survival. It is the route to profitable growth.

Six Sigma should be used as a fully integrated management system, only then will it drive a real, measurable business transformation aligned to a winning business strategy.

It is recommended that the presented framework in Chapter 4 is used as a basis for Six Sigma implementation, however flexibility is at the core of Six Sigma success. The firm's leaders must be willing to be flexible in their management styles. Top management must be willing to change when required. It is recommended that top management develop a business structure which is flexible in dealing effectively with change and employees' resistance to change. Management must be able to manage flexibly from being coercive to coaching as demand arises.

The business structure must also ensure that every key employee in the firm participates in the Six Sigma process. Through this participation management must foster three key concepts the employees must commit to, to ensure Six Sigma success:

- the external customer,

- the internal customer, and
- the process

A study conducted by the market research firm Greenwich Associates (2003) confirms that Six Sigma's productivity is highest when the voice of the customer becomes the program's focus. It is vital to involve sales and marketing people as they can provide valuable intelligence for the selection of Six Sigma projects that focus on the voice of the customer. They also can help allay customers' fears that Six Sigma's purpose is only to cut costs, irrespective of what customers want.

The first step in the proposed framework is to identify and define the firms' current 'undesired status' i.e. declining profits, losing market share, manufacturing costs too high, sub-standard quality products, unsatisfied customers etc. Representative data over a significant period is collected to establish performance over time; this must provide a clear picture of the performance gap which exists to meet the set goals.

The data will provide a start for the team to identify the root causes of performance gaps. As soon as the root causes have been identified improvement initiatives can be launched. The outcome should be dedicated projects that will be sufficient to close the gap, with a clear definition of deliverables and timelines. The improvement projects launched should be driven vigorously by top management. Top management's engagement in these projects must ensure commitment from the employees. Strategic objectives are set based on different requirements. One of these requirements should be the customer perspective, thus setting the objectives against customer expectations. The firm should analyse how its performance impacts on customers. During the crafting and implementation phases of business strategy, Six Sigma can be used to ensure that the strategic objectives are aimed at the right targets. Six Sigma adds another dimension to the setting of strategic objectives, ensuring that the objectives are defined as precisely as possible with a clearly defined metric and time frame.

Some of the respondents in the survey study's Six Sigma implementation cost are far less compared to others. This is attributed to the fact that they have accommodated the majority of their Six Sigma training in-house. Thus if a firm has a developed and

integrated quality system and department it is recommended that they accommodate their own training which could generate a significant cost saving.

5.3.1 Selecting a Six Sigma partner (key considerations)

Ferguson (2007) argues that many firms embarking on a Six Sigma program realise that they will need some form of external help. Given the multitude of Six Sigma service providers, choosing the right one can be a challenge. Before embarking on the selection process, a firm should be clear on the overall objectives and scale of the program. Is it to up-skill a number of employees to make them more quality-conscious and achieve small incremental gains, or to deliver step-change results and truly improve the behaviours of the firm?

Whatever the objective, it's important to choose a partner with real implementation experience. Having agreed the objectives of the program, many firms find it helpful to identify and prioritise the criteria by which they will select their partner.

A further consideration before starting off is to have a strong sense of building on what has been achieved already. This will automatically require a high degree of tailoring in the Six Sigma program, which providers should be able to demonstrate. Cost is clearly an important factor in any choice provider – but it needs to be seen in the context of the benefits that will be delivered. A serious provider will put their own fee at risk, dependent on results.

In order to assist with the implementation of Six Sigma it is also recommended that the firm joins a user group to share and exchange experiences of successful Six Sigma projects as well as with similar firms which have implemented Six Sigma. The networking advantages gained at these forums can be very valuable for any Six Sigma initiative.

5.3.2 Extending Six Sigma

If firms want to utilize the full benefit of the Six Sigma methodology, they must, once their internal processes have been improved, extend it to their external processes. This implies the implementation of Six Sigma across their supply chain.

They must therefore also assist clients, suppliers and customers to increase their bottom line results. This will inevitably result in a financial return for them, because anything that makes the clients, suppliers and customers more effective and efficient will benefit the firm. Once this whole process has been established, it will result in a culture change focusing the entire supply chain on analysis and data driven methods to increase revenue, improve profits and generate cost reductions.

5.3.3 Steps to success

A survey conducted by the Aberdeen Group (2006) has suggested recommendations for action. These recommendations correspond to core elements and stages in the proposed framework (roadmap).

Whether a firm is looking to initially implement Six Sigma or trying to gradually move its firm from “Laggard” to “Industry Average,” or “Industry Average” to “Best in Class,” the following actions will help spur the necessary performance improvements:

- ***Implement a corporate wide training program*** to educate employees on the benefits and results of data-driven decision-making. Establish goals and timeliness for education and certifications. Bring in outside consultants to guide the process and initially serve as both Master Black Belts and Black Belts.
- ***Identify individuals who will be dedicated and trained as Black Belts.*** This is not a part time job and requires assignment of some of the best and brightest.
- ***Implement DMAIC (Define-Measure-Analyse-Improve-Control) methodologies.*** This is a structured, problem-solving approach to phased projects. While many quality initiatives rely on measurement, analysis and

improvement, Six Sigma distinguishes itself in the Control phase of the program. Determine long term control measures which will ensure that the contributing factors remain controlled.

- ***Identify and prioritize business impact projects according to anticipated savings and improved throughput.*** Identify those criteria that are critical to quality in the eye of your customer. Look first for low hanging fruit and act now for immediate benefit. Start with those projects which will yield the best results in the fastest time frame.
- ***Identify process and project owners who will accept ownership of and accountability for the improvement process.*** These process owners must uncover methodologies that lead to continuous improvement. This discovery process is an important aspect of developing ownership of improvement and driving to real results.
- ***Flow chart selected processes.*** Start mapping the process from the end result back to initial stages. Much like the value stream mapping intrinsic to Lean Manufacturing, this is the first step in removing non-value added steps in the process. Determine the critical characteristics affecting quality which are upstream from the results. Attempting to manage the end results only will not eliminate costs due to rework, inspection and test.

5.4 FUTURE RESEARCH DIRECTIONS

Future research regarding the following can be beneficial for Six Sigma implementation:

- Since the deployment of Six Sigma in South Africa is still fairly recent, additional research is required to validate the proposed framework (roadmap), thus future research will need to be performed to identify whether the framework components and the critical success factors from the study will ensure the successful implementation of Six Sigma.
- Investigate how firms have extended Six Sigma to their suppliers and or customers
- Investigate how the proposed framework can be utilized or tailor made by SMEs to implement Six Sigma.

- Composing the measures to evaluate readiness for Six Sigma implementation where customers and suppliers are considering deployment.
- Identifying the gap between theory and practices and the major factors causing the gap.
- Culture and change management in implementing Six Sigma is a topic in its own right which needs additional research to determine how it has been successfully applied by different firms.

The industries that have not yet implemented Six Sigma certainly provide a broad spectrum of future research opportunities.

BIBLIOGRAPHY

ABERDEEN GROUP. 2006. The Lean Six Sigma Benchmark Report. *Aberdeen Group*. Available: http://www.aberdeen.com/c/report/benchmark/RA_SixSigma_3490.pdf. 22p

ANTONY, J. 2006. Six Sigma for the little guy. *MMSmag (Mining & Manufacturing Systems)*, Available: <http://www.mmsmag.co.za/articledetail.aspx?id=252>
Date of access: 28 Nov. 2006.

ANTONY, J., ANTONY, F.J. & KUMAR, M. 2007. Six Sigma in service organizations Benefits, challenges and difficulties, common myths, empirical observations and success factors. *International Journal of Quality & Reliability Management*. Vol. 24(3): 294-311

ANTONY, J. & BANUELAS, R. 2001. A strategy for survival. *Manufacturing Engineer*, 80(3): 119-21.

ANTONY, J. & BANUELAS, R. 2002. Key ingredients for the effective implementation of Six Sigma program. *Measuring Business Excellence*, 6, 20-27. Available: <http://www.emeraldinsight.com/1368-3047.htm> Date of access: 29 Aug. 2007.

ANTONY, J. & KUMAR, M. 2005. Six Sigma in small and medium-sized UK manufacturing enterprises - some empirical observations. *International Journal of Quality & Reliability Management*, 22(8): 860-874. Available: www.emeraldinsight.com/0265-671X.htm
Date of access: 28 Nov. 2006.

BYRNE, G. 2003. ENSURING OPTIMAL SUCCESS WITH SIX SIGMA IMPLEMENTATIONS. *JOURNAL OF ORGANIZATIONAL EXCELLENCE*, 43-50

CHASE, R.B., JACOBS, F.R. & AQUILANO, N.J. 2004. Operations management for competitive advantage. 10th ed. New York: McGraw-Hill/Irwin. 765 p.

CLARK, G. 2007. Passion is the seed of change. *blogs.isixsigma.com*. Available: http://blogs.isixsigma.com/archive/passion_is_the_seed_of_change.html
Date of access: 14 Aug. 2007.

COETSEE, L. 2002. Peak Performance and Productivity: A Practical guide for the creation of a motivating climate. 2nd Print 2003

CONNOLLY, M. 2003. Six Sigma deployment at DuPont. *R&D Magazine*, 29, April.

COOPER, D.R. & SCHINDLER, P.S., 1998. *Business Research Methods*, 6th Edition, New York: McGraw-Hill.

CORONADO, R.B. & ANTONY, J. 2002. Critical success factors for the successful implementation of Six Sigma projects in organizations. *The TQM Magazine*, Volume 14 (2): 92-99

DAS SARMA, A. 2007. Six Sigma approach dictates program success or failure. *iSixSigma.com*. Available: <http://www.isixsigma.com/library/content/c070813a.asp>
Date of access: 13 Aug. 2007.

DeFEO, J.A. 1999. Six Sigma: a new approach to quality management. *Directorship*; 25 (11): 8. December. Available: Business Source Premier Date of access: 29 Jul. 2007.

DeFEO, J.A. 2000. An ROI Story. *Training & Development*, 25-27 July.

DUSHARME, D. 2001. Six Sigma survey: breaking through the Six Sigma hype. *Quality Digest*, Available: <http://www.qualitydigest.com/nov01/html/sixsigmaarticle.html>
Date of access: 24 Aug. 2007.

DUSHARME, D. 2003. Survey: Six Sigma packs a punch. *Quality Digest*, Available: http://www.qualitydigest.com/nov03/articles/01_article.shtml
Date of access: 24 Aug. 2007.

EMERALD GROUP PUBLISHING LIMITED. 2003. A revealing study of Six Sigma - gains but missed potential. *Strategic Direction*, 19(8): 34-36.

FERGUSON, J. 2007. Why Six Sigma for financial services? *onesixsigma.com*, Available: <http://www.onesixsigma.com/celerant/Why-Six-Sigma-for-Financial-Services-240420> Date of access: 26 Jun. 2007.

FURTERER, S.L. 2004. *A framework roadmap for implementing lean six sigma in local governmental entities*. Florida: University of Central Florida

GALE, S.F. 2003. **Building Frameworks for Six Sigma Success Available:**
<http://www.workforce.com/section/11/feature/23/44/46/index.html>
Date of access: 10 Jul. 2008

GIJO, E.V. & RAO, T.S. 2005. Six Sigma implementation – hurdles and more hurdles. *Total Quality Management*, 16(6): 721–725, August.

GREENWICH ASSOCIATES. 2003. A revealing study of Six Sigma - gains but missed potential. *Strategic Direction*, 19(8): 34-36.

HARBERT, T. 2006. Lean, mean, Six Sigma machines. *Electronic Business*, 6/1/2006, Available: <http://www.edn.com/article/CA6339520.html> Date of access: 12 Jun. 2007.

HENDERSON, D. 2006. Executive Champions Drive the Race for Six Sigma Success. *Human Resources Guide – Supplement to the San Diego Business Journal*. p10, September.

JACOWSKI, T. 2006. Six Sigma training & certification's impact on quality. *sixsigmaonline.org* Available: <http://www.sixsigmaonline.org/articles/117/1/SIX-SIGMA-TRAINING--CERTIFICATIONS-IMPACT-ON-QUALITY/Page>.
Date of access: 26 Jun. 2007.

JUTRAS, C. 2006a. Benchmarking Lean Six Sigma. *The Aberdeen Group*, Available: http://www.aberdeen.com/c/report/research_briefs/RB_LeanSixSigma_CJ_3350.pdf Date of access: 11 Jul. 2007.

JUTRAS, C. 2006b. Technologies enable Six Sigma. *The Aberdeen Group*, Available: http://www.aberdeen.com/c/report/enterprise_strategies/ES_SixSigma_CJ_3438.pdf Date of access: 11 Jul. 2007.

JUTRAS, C. 2006c. Mid-size companies reap financial benefits from Six Sigma. *The Aberdeen Group*, Available: http://www.aberdeen.com/c/report/sector_insights/Sl_SixSigma_CJ_3515.pdf Date of access: 13 Jul. 2007

KELLER, P. 2003. Does Six Sigma work in smaller companies? Available: <http://www.qualityamerica.com/knowledgecente/articles/PAKSmallCompanySS.htm> Date of access: 12 Apr. 2007.

KLEFSJÖ, B., WIKLUND, H. & EDGEMAN, R.L. 2001. Six Sigma seen as a methodology for total quality management. *Measuring Business Excellence*, 5(1): 31-35, Available: <http://www.emerald-library.com/ft>

LeBLANC, F., McLAUGHLIN, S., FREEDMAN, J., SAGER, R. & WEISSMAN, M. 2004. A Six Sigma approach to maximizing productivity in the cardiac cath lab. *Journal of Cardiovascular Management*, 19-24, March/April.

LEE, K. 2002. *Critical success factors of Six Sigma implementation and the impact on operations performance*. Cleveland: State University.

LEVINE, D.M., STEPHAN, D., KREHBIEL, T.C. & BERENSON, M.L. 2005. Statistics for managers using Microsoft Excel. 4th ed. New Jersey: Pearson Education. 886 p.

LONG, J. 2004. What is Six Sigma? *Connections Magazine*, Available: <http://www.connectionsmagazine.com/papers/3/16> Date of access: 6 Jul. 2007.

MARX, M. 2007. Six Sigma saves a fortune. *iSixSigma Magazine*: 28-32, January/February.

McCARTY, T. 2004. Six Sigma® at Motorola. Available: <http://www.isixsigma.com/offsite.asp?A=Fr&Url=http://mu.motorola.com/> Date of access: 6 Jul. 2007.

MOTWANI, J., KUMAR, A. & ANTONY, J. 2004. A business process change framework for examining the implementation of Six Sigma: a case study of Dow Chemicals. *The TQM Magazine*. Volume 16(4): 273-283

NEUSSCHELER-FRITSCH, D. & NORRIS, R. 2001. Capturing financial benefits from Six Sigma, *Q. Progress*. Available: <http://www.isibang.ac.in/SQC/newsletter/december2001/article2.htm> Date of access: 26 Jun. 2007.

NONTHALEERAK, P. & HENDRY, L., 2008. Exploring the Six Sigma phenomenon using multiple case study evidence. *International Journal of Operations and Production Management*. Vol. 28(3): 279-303

OKE, S.A.. 2007. Six Sigma: A Literature Review. *South African Journal of Industrial Engineering*, Vol 18(2): 109-129

RATTEY, T. 2004. Six Sigma – no easy road to process improvement. *MMSmag (Mining & Manufacturing Systems)* Available: <http://www.mmsmag.co.za/articledetail.aspx?id=88> Date of access: 28 Nov. 2006.

ReVELLE, J.B. 2004. Six Sigma problem-solving techniques create safer, healthier worksites. *Professional Safety*, 38-46, October.

ROWLANDS, H. 2003. Six Sigma: a new philosophy or repackaging of old ideas. *Engineering Management*, 18-21, April. Available: Academic Search Premier.

RUDISILLI, F. & CLARY, D. 2005. Six Sigma: saving and making money. *Chartered Accountants Journal*, April. 21-25

Siviy, J. 2001. Six Sigma - Software Technology Roadmap. *Carnegie Mellon Software Engineering Institue*, Available: http://www.sei.cmu.edu/str/descriptions/sigma6_body.html Date of access: 23 Jun. 2008.

SIX SIGMA TUTORIAL. Six Sigma Capability Improvement, *sixsigmatutorial.com*, Available: <http://sixsigmatutorial.com/Six-Sigma/Six-Sigma-Capability-Improvement.aspx> Date of access: 24 Aug. 2007.

SNEE, R.D. 2001. Focus on improvement not training: how Six Sigma can do it right. *Quality Management Forum*, March, Available: http://www.kwtunnell.com/IMAGES/ronsnee_2.doc. Date of access: 24 Aug. 2007

STRUWIG, F.W. & STEAD, G.B., 2004. Planning, designing and reporting research. Third impression. South Africa: Pearson Education.

THEVNIN, C. 2004. Effective management commitment enhances Six Sigma success. *Handbook of business strategy*, 195-200.

TÖRÖK, J. 2007. The perfect storm – the Six Sigma phenomenon. *iSixSigma Magazine*, 33-37, January/February.

VAN ARNUM, P. 2003. Quality focus: the next phase of Six Sigma. *Chemical Market Reporter*, September 15, 10.

WAXER, C. 2002. Six Sigma costs and savings. *iSixSigma.com* Available: <http://www.isixsigma.com/library/content/c020729a.asp> Date of access: 26 Jun. 2007.

WESSEL, G. & BURCHER, P. 2004. Six Sigma for small and medium-sized enterprises. *The TQM Magazine*, 16 4): 264-272, Available: www.emeraldinsight.com/0954-478X.htm

APPENDIX 1: EXAMPLES OF SIX SIGMA PROJECTS AND COST SAVINGS

Air Academy Associates, a consulting and training firm, lists examples of Six Sigma projects and cost savings from a variety of industries:

Industry: Oil exploration and drilling company

Project	Results	ROI - annualized
Response time to "No Fluid Detected" wells	1. Well downtime reduced from 467 to 138 days/ month 2. Production increase of 377 Barrels of Oil per Day (BOPD)	\$2,500,000
Soft water usage by steam generators in oil reclamation	1. Reduced CGS by 65% through proper chemical mixture 2. Increased soft water production by 30,000 barrels per day 3. Increased oil reclamation	\$1,000,000 – chemical savings \$18,900,000 – increased oil production
Improving automatic well test process	1. Increased test accuracy by 25% 2. Improved % of successful "workovers"	\$500,000
Oil content of injection water	1. Reduced content from 40 ppm to 25 ppm 2. Increased oil production by over 100 BOPD 3. No increase in chemical use	\$800,000
Periodic well test process	1. Increased accuracy by 25% 2. Improved well work decisions 3. Increased number of tests per month by 423	\$400,000 – well work decisions \$100,000 – value of extra tests.

Industry: Water Treatment

Project	Results	ROI - annualized
Water Treatment – total solids were 7 times the specification; treatment costs were \$.14 per barrel	1. The quality of the water was improved 7 fold while the operational costs were lowered to \$.08 per barrel. 2. Training on "variation reduction" was instituted for all operators. New SOPs were accomplished.	\$854,000

Industry: Vehicle maintenance support unit (large company)

Project	Results	ROI - annualized
Reduce the high cost of vehicle maintenance	1. Moved technical experts to the field 2. Improved data collection techniques	
Lower "no evidence of failure" (NOEF) rate	1. Reduced NOEF rates from 30-40% to less than 5% 2. Improved training and awareness of operators	
Cut vehicle time out of commission rate	1. Implemented improved Control Plan 2. Used Measurement System Analysis to improve diagnostic equipment	Total: \$1.8 million

	3. Implemented electronic technical manuals	
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Industry: Transactional

Project	Results	ROI- annualized
Human Resources: Employee productivity is reduced when employees transfer to different jobs within the company	1. Lost productivity due to failure of direct deposits, interrupted health care, large out-of-pocket expenses, as well as lot access to computer/phone was calculated. 2. DMAIC process resulted in improved process flows and SOPs to include a transfer binder, use of intranet, and pre-transfer training. 3. Annual survey instituted.	\$479,700

Industry: Large Electronics Company

Project	Results	ROI- annualized
Upgrade Monoblock duplexer	1. Upgraded the product using VOC, IPO diagram, and DFSS tools	\$724,000
Deflection yoke for TV	1. Upgraded the design using DFSS tools and improved the overall production process	\$240,000

Industry: Automotive

Project	Results	ROI- annualized
Crankshaft production failures	1. Decreased the number of crankshaft failures from 15,000/million to 1,000/million 2. Used Six Sigma tools to stratify the errors; most were due to grinding failures. DMAIC decreased the interference caused by design of main axle pocket and flange area 3. Improved operator training	\$100,000

Industry: Pharmaceutical

Project	Results	ROI- annualized
Pharmacist Information (PI) Outsert (shrink wrapped on outside)	1. PI Outsert bottleneck on the drug secondary packaging line was eliminated. 2. New adhesion process and automated cartoner installed. 3. Eighteen FTE moved from process to another process within the business 4. A new, smaller, and less expensive outsert created.	\$4 million (after the cost of capital equipment)

Industry: Alumina Refinery

Project	Results	ROI- annualized
High variability in titration measurement system resulting in high variability in the process	1. The pooled standard deviation of the A/C Ratio for the four titration systems in use reduced by 69%.	1. \$180,000

chemistry (A/C ratio =g/l Alumina / g/l Sodium Hydroxide)	2. The variability of the individual components reduced from 41% to 71%. 3. Improved plant A/C Ratio control and reduced lost production due to not maintaining target production Ratios 4. Reduced downstream problems caused by high A/C Ratios	2. Indirect savings – increased productivity due to less maintenance problems caused by poor ratio control
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Industry: Pharmaceutical Company

Project	Results	ROI- annualized
Packaging- downtime of machines on the packing line was excessive causing lower than expected/desired productivity.	1. SOPs were developed 2. Training was improved 3. Variation in the adjustments and adjustment frequencies was reduced	\$90,000

Industry: Chemical Production

Project	Results	ROI- annualized
Methyl Ethyl Ketone (MEK) and Ethanol Separation Unit – improve production capacity and reduce variability	1. Cpk was increased from .77 to 4.3 2. Normal production rates for MEK and Ethanol improved more than 4% above previous maximum rate 3. Ethanol losses reduced	1. \$100million for MEK 2. \$70 million for Ethanol 3. Soft savings - \$25 million

Industry: Medical Device Company

Project	Results	ROI- annualized
Combine two existing rejection systems used for tracking defective materials.	1. The two systems were combined, streamlined, and placed on the web. 2. Process flow created for new process	\$118,000

Industry: Machining, Tooling, and Assembly

Project	Results	ROI- annualized
Customer Service/Warranty claims- the process too cumbersome and costly	1. New streamline process created permitting better tracking of supplier related warranty costs 2. SOPs developed(PF/CE/CNX/SOP)	\$100,000

Industry: Submersible Pump Repair

Project	Results	ROI- annualized
Process –process to produce submersible pumps was too	1. Process streamlined and waste removed.	1. Reduced waste yielded \$436,370

slow resulting in a large volume of lost sales	2. Cycle time reduced from 24 hours down to 19 hours. 3. Physical layout and tool control dramatically improved. 4. Number of temporary storages reduced from 24 to 6.	2. Sales increased \$4.9million
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APPENDIX 2: SIX SIGMA RESULTS RANKED BY COMPANY SIZE

Survey Respondents' Six Sigma Results Ranked by Company Size		
Results	Employees in site	Employees in firm
Waste reduction saved \$120,000	75	100,000
Reduced costs by \$50,000 per year	120	350
On-time delivery improved to 97%; yields improved to 97%	120	125,000
Saved \$1 million	200	3,000
Saved approximately \$150,000	240	4,500
Reduced scrap by 15%; reduced rework by 25%	250	5,000
Reduced downtime by 30%	300	7,000
Saved \$4 million per year	300	30,000
Improved production throughout by 43%; reduced No. 1 defect in plant by 50%	400	2,500
Increased production capability 12-16%	450	6,000
Saved \$780,000 per year	500	
No. 1 customer complaint 99% eliminated, saving more than \$1 million per year	600	93,000
Saved \$20 million in two years	1,000	7,500
Saved \$12 million in 2001	1,000	20,000
Increased productivity by 20%	1,000	4,000
Reduced manufacturing defects by 67%	1,100	1,500
30 Black Belt and Green Belt projects completed; saved \$14,625,800	1,400	65,000
Saved \$5 million in cost during first two years	1,800	10,000
Improvements ranging from a 50% to 90% decrease in defects	3,000	48,000
Increased productivity of call centre analysts by 23%	3,000	350,000
Customer service incidents reduced more than 50%	4,000	330,000
More than \$7 million in direct savings in six months	8,000	21,000

APPENDIX 3: Survey Questionnaire

SIX SIGMA SURVEY

All your responses will remain anonymous and confidential and will only be used as part of a statistical analysis. Your company details will not be revealed in the results.

Section A COMPANY PROFILE

1. Your position / six sigma role e.g. Manager, Green belt etc.

- | | |
|--|---|
| ☐ Green Belt (GB) | ☐ Non-Six Sigma Role |
| ☐ Black Belt (BB) | ☐ Manager |
| ☐ Master Black Belt (MBB) | ☐ Coordinator |
| ☐ Process Owner | ☐ Technical |
| ☐ Champion | ☐ Specialist |

2. Choose the type of industry in which your firm operates.

- | | |
|---|---|
| ☐ Aerospace | ☐ Manufacturing |
| ☐ Agencies and other services | ☐ Mechanical |
| ☐ Agriculture, forestry and fishing | ☐ Medical, dental and other veterinary services |
| ☐ Automotive | ☐ Metal products |
| ☐ Catering and accommodation | ☐ Mining |
| ☐ Ceramics | ☐ Paper |
| ☐ Chemicals | ☐ Pharmaceuticals |
| ☐ Clothing and footwear | ☐ Plastics |
| ☐ Coal / petroleum products | ☐ Research and scientific services |
| ☐ Construction | ☐ Retail trade |
| ☐ Educational Services | ☐ Rubber and plastic products |
| ☐ Electronics | ☐ Semi-conductors |
| ☐ Financing / Insurance / Business services | ☐ Textile |
| ☐ Food | ☐ Transport |
| ☐ Leather industry | ☐ Wholesale trade |
| ☐ Machinery | ☐ Wood and furniture |

3. Number of employees in your firm.

- | | |
|-----------------------------------|------------------------------------|
| ☐ <250 | ☐ 2,500-5,000 |
| ☐ 250-500 | ☐ 5,000-7,500 |
| ☐ 500-1,000 | ☐ 7,500-10,000 |
| ☐ 1,000-2,000 | ☐ >10,000 |

Section B SIX SIGMA PROFILE

4. What stage best describes your firm's current Six Sigma status?

- ☐ Considering a deployment
- ☐ Deployment planned but not yet launched
- ☐ Partially deployed in one business unit
- ☐ Partially deployed in multiple business units
- ☐ Fully deployed in one business unit and no other areas
- ☐ Fully deployed in one business unit and partially in other areas
- ☐ Fully deployed throughout the organization
- ☐ Not specified

5. How long has your firm been using six sigma?

- ☐ Less than 1 year
- ☐ 1 to 2 years
- ☐ 3 to 4 years
- ☐ 5 to 6 years
- ☐ 7 to 10 years
- ☐ 11 or more years

6. Number of trained Six Sigma Black Belts?

- ☐ None
- ☐ 1
- ☐ 2
- ☐ 2-5
- ☐ 5-10
- ☐ 10-15
- ☐ 15-20
- ☐ 20-25
- ☐ 25-30
- ☐ 30-40
- ☐ 40-50
- ☐ 50-60
- ☐ >60

7. How many Six sigma Black Belts projects have been completed in your firm or department?

- ☐ None
- ☐ 1
- ☐ 2
- ☐ 2-5
- ☐ 5-10
- ☐ 10-15
- ☐ 15-20
- ☐ 20-25
- ☐ 25-30
- ☐ 30-40
- ☐ 40-50
- ☐ 50-60
- ☐ >60

8. How long, on average, do you take for the completion of a Six Sigma Black Belt project?

- ☐ 1 to 2 months
- ☐ 3 to 4 months
- ☐ 5 to 6 months
- ☐ 7 to 9 months
- ☐ 10 to 12 months
- ☐ More than 12 months

9. What metrics have you used to quantify the success of Six Sigma in your firm?

- ☐ % of Profit
- ☐ % of Revenues
- ☐ Gain in investment
- ☐ Increase in Sales
- ☐ Increased yield
- ☐ On time delivery
- ☐ Optimized process
- ☐ Reduction in customer complaints
- ☐ Reduction in cycle time
- ☐ Reduction in defects
- ☐ Reduction of cost
- ☐ Scrap reduction
- ☐ Not Calculated

Section C FINANCIALS

10. What was the costs of your Six Sigma implementation?

- ☐ <R 500 000
- ☐ R 500 000 - R 1 million
- ☐ R 1 - 2 million
- ☐ R 2 - 5 million
- ☐ R 5 - 10 million
- ☐ >R 10 million

11. Please assign a monetary value to the financial benefit obtained, because of Six Sigma implementation.

- ☐ <R 500 000
- ☐ R 500 000 - R 1 million
- ☐ R 1 - 2 million
- ☐ R 2 - 5 million
- ☐ R 5 - 10 million
- ☐ >R 10 million

12. What is the total annual revenue for your firm?

- ☐ Less than R10M
- ☐ R11M to R50M
- ☐ R51M to R100M
- ☐ R101M to R999M
- ☐ R1B or more

Section D SIX SIGMA IMPLEMENTATION

13. Rate each of the following Critical success factors required for the implementation of Six Sigma within your firm.

	Least important	Less important	Important	Very important	Crucial
Management involvement and commitment	☐	☐	☐	☐	☐
Organisational Infrastructure	☐	☐	☐	☐	☐
Cultural change	☐	☐	☐	☐	☐
Training	☐	☐	☐	☐	☐
Linking six sigma to customers	☐	☐	☐	☐	☐
Linking six sigma to business strategy	☐	☐	☐	☐	☐
Technological tools / solutions	☐	☐	☐	☐	☐
Linking six sigma to suppliers	☐	☐	☐	☐	☐
Understanding of six sigma methodology	☐	☐	☐	☐	☐
Project management skills	☐	☐	☐	☐	☐
Project prioritisation and selection	☐	☐	☐	☐	☐
Communication strategy	☐	☐	☐	☐	☐

14. With reference to Six Sigma, rate the benefits your firm has realized:

	No benefit	Weak benefit	Moderate benefit	Good benefit	Excellent benefit
Reduce Costs	☐	☐	☐	☐	☐
Reduce cycle time	☐	☐	☐	☐	☐
Reduce rework, errors and waste	☐	☐	☐	☐	☐
Increase competitiveness	☐	☐	☐	☐	☐
Improve customer satisfaction	☐	☐	☐	☐	☐
Increase shareholder value	☐	☐	☐	☐	☐
Change the culture	☐	☐	☐	☐	☐
Improve quality	☐	☐	☐	☐	☐
Not specified	☐	☐	☐	☐	☐

15. What is your primary measure of success for your Six Sigma/performance improvement program(s)?

- | | |
|---|---|
| ☐ Cost savings | ☐ Number of trained employees |
| ☐ Customer satisfaction | ☐ Employee attitude change |
| ☐ Top line revenue growth | ☐ Not specified |

16. What technology solution/solutions are you using to track your projects and performance improvement initiatives?

- ☐ Affinity Diagrams
- ☐ Analysis of Variance (ANOVA)
- ☐ Benchmarking
- ☐ Brainstorming
- ☐ Capability Analysis and Capability Indices (Cp and Cpk)
- ☐ Cause and Effect/Fishbone Diagrams
- ☐ Check sheets
- ☐ Excel
- ☐ Evolutionary Operation (EVOP)
- ☐ Failure Mode and Effect Analysis (FMEA)
- ☐ Histograms
- ☐ Home-grown program
- ☐ Measurement system assessment (Gage R&R)
- ☐ Pareto Chart and 80/20 rule
- ☐ Process Mapping
- ☐ Quality Function Deployment (QFD)
- ☐ Regression Analysis
- ☐ Response Surface Methodology (RSM)
- ☐ Run Charts
- ☐ Scatter diagrams
- ☐ Statistical Process Control
- ☐ None of the above

17. Rate each of the following fundamental barriers to the implementation of Six Sigma within your firm.

	Very Weak barrier	Weak barrier	Moderate barrier	Strong Barrier	Very Strong Barrier
Choosing and prioritizing the right projects	☐	☐	☐	☐	☐
Financial constraints	☐	☐	☐	☐	☐
Gaining employee buy-in / Internal resistance	☐	☐	☐	☐	☐
Gaining management support / commitment	☐	☐	☐	☐	☐
Getting projects finished	☐	☐	☐	☐	☐
Limited resources	☐	☐	☐	☐	☐
Overcoming language barriers / cultural barriers	☐	☐	☐	☐	☐
Promoting a continuous improvement mindset	☐	☐	☐	☐	☐
Time constraints	☐	☐	☐	☐	☐
Committing Black Belts full-time	☐	☐	☐	☐	☐
Allowing the time for training	☐	☐	☐	☐	☐
Getting alignment within the organization	☐	☐	☐	☐	☐

18. Will your company encourage it's suppliers to get involved in the Six Sigma initiative?

- ☐ Yes
- ☐ No