Politecnico di Milano
Facoltá di Ingegneria dei Sistemi

POLO REGIONALE DI COMO

Master of Science in Management, Economics and Industrial Engineering

A Framework for Six Sigma Initiatives

Supervisor: Prof. Alessandro BRUN

Master graduate thesis by:

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Abstract

Nowadays, the exponential grow of Six Sigma programs arise several concerns and holes in the theory background of this quality approach. These concerns are argued by the increasing number of failing Six Sigma programs in all kind of industries.

This thesis work is aimed to help to reduce the increasing number of failing Six Sigma initiatives by the introduction of an empirical framework expressed into a checklist shape, which will make a connection between best practices and theory foundations on the basis of an empirical research.

Thus, here it is presented a checklist that covers the life-cycle of the Six Sigma programs: Readiness, Implementation, Execution and Results, under the name of Six Sigma initiative. Each phase has several questions aligned with the critical successful factors used in successful implementation and those establish by the practitioners.

The final objective of the checklist is to be used as a tool to set the theoretical basic for a practitioner and help him/her to reduce the successfulness, uncertainty and increase the initiative performance.

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I. Introduction

This work is done with the purpose of understanding how Six Sigma projects' performances are evaluated and in that sense, coming up with a comprehensive framework presented as a checklist which can be used as a guideline to reach success for the firms working in Six Sigma field.

To understand the main issues emphasized in the companies, cases of study from one sector were analyze, letting to gather mutual needs of companies which has to be accomplish during the project phases. We chose the chemical sector in which many projects have been done with the cases; Viracon, Dupont, Dow Chemical.

In the second chapter, we focused on theoretical background more. Our starting points were what quality was and what Six Sigma means for quality. We tried to explain what Six Sigma is, how it differentiated itself from other quality methods and why it is very popular among companies. We highlighted the core philosophy of Six Sigma and its process according to DMAIC . Literally, there are a lot of cases solved by using Six Sigma but here we wanted to show some cases for the usage of proper tools. Then we also had a look the roles in the Six Sigma organization, their required skills and their impacts on the project performance.

On the other hand, we considered with Six Sigma in the sense that how much it guarantees the success at the end and whether all of companies are successful or not after Six Sigma implementation. In order to understand, we searched the success stories and the reasons why all the companies couldn't reach the success at the same level.

In the third chapter which is the main part, we prepared a checklist as a guideline for the evaluation of Six Sigma projects. The aim is not to ensure companies that at the end, they will reach success through that checklist certainly but to show them a path which is full of important activities step by step and it is better to follow the checklist which assists the project to get the expected successful results.

According to the our knowledge, a company should inquiry itself to understand how much the project phase is ready to go forward that's why we prepared set of questions in four chapters; **Readiness, Implementation, Execution** and **Results**.

In readiness chapter, we asked the questions to make the companies be aware of that in which point they are in the starting path. We want to have them get the idea if Six Sigma concept fits the one in their mind with their expectations. Even though, the company has worked with Six Sigma previously, sometimes they might not really realize the importance of management commitment, cultural change, communication, organizational structure, training, link to the strategic imperatives, resource availability. That is the reason why we focused on those topics.

In implementation chapter, the questions prepared aim at defining whether the company's work done until now is enough to start execution or not. Our belief is, if the company starts execution just after the readiness part, they will have many obstacles in terms of requirements to run execution of the project so this part is quite important for them because mainly that's the common mistake done by the companies. Without checking their foundation, they run directly to the execution and unfortunately, it ends with disappointment.

In the execution chapter, we asked the questions in the order of DMAIC phases which are define, measure, analysis, improve and control. During the whole project, all those items should be checked before passing the results chapter.

In the result chapter, we wanted to inquiry in which level the expected contribution is done by sides and the actual results corresponds with the ones expected. Beside those two, we want companies to pay attention to the results replication, projects sustainability and also awarding people at the end of the project for motivation.

After completing the checklist, we needed a review from professional point of view so we sent the checklist to Mr. OZTURK (champion) who is the general manager of Ekoten Textile A.S. We added the feedback coming from him and one of the master black belt in the same company to our work to improve it.

II. Theoretical Background

1. Six Sigma Basis

1.1 Quality Definition and Six Sigma

The quality concept, which is nowadays wide-spread, has been subject of constant evolution and has been adapted for the sake of different situations. According to the American Society for Quality (ASQ), the quality awareness for the first time can be place in the medieval Europe (late 13th century). Today, the concept has different perspectives and levels due different criteria, purpose or need. Each part of the productive cycle and/or business process can associate the concept of quality to its interest making confusing or ambiguous to establish a universal definition (LINDSAY and EVANS, 2005). The discussion of the quality definition is not the purpose of this dissertation but is important to stand clear in this basic concept, then, trying to set up a definition, it is sane to refer to an organization mastering quality issues; the quality definition used by the ASQ is as follows:

"A subjective term for which each person or sector has its own definition. In technical usage, quality can have two meanings: 1. the characteristics of a product or service that bear on its ability to satisfy stated or implied needs; 2. a product or service free of deficiencies. According to Joseph Juran, quality means "fitness for use;" according to Philip Crosby, it means "conformance to requirements."

As was mentioned, the evolution of the concept made it difficult to shape, so what is most important is not the concept but to understand the perspectives behind it; they will be shown but further reference is up to the lector will. The perspectives on quality definition according to (LINDSAY and EVANS, 2005) are:

- Judgmental perspective
- Product-based perspective

- User-based perspective
- Value-based perspective
- Manufacturing-based perspective
- Customer-driven quality

Contrary to the evolution of the quality approach, in a very short period, Six Sigma have evolved exponentially from its first appearance in Motorola during the mid 80's (PANDE *et al.*, 2000);(LINDERMAN *et al.*, 2002)and the literature grew synchronously with a similar behavior from the beginning of 90's to nowadays where many titles are available (more than 417 journal papers from 1992 to 2008) (GOH, 2002);(ABOELMAGED, 2010); also several organizations e.g www.asq.org are trying to spread six-sigma knowledge as the new fad in quality management approach and consulting companies are showing-up giving away successful practices and best expertise applying six sigma projects e.g www.isixsigma.com. However, some papers are also trying to change fiction to reality and state that many six sigma implementation had failed and many companies are not willing to adopt such approach (CHAKRAVORTY, 2009) ; others authors, instead, goes beyond the actual six sigma practice and propose to expand the capabilities of it by increasing the number of tools use during the training of the specialized workforce (THOMAS *et al.*, 2008) or using new technologies like simulation techniques (MONTGOMERY, 2007).

So, what is six sigma?

The initial conception of Six Sigma recall Sigma(σ) as a letter which comes from Greek alphabet and it is the symbol of the standard deviation. Standard Deviation, of a data set, is the measure of the dispersion. Six Sigma is a statistical term which shows how far the process is to meet the customer satisfaction perfectly. (Konak *et al.*, 2004) Six Sigma is defined by many authors from different perceptions. Six Sigma is…

i) **A management strategy:** which takes a big role for big companies such as Motorola to reach marvelous successes.

ii) **A goal:** which aims to meet customer needs perfectly with the minimum defect less than 3.4 DPMO.
iii) **A Statistical Method:** which is used to decrease the variation in processes and products.
iv) **A Cultural Change:** which is required to increase customer satisfaction and margin to power the competitiveness of the company.

Among the literature available, many definitions can be easily found (STAMATIS, 2004); (LINDSAY and EVANS, 2005); (LİNDERMAN *et al.*, 2002)as shown before; (ABOELMAGED, 2010) present an extensive research of all available literature on Six Sigma and present a list of different definitions. Each of those can infer something in common but tackle the meaning from different perspectives. (IWAARDEN *et al.*, 2008) carried out a survey to find out how the six sigma methodology is sensed in a transnational environment among different kinds of industries; the result was the following:

"…is perceived as a well-structure improvement approach with strong links to an organization strategy, high level of management involvement with highly customer-driven and linked with financial results…"

The previous statement supports the idea of (SCHROEDER et al.,2008) in which the lack of research from the academic field over the impact of Six Sigma, encourage the industry and its practitioners to lead the Six Sigma theory without conceptual basis. Because of this, this dissertation, following an academic approach will add the definition suggested which explanation can be found on the paper mentioned.

"… is an organized, parallel-meso structure to reduce variation in organizational processes by using improvement specialist, a structured method, and performance metrics with the aim of achieving strategic objective." (SCHROEDER *et al.*, 2008)

In general, Six Sigma is a strategy which enables the companies to improve their systems to raise customer satisfaction by designing and monitoring daily processes by minimizing the waste and non-value adding activities.

1.2 The core philosophy of Six Sigma

Considering Six Sigma as the latest management approach for improvement, aiming customer satisfaction and the big momentum that is gaining on the industry, the literature shows up the philosophy followed in order to get the title, the position and most important, the results.

Six Sigma is based on some key factors; all of them reflect a comprehensive idea of the definition given previously;

- Thinking in terms of key business processes and customer requirements which bring back to the strategic objectives.
- Relay on the sponsorship to break the resistance to change and get the needed resources to work with. Top-bottom approach.
- Emphasize on metrics – DPMO- and identified them properly and before taking actions.
- Project team deployment based on previous capabilities – training-.
- Set challenging objectives but feasible. (LINDSAY and EVANS, 2005)

The objectives of Six Sigma are;

i) **At the strategic level**: to align an organization to its market place and deliver real improvements to the bottom line.
ii) **At the operational level**: to move the business product or service attributes within the zone of the customer satisfactions and to significantly shrink the process variation. (BAS, 2003)

It is very important to understand the process which creates the defects and devise process improvement methods to reduce the occurrence of such defects which improve the overall customer experience. The focus must be on four issues; (Antony *et al.*, 2006)

- What is the nature of the defects which are occurring in the process?
- Why are such defects occurring and at what frequency?
- What is the impact of a defect on customers?
- How can these defects be measured and what strategies should be implemented to prevent the occurrence of such defects?

1.3 Six Sigma as a quality framework

Once the definition is understood, it is needed to know that Six Sigma infer a scientific method to fulfill the strategic objectives and shape its framework. The scientific method adapted to this matter can be seen in (PYZDEK, 2003). Having that approach in mind, the practical framework of Six Sigma derives – Define, measure, analyze, improve and control (DMAIC). In other words, once a project is "*define*, key process characteristics are identified, studied and benchmarked in the *measure* and *analyze* phases. This is followed by the *improve* phase where a process is changed for a better or optimize performance. The *control* phase ensures that the resulting gains are sustained beyond the completion of the project" (GOH, 2002). This is the common methodology for six sigma' projects. In addition, (CHAKRAVORTY, 2009) expose a guidance for effective implementation model, consisting on six steps:

- Perform strategic analysis driven by the market and the customer
- Establish a high-level, cross-functional team to drive the improvement initiative
- Identify overall improvement tools
- Perform high-level process mapping and to prioritize improvement teams
- Develop a detailed plan for low-level improvement teams
- Implement, document, and revise as needed.

1.4 Six Sigma: a phenomenon

Seeking for the reduction of waste and defect is not a new subject in quality field but the Six Sigma approach is different than the others, it provides an organizational structure not previously seen (Schroeder *et al*., 2008). Six Sigma it's not only quality driven, also a management strategy which includes more than reduction of defects. It consist the best ideas and tools of last century. Easy solutions aren't jumped at in the companies where Six Sigma is used. The time is spared to understand the pre-solution phase, problem and improvement opportunities. Considered phases are examined by using six sigma tools and all the decisions are taken according to them.

Six Sigma became a necessity for all the companies since all other methods such as just in time, kaizen, total quality management, etc, which are used to improve the system, are not able to come up with a radical improvement. For instance, Kaizen can reach 3-4 sigma by doing little improvements which cannot be translated into business improvements so companies were looking for a strategy which would help them to develop their systems in all cases mentioned above…Then Six Sigma was discovered. (BAS, 2003)

Sigma strategy places a clear focus on achieving measurable and quantifiable financial returns to the bottom-line of an organization. This places an unprecedented importance on strong and passionate leadership, and the support required for its successful deployment. Six Sigma methodology of problem-solving integrates the human elements (culture change, customer focus, belt system infrastructure, etc.) and process elements (process management, statistical analysis of process data, measurement system analysis, etc.) of improvement. Six Sigma methodology utilizes the tools and techniques for fixing problems in business processes in a sequential and disciplined fashion. Each tool and technique within the Six Sigma methodology has a role to play, and when, where, why and how these tools or techniques should be applied is the difference between success and failure of a Six Sigma project.

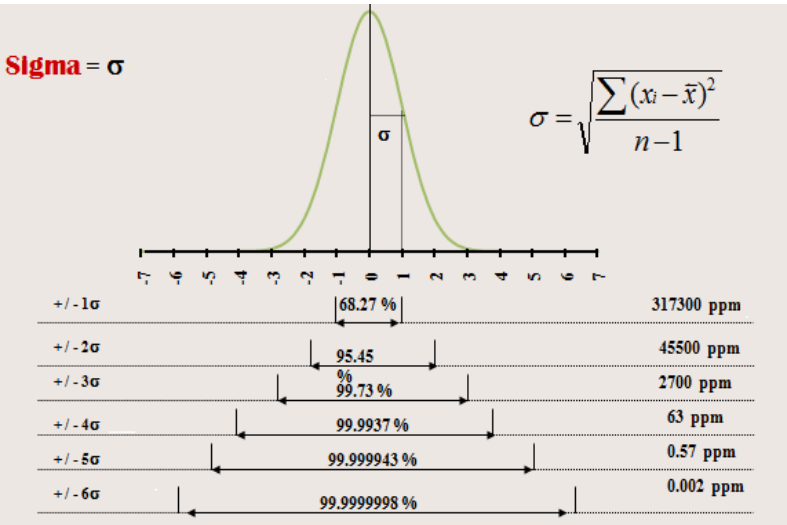


Figure 1: Normal distribution and sigma level, adapted from (KOCAKOC, 2007)

Six Sigma approach uses DPMO (Defects Per Million Opportunities) which is a good tool to measure the quality of a product or a process. Defects make a relationship between time and cost. The sigma value shows how often the defects occur. Higher sigma value means fewer defects. The companies which are on 6 sigma levels are accepted as the best firms in their field. Today, many of the firms have 3 or 4 sigma level which means that defects occur between 6210 and 66807 DPMO.

Sigma Level	Defective DPMO*	Cost of Quality
6 σ	3.4	<10%
5 σ	233	10-15%
4 σ	6210	15-20%
3 σ	66807	20-30%
2 σ	308537	30-40%
1 σ	690000	>40%

Figure 2: Sigma level, DPMO and Cost of quality, adapted from (KONAK *et al*, 2004)

The companies with three sigma level lose many customers because of the low level quality and often they are not powerful in cost competition. Quality problems are tried to be solved by increasing the number of tests. As a consequence, it can be observed that, the number of defects might reduce but the cost increase. When the quality level is low, the customers don't purchase the products. When the quality is improved, the customers are not willing to pay because of the cost increase. In typical company with three sigma level, margin is max when the cost of low quality is 25% of the sales, but with this level of cost, the margin is very low. While the company three sigma levels spend 25% of its sales, the company with six sigma level spends 5%.

It is important to note that a Six Sigma quality level of performance should not be the goal for all processes. A lower Sigma quality level of performance may be acceptable for some processes. For example, a credit card company had a target that 95% of customers wishing to speak to an available customer service agent or representative must be connected within six rings. The company had established through a customer survey that customers were willing to wait up to seven or eight rings provided they were informed by a recorded voice that a customer service agent or representative would attend to their queries soon. The company also found through research that a further reduction to five or less rings would not increase customer satisfaction significantly. In such cases, we do not really need a Six Sigma process capability. On the other hand, in some processes, even Six Sigma may not be enough. For example, the Sigma quality level for an airline industry for safe landing must be higher than Six Sigma. (ANTONY *et al.*, 2006)

1.5 What does "critical to quality factor'' mean for Six Sigma project?

As any other approach, Six Sigma projects rely it's successfulness on the core philosophy, which must be carried out strictly. Nevertheless, the core philosophy might be support by taking the right decisions when implementing the methodology. Being the customer satisfaction the aim of Six Sigma projects and being implicit on the given definition under performance metrics (customer-oriented metric) lead the understanding

of customer need as the root and a fundamental aspect of Six Sigma. The so called critical-to-quality factor (CTQ) represent the characteristics of the voice of the customer (internal and external) on the product or service which influence the most the behavior and acceptance of it, the identification of them is critical to assure high customer satisfaction. (LİNDSAY and EVANS, 2005)

It is important to increase the understanding of customer needs and expectations, especially the critical-to-quality and service performance characteristics which will have the greatest impact on customer satisfaction and loyalty. The importance of identifying and working around CTQ factors will traduce in competitive advantages for the company, some of them are in general terms: (BONACORSİ, 2002)

- Increased cash flow by making processes more efficient and reliable.
- Improved knowledge across the organization on various tools and techniques for problem-solving, leading to greater job satisfaction for employees.
- Reduced number of non-value-added operations through systematic elimination, leading to faster delivery of service, faster lead time to production, faster cycle time to process critical performance characteristics to customers and stakeholders, etc.
- Reduced variability in process performance, product capability and reliability, service delivery and performance, leading to more predictable and consistent level of product quality and service performance.
- Transformation of organizational culture from being reactive to proactive thinking or mindset.
- Created new customer opportunities.
- Improved market position relative to competitors.
- Improved internal communication between departments, groups.
- Improved cross-functional teamwork across the entire organization, employee morale and team spirit.

Clearly, the lector can associate the effects of working with CTQ and can easily link them to the most common objectives of Six Sigma projects and its core philosofy.

1.6 Six Sigma Process

Six Sigma makes use of sound statistical methods and quality management principles to improve processes and products via the Define–Measure–Analyze–Improve–Control (DMAIC) quality improvement framework to meet customer needs on a project-by-project basis. (KONAK *et al.*, 2004)

1.6.1 Define Phase

In this phase, the concept and the purpose of the projects are defined. The information about the customer and the term is gathered. It is important that the project chosen has a high probability to create a higher quality and reduce the cost. The outcomes of the define phase are, the detail definition of planned improvement, the list of factors which are important for the customer, a detail flow diagram of the process.

Below, the common tools of this phase are given;

- Project selection
- Probabilistic risk thinking and strategic planning
- Decision analysis
- Process mapping
- Project management tools

In project selection step, critical to quality factors (CTQs) also should be taken into account. Before starting the project, the project team should be sure on one point; in the case of solving the problem, the company will profit. CTQ refers to certain factors, attributes or features of any service or product. Those factors that embody quality for the customer. It defines the basis of satisfaction for the customers of your products and

services, what means is that the better your product or service performs on its CTQs, the higher will be the customer satisfaction.

Understanding the customer CTQs, communicating to the whole organization, measuring and managing the business processes on that and allocating resources to drive up CTQ performance of your business processes are imperatives to customer satisfaction and success.

1.6.2 Measurement phase

The information that explains the actual situation is collected. The aim of this phase is to indicate the problem sources or places by forming a real mindset to which the process case and problems lead. This information helps us to tighten the area of the potential reasons which need to be searched in analysis phase. It is not possible to determine the effects of the actual performance and the improvements done without valid and correct measurements. The outcomes of this phase are; the actual performance of the term, the data which explains the problem or the formation of problem, and more specific and detail definition of the problem.

The common tools are used in this phase are;

- QFD and Kano analysis
- Sampling (data quantity and data quality)
- Measurement system analysis
- SPC Part I (concepts, implications of instability)
- Capability analysis
- Monte Carlo simulation and statistical distributions

1.6.3 Analysis phase

The measurement phase manifests the main performance of the process. During analysis phase, some theories will be developed about main reasons, these theories will be verified by data and finally, the main causes of the problems will be defined. Reason or reasons (their correctness is verified) form a case in which the solutions which will be discussed in the following phase. The purpose of this phase is to define the main reasons of the problems and to verify them. By this way, the outcome is the hypothesis which is tested and verified. The causation/s verified will be the income of the next phase.

The tools which are commonly used are;

- Basic graphical improvement tools
- FMEA
- Hypothesis testing
- Confidence intervals
- ANOVA
- Correlation and regression analysis
- Reliability models and measures

1.6.4 Measurement Phase

The solutions are developed which is aimed at elimination of the causations, are implemented and evaluated. These solutions may include a better estimation, scheduling, procedure or equipment. The aim is, by using the data, the solution given solves the causation and guide for improvement. In this phase, a plan should be formed which shows how the results will be evaluated in the following phase.

Below, the main tools are given;

- DOE (factorial, fractional factorial, blocking, nested and RSM)
- Robust design

1.6.5 Control phase

It is the phase to control and make stable the solutions and implementations provided at the end of the improvement phase. The objectives of this phase are to evaluate the improvement plan being implemented and the results achieved and to maintain the acquirements achieved and to meet the requirements in order to increase them. At the end of this phase, new methods can be developed.

These are the tools which are used frequently;

- Sensitivity analysis
- Mistake proofing
- Validation testing
- Control plans
- SPC Part II (control charts)

1.7 The Roles in Six Sigma Organization

Success of Six Sigma highly depends on the clear definition of each role, however, due to the lack of a standard training program for the Six Sigma organization structure, different titles and responsibilities can be found within companies. Even though, a common and most practical structure is as given in the following scheme.

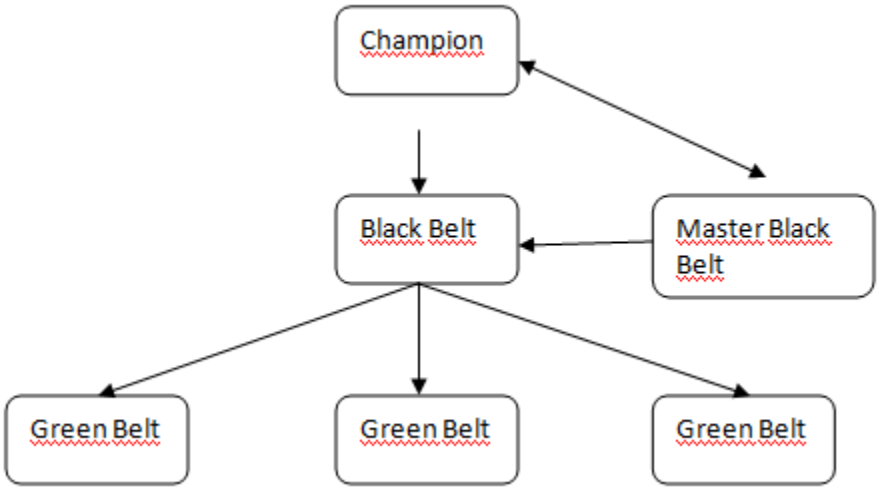


Figure 3: Organization of Six Sigma

Roughly, each one of the roles is going to be explained. (MARRY and SCHROEDER, 2004); (CHOWDHURY, 2002); (SNEE and HOERL, 2003)

Champions are senior managers who determine the projects and they are responsible for the success of the Six Sigma work. They approve the projects, provide sources and solve the trouble. They don't have to work full-time in the program but in order warrant the success, they are expected to work enough. In general they have a work experience such as 12-15 years and beside this, it is important to work in that company at least four or five years and they should know the critical terms and success factors of the company very well.

Here, the main functions of champions:

- To provide conformity of the projects with company's goal.
- To coordinate the improvement team.
- To intervene to the projects which goes slowly, if necessary, changing the concept or role.
- To determine the delivery time of the projects.

Master Black Belts are the ones who have the highest level of technical knowledge. This function can be done by a consultant from outside of the company in the beginning.

The main functions of a master black belt are:

- To support the improvement team in terms of choosing statistical methods and their usage.
- To give a trainee program about Six Sigma.
- By informing the participants, to help the naturalization of organization.

Master black belts check the black belts and guide them. For being a guide and also trainer, they are educated for two weeks.

Black belts are full-time quality executers who guide teams and focus on the critical times, and report the results to the champions. They should be chosen among either functional or technical people who have two or three years of work experience. They manage the Six Sigma projects and try to get a margin rate every year regarding to the management decision.

These team leaders are responsible for measurement, defining, improvement and control of critical terms which effect the customer satisfaction or increase in efficiency. A project is successful (if it starts less than three sigma) when the defects reduces ten times or (if it starts more than three sigma) when the defects reduce fifty percent. (KONAK *et al*,. 2004)

In order to take a certificate, black belts' success also should be approved by champions. They consider with the selection, execution and the results of the projects. The person who is black belt leaves his main job temporarily till the project ends. After the project, he can go on with his job or promote as well. They should have enough capability to bring fast and easy solutions that's why they need to be educated more or

less four months by master black belts or an institution. However, since the education includes one week theory, three weeks implementation, after the first week, the black belts are able to guide the short projects.

The main functions of Black belts are:

- By determination of the project, offering to champion.
- Offering the change in the concept and subject to the champion.
- The determination of the team members or involve in this to help champion.
- To deliver the missions among team members.
- To manage the project and support it to end on time.
- To determine the need of information and resource and declare it to the champion.
- To give technical support while the Six Sigma tools are being used and the projects are being done.

Green belt is a name given to the team members who run the improvement functions. They should know and implement main measurement and analysis methods very well beside this; they should be able to use the soft programs without any problem. For this, in order to determine the green belt project team, they are given a education program for two weeks. They don't work full-time on the projects. They run their projects while they are working on main jobs.

1.8 Organizational perspectives for Six Sigma process

In every organization, Six Sigma must be understood and supported in each level of the system. These levels are;

- Business level
- Operations level
- Process level

Executives at the **business level** can use Six Sigma for improving market share, increasing profitability and organizations long term viability. Managers at **operations level** can use Six Sigma to improve yield and reduce the labor and material cost. At the **process level** engineers can use Six Sigma to reduce defects and variation and improve process capability leading to better customer satisfaction. Each one of the levels, have a different perspective as explained and thus, the DMAIC framework is appreciated as follows.

Business perspective of Six Sigma strategy

- **Define** what plans must be in place to realize improvement of each state.
- **Measure** the business systems that support the plans.
- **Analyze** the gaps in system performance benchmarks.
- **Improve** system elements to achieve performance goals.
- **Control** system-level characteristics that are critical to value.

Operations perspective of the breakthrough strategy

- **Define** Six Sigma projects to resolve operational issues.
- **Measure** performance of the Six Sigma projects.
- **Analyze** project performance in relation to operational goals.
- **Improve** Six Sigma project management system.
- **Control** inputs of project management system.

Process perspective of the breakthrough strategy

- **Define** the processes that contribute to the functional problems.
- **Measure** the capability of each process that offers operational leverage.
- **Analyze** the data to assess prevalent patterns and trends.
- **Improve** the key product/service characteristics created by the key processes.
- **Control** the process variables that exert undue influence.

1.9 Brief successful stories of big companies.

The beginning of Six sigma phenomenon began in the mid 80's with the sensitive and successful case in Motorola. Next to Motorola, GE followed the new methodology and both obtained appreciable results. For the first one saved over $940 million in three years and the second increased its operating margin 4% during 5 years of program implementation. Other high-reputation firms like Samsung Electronics, Du Pont, Dow Chemicals, among others, experience saving between $100.000 and 200.000 per implemented project. (GUTİERREZ *et al.*, 2008). After these experiences went public and proudly shown by the former practitioners, a bunch of companies around the world went after those numbers. After the mid 1990's can be seen an increase of the number report of successful projects in any kind of firms and very quickly left the manufacturing boundaries to flood over the service sector.

The following chart provides the year in which the Six Sigma program began in certain companies and the next table summarizes the financial gains from Six Sigma implementation at certain well-known companies.

Due to Six Sigma's rigorous problem-solving progress, the program is well suited to bring about targeted improvements in all strategic priorities and not just cost and quality. Indeed, in customer-focused analyses, Six Sigma has registered a record of commendable results for the companies listed in table, and many others such as Sony, ABB, Texas Instruments, Citicorp, Chase Manhattan, Caterpillar, Raytheon, and Bombardier Transportation. (ANTONY *et al.*,2006)

Year of inception of Six Sigma at pioneering companies

Company name	Year of Six Sigma Inception
Motorola	1986
AlliedSignal (merged with Honeywell in 1999)	1994
GE (NYSE: GE)	1995
Honeywell (NYSE: HON)	1998
Ford (NYSE: F)	2000
Dow Chemical Company	1999

Figure 4: Year of inception of Six Sigma initiatives. Adapted from (ANTONY et al, 2006)

Savings from well-known Six Sigma programs

Year	Revenue ($ billions)	Savings ($ billion)	Revenue savings (%)
Motorola			
1986–2001	356.9	16.1	4.5
AlliedSignal			
1998	15.1	0.52	9.9
GE			
1996	79.2	0.2	0.2
1997	90.8	1	1.1
1998	100.5	1.3	1.2
1999	111.6	2	1.8
1996–1999	382.1	4.43	1.2
Honeywell			
1998	23.6	0.5	2.2
1999	23.7	0.6	2.5
2000 25 0.7 2.6			
1998–2000	72.3	1.84	2.4
Ford			
2000–2002	43.9	1.6	2.3

Figure 5: Savings from well-known Six Sigma programs. Adapted from (ANTONY et al., 2006)

1.10 Are Six Sigma Projects always successful?

A survey made by Aviation Week Magazine involving the major aerospace companies concluded that, ". . . less than 50% of the survey respondents expressed satisfaction with results from their Six Sigma projects; nearly 30% were dissatisfied and another 20% or so were only somewhat satisfied." Many stated the most concerned problems are concentrated on the project selection and the implementation process, or at least, most of the failure reason lies on this two aspects (ABOELMAGED, 2010) is one of the few papers were an academic research is done to Six Sigma failures. It claimed the raising concern regarding the failure of many six sigma programs. The research focus on the problematic of the escalation of commitment to explain why so many projects of Six Sigma have failed and concluded some determinants of escalation which can be responsible of that. The unavailability of accurate and unbiased data, unclear objective and incorrect sequencing of Six Sigma projects were some issues to point out. (CHAKRAVORTY, 2009) blame the negative results of many six sigma projects to the lacking of an implementation model detailing the sequence of Six Sigma elements/activities to follow based on sound arguments. The research came up with a step-by-step shown on this document under the 1.2 numeral.

Implicit on (ABOELMAGED, 2010), analysis of Six Sigma implementation failures is completely set aside. None of the 417 articles undertakes directly the matter that Six Sigma can fail or how can it fails but 1, (CHAKRAVORTY, 2009). One can be induce to think that is a perfect methodology. Although, A series of articles on the web written by experts with vast years on the industry (ZIMMERMAN and WEISS, 2005); (Ranjan, www.isixsigma.com) in a tacit way, express that many Six Sigma projects have failed and give some of the possible reasons and expose lesson learned to reduce the probability of failure.

According to our references; (MONOPOLI and BUTHMANN, ww.isixsigma.com)(Six Sigma Training Assistant, 2008)(Six Sigma Training Assistant, 2009) a big part of Six Sigma failures are blamed to the belt system actors, Master Black Belt, Black Belt and Green Belt. A list of some issues regarding punctual items are shown as follows:

i) Personal commitment

- Treating Six Sigma projects as an academic exercise.
- Not severing themselves from their old job, at least through training.
- Generating false data.
- Not getting at least a basic understanding of the tools required to do an analysis.
- Running to the Champion to break a roadblock before they try themselves.
- Not taking a roadblock to the Champion after they have tried themselves.

ii) Team commitment

- Creating a exclusive club attitude around the program.
- Not sharing the credit for the solution with the team.
- Taking credit for work accomplished by another initiative or an ongoing project.
- Not providing the team the opportunity to share the spotlight (have them attend a management presentation or better yet use them in the presentation).
- Champions do not show up for report-outs.

iii) Communication

- Failing to appreciate the complexity of dealing with people.
- Not communicating effectively with management.
- Presenting results as if it were a science project - using things such as ANOVA tables to convey results (graphical representations convey more information faster - you are communicating an idea)
- Avoiding resistance - when you know it is present you have to deal with it.

iv) Clearence of procedures and objectives

- Failing to recognize Control as the most difficult phase to implement effectively.
- Not transferring ownership of the solution to the team as the project progresses (the solution becomes personality dependent).
- Spending too much time on the computer and not enough time in the process.
- Focusing on certification rather than the team project and the company's results.
- Including special effects in the presentation to cover a lack of content.
- Using a large number of slides to cover a lack of content in project reviews.
- Champions do not break roadblocks.

In addition, some other reasons are done by the organization itself and upper levels. Some failures sourcing from management and company are:

i) Management involvement

- No visible leadership at the executive level.
- Business executives do not show up for report-outs (conveys a lack of priority).
- Abdicating the deployment plan to a consulting company.
- Inadequate information.
- Lack of actively manage project-in-progress.

ii) Clearence of strategic objectives and/or business processes

- No concept of customer expectations.
- No follow-up on the operating plan.
- Lack of alignment (horizontal or vertical).
- Deploying Six Sigma without a goal (reason for deployment).
- Trying to change the organization without a detailed change process.
- Project selection process does not identify projects related to business objectives.
- Serving the wrong customer.
- Misunderstanding the real problem/ incorrect project selection.

iii) Procedures and guidelines

- Deploying Six Sigma with a goal but no plan on how to get there.
- Not having metrics in place for management participation nor champions.
- Having metrics in place but no feedback (or limited feedback annually, semi-annually, quarterly).
- Not having multiple projects queued up for each MBB, BB or GB (so when they complete a project the next one has already been selected) .
- No rewards or recognition program.
- A rewards or recognition program that does not recognize teams.
- Trying to use contract type agreements to retain MBBs and BBs
- No accountability
- Middle management operates on their own agenda (feel support is optional).
- No buy-in at the Process Owner level.
- Process Owner believes they have the option to not buy-in.
- Believing a single initiative can/will solve all your problems.
- Using BBs for fire-fighting.
- Buying cheap software to save money on the deployment.
- Training BBs without providing a computer.
- Part-time black bells/ shortage in trained personnel/ certification and training misalignment.
- Miss-adaptation to a new organization mindset.
- Faulty implementation.
- Failed to track results rigorously.

iv) Communication

- Not communicating deployment plans effectively through the organization
- Broken communication channels/segregation of efforts

Another important aspect is the attention that has been focus on the project selection and implementation process, not only by practitioners but now by the academia as well. However, taking care of those two fact doesn't guarantee a successful project. We have found little research on the performance of on-going project, i.e, after the implementation process and before the deadline to give results. An important part which should be track continuously in order to complete on time the milestone, deliverables and due date reach the overall objective of the project.

(WURTZEL, 2009) stated that "Six Sigma should pay as you go and be confirmed by objectives parties" and claim that when a project is not going well, adjustments should be made. But are those adjustments made base on expertize or theory? If the project doesn't get the desirable milestone, is it possible something on the way is gone wrong? Besides, project selection or the implementation process? Maybe, the execution? Are companies relying on belts subjectivity to qualify the performance of the on the run projects?

Poor performance during the on-going projects can lead to a failure. The objective of this dissertation will be to develop a framework to keep tracking on the performance of Six Sigma project on the run, a checklist easy to follow and aiming to help all the team to keep in mind the basis and the must do on all kind of projects. Missing a core principle of Six Sigma can cause a butterfly effect and an imminent fail.

2. Six Sigma Competitiveness

As shown in chapter 1, Six Sigma is being considered the new "fad" in quality management approaches, possesses high momentum in the manufacturing industry and is immersing also into the service field. The following chapter is an attempt to explain why Six Sigma is going over the other methods, why so many companies go after it. A briefly comparison is made between Six Sigma, lean manufacturing/production, TQM, ISO 9000 and MBNQ. In the second part of this chapter, a description of functions and skill requirements for the member of Six Sigma projects is included as was found that the human structure is the main difference between approaches and also a key factor to the happy ending of the projects.

2.1 Why is Six Sigma preferred to the others quality approaches?

Six Sigma is usually perceived as a method to make the product or processes perfect, even though it is a miss conception; it's not so far from its primary intent, and it is better to say that it is a broad and flexible framework used to provide business success maximizing key performance indicators of the company due to the decrease of variation and increment of customer satisfaction. Statistic is the main weapon of this approach and is supported because them can show with argument what is going on and how to pursuit an objective base on visible data and arguments instead of following instincts that can end addressing wrong solutions.

Six Sigma differentiates itself with all these items;

- It provides integration and makes quality a part of daily work.
- It describes the strong leader support as a pre-condition and activates it.
- It eliminates the confusion about the terms and gives clear and short messages.
- It determines clear and motivating goals.
- It addresses to pick the easiest and simple technique.

- It tries to overcome all the internal obstacles and doesn't restrict quality work within the department.
- It doesn't force to choose between an incremental or a radical change, it advices the optimum. It gives a solution to the conflict between Re-engineering and Kaizen. It recommends to keep searching small improvement opportunities in a systematic way, but whenever the actual capacity cannot meet the customers' demand, the radical changes should be done.
- It determines high standards in education. In other words, it doesn't measure the success of the education with the number of people being educated. In the other hand, It needs investment of time and money to help Six Sigma participants to work on the desired standards. For black and green belts, it foresights an education that takes weeks. In this way, beyond the introduction of the improvement tools and how and when they need to be used, it presents a context which shows when and how the improvement will be accomplished. Six Sigma forms a link between the education and the actual work which is being done and it evaluates the success of the projects by the improvements achieved in tangible projects.
- It forms the necessary foundation for institutional change, and after education, it gives the mission to the change agents. While black and green belts are doing their routine works, by the other side, they form the foundation of organization to provide the institution alteration.

They don't only pay attention to product quality, also all the working processes are taken into account. Six Sigma pays attention to all areas, as well as it does to production processes. It underlines improvement opportunities in service and the other operational areas. It shows regard to different parameters and activities which add value as well as product specifications. (www.alialtugkoca.com)

To go more in detail, is necessary to understand the differences and similarities between Six Sigma and the others quality management approaches; based on the authors opinion the most promptly approaches to do this are the TQM and Lean approaches, since they are the previous methodologies to enhance the quality system towards the efficiency

and effectively of the production capacity and customer satisfaction; and then a review between Six Sigma and ISO 9000 and Malcone Baldrige National Quality Award is done.

2.1.1 Six Sigma Vs TQM and Lean

Many have been the studies carried out that relate the most wide-known approaches, TQM and Lean Manufacturing, in different aspects with the aim of establish the advantages and differences between them. Here a parallel between them and Six Sigma is shown. Undoubtedly, refer to the definition of each one of them is the first step of the comparison .TQM and Lean manufacturing, have punctual and commonly accepted definitions that won't differ much from author to author.

TQM is defined as:

It is a management approach to long-term success through customer satisfaction. TQM is based on all members of an organization participating in improving processes, products, services and the culture in which they work (http://www.asq.org/glossary/t.html)

Lean Manufacturing is seen as:

Lean is a series of tools and techniques for managing your organization's processes. Specifically, Lean focuses on eliminating all non-value-added activities and waste from processes. Although Lean tools differ from application to application, the goal is always incremental and breakthrough improvement. (http://www.asq.org/glossary/t.html)

And last, Six Sigma, which definition was given previously,

"... is an organized, parallel-meso structure to reduce variation in organizational processes by using improvement specialist, a structured method, and performance metrics with the aim of achieving strategic objective." (SCHROEDER *et al.*, 2008)

Initially, all the definitions have not much in common; TQM focus on customer satisfaction by improving the whole organization culture, meanwhile, Lean directly goes after the reduction of all kind of wastes and Six Sigma to the reduction of variation of

processes. However, this comparison does not cover the whole approach behind the name. Both, (DAHLGAARD *et al.,* 2006) and (ANDERSSON *et al.*, 2006) overtake a comprehensive comparison from different panoramas. The following is based on those papers and stand the position between TQM, Six Sigma and Lean manufacturing as quality management approaches in the industry.

Clearly, TQM was introduced to the industry in the very first place (not precisely under the name TQM). An approach developed thanks to Japan's manufacturing industry necessities right after WWII. Lean manufacturing arose under the umbrella of Toyota Company, a Japanese company, after its engineers visited the facilities of western car manufactures, exactly, Ford, in an attempt to enhance its production capacity system. However, lean approach was not a replica of ford system but the contrary. The engineers learned what exactly not to do, generate waste, and translated this simple idea into a whole principle that got along very well with the current evolution of quality at that moment. Six Sigma appearance followed somehow the lean story, but instead of remove waste of production, focus on reduce the process variation in order to reduce the defects. In other words, lean and Six Sigma born under similar circumstances and beneath the same evolution of quality.

TQM stress the continuous improvement of the process on the foundation of everybody commitment around the company, this form differs the Six Sigma and lean production, which incur in a reduction of variation of the processes and improving the flow of the processes respectively; nevertheless both use the project management approach to conduct this.

Regarding the methodologies used, these three systematic approaches use different positions; TQM use the plan, do, study and act, lean uses a more product-driven view based on customer requirements: understanding of the customer value, value stream, analysis, flow, pull and perfection, meanwhile, Six Sigma uses the DMAIC (KUMAR *et al.*, 2008) Nevertheless, all of them use the same type of tools, the analytical and statistical ones with the exception of lean that forget about the statistical part.

One important issue to outline is that lean and Six Sigma does not have as primary objective the customer satisfaction nor loyalty, instead those aspects are relegated to a secondary position and are product of the synergies of decreasing variation and removing waste. The motor of Six Sigma is saving money and lean turns to reduce lead time. In the other hand, TQM came out to solve the problem of customer satisfaction and looks forward to increase it, this also goes further and the result of increasing the satisfaction is attaching the customer to their product or in other words, customer loyalty.

These previous comparison evidently expose the main criticism which are usually raise against each one of them. Using TQM is very difficult to measure the improvements inside the company, the companies whose leader team believes in TQM philosophy, are aware the success occurs due to culture change and strategic thinking but needs a tangible, detail road map and consultancy for implementation. It is hard to appreciate if the personal has understood and are applying the concepts behind of the organization's TQM guidelines and at the same time is a resource-consuming activity. Lean production, in the other hand, tends to reduce the flexibility of the processes causing congestion in the supply chain and in addition, being the objective to reduce waste, cannot be apply in all industries.

Summarizing and answering to the question mark of this chapter, the big success of prestige enterprises and the results in tangible terms, i.e save money, encouraged many companies of all types and size to try to replicate the experiences from their own. This seems to be the very first reason of the wide-spread for Six Sigma and would explain why so many books have been published alluding the achievements of companies like GE or Signal Allied. To be fair, companies wants methodologies that brings them greener numbers in the financial statements with the minimum effort, and Six Sigma is able to do that, if it is well apply.

Six Sigma can be introduce into the company in a parallel way, how is establish in the definition given in chapter 1. There is no necessity to stop the production in order to train all the personal, the projects carried out might give results in the short term -6 to 12 months-, and are not resource consuming.

Moreover, the projects tackle particular issues employing an easy understandable methodology which is DMAIC, highly flexible for special cases due the among of capable tools used in each phase. Furthermore, the results of the singles projects act as wave and joint all together impact on customer satisfaction.

2.1.2 Six Sigma vs. ISO 9000 and Baldrige Award

A fitting place to start is with a definition of what performance is. While there are many potential definitions out there, the following one looks at performance from an organizational context:

''Performance is the value added to the organization that the person and/or the group can give with reference to the achievement of organizationally relevant objectives.''
(MONOPOLI and BUTHMANN, www.isixsigma.com)

Whether one agrees or not with the methodology of Six Sigma, at this juncture, it is an academic argument. The fact of the matter is that major corporations all over the world are following this particular methodology with the hopes that customer satisfaction will increase and the financial position of the organization will strengthen.

After World War II, several national economies grew significantly, leading to a global competitive environment. From time motion studies to quality improvement tools, businesses deployed methods to improve their performance. Beginning in the 1970s, Japanese automakers challenged U.S. industry by deploying quality management tools taught by J. M. Juran, Edwards Deming, Phil Crosby, Genichi Taguchi, and others. In the 1980s, other ways to promote process and performance standards were created, such as the ISO 9000 quality management system developed by the International Organization for Standardization (ISO) and the Malcolm Baldrige National

Quality Award (MBNQA) guidelines established by the U.S. Motorola-pioneered Six Sigma methodology and successfully to reap rich benefits. (GUPTA, 2003)

The ISO 9000 system evolved when the European Union (EU) was forming in the mid-1980s. Its main purpose was to provide standards that would facilitate trade between EU member countries. Later it became an international standard for quality management under the auspices of the International Organization for Standardization (ISO). In reality, the ISO 9000 system is a business management system. (www.akademiyatirim.com)

When the ISO 9000 quality management system was launched in the United States in 1987, the U.S. Congress established the Malcolm Baldrige National Quality Award to improve business performance. The resulting MBNQA Criteria for Performance Excellence (also known as the Baldrige Criteria) provided a system for managing process performance. (ASQ website)

The three major performance measurement and improvement systems of ISO, the Baldrige Criteria, and Six Sigma all launched at about the same time. ISO launched ISO 9000 and Motorola launched the Six Sigma methodology in 1987, and Congress launched the Baldrige Criteria in 1988.

ISO 9000	MBNQA	Six Sigma
A framework for creating ''Quality Thinking.''	A framework for creating ''Performance Thinking.''	A framework for linking improvement to profitability.
Facilitates process management through documentation and compliance.	Facilitates benchmarking to improve performance levels to best in class levels.	Facilitates dramatic improvement to achieve performance excellence.
Specifies all business functions except accounting.	Specifies key aspects of business.	Specifies a methodology for improvement for improvement irrespective of functionality.
Promotes Management Responsibility through communication and management review.	Promotes exceptional leadership behaviors as a way of life in society.	Requires leadership to aim at highest performance with the highest profitability.
Main aspects is compliance to documented practices and improving effectiveness.	Main aspects is to achieve total customer satisfaction through superior practices and performance.	Main aspects is achieving and maintaining a high improvement rate for the business aspects that affect profitability.
About 500.000 companies have implemented worldwide.	About 4 to 8 companies win the national level; similar	Has been adopted by several companies to achieve a

	number at state level and in other countries.	dramatic improvement and profitability.
Saving are difficult to quantify.	Performance of publicly traded companies has shown advantage over the others by 3 to 4 times.	Companies have reported huge amount of savings in production and service areas.
Mass application of the standards .	Limited to a few companies.	Selectively used by the companies committing to be a superior company.
It is a third-party certification.	It is recognition for excellence.	It is a methodology to optimize performance and maximize profitability.
Is on decline due to diversification in series of industry-specific standards.	Stabilized due to limited recognition. Has expanded into health care and education.	Growing rapidly as an attractive means to realize superior financial results.

Figure 6: Difference between ISO 9000, MBNQA and Six Sigma. Adapted from (GUPTA, 2003)

- **What distinguishes Six Sigma in terms of evaluation on the performance of a project?**

The process to evaluate the performance of Six Sigma projects can be carry out in two modes; the first one is the evaluation of the projects phase by phase due the methodology and personal criteria, and the second is to measure the performance of the project once is finished; this is allowed since the projects are done in a short lapse of time and the objectives are highly measurable. This is the preferable way to control the efficiency and effectiveness of the projects meanwhile; controlling the performance of each phase is limited to black belts and champion on the basis of subjectivity. This answer helps to complement the arguments in favor of choosing Six Sigma over the others.

2.2 Six Sigma Methodology and their impacts

For manufacturing companies, the direct benefit of Six Sigma results from the reduction in the number of defects due to improved manufacturing processes. For these companies, Six Sigma or Six Sigma quality level is a measure of the process defect rate that is to say that high sigma level indicates the process results in a lower defect rate whereas, a low sigma level illustrates a higher defect rate. Moreover, Sigma quality level also helps to set a realistic target for improvement of process quality during the DMAIC cycle, in other words, it can be used as a benchmarking tool.

Reducing process variations is the core objective of Six Sigma projects, since process variations result in higher quality loss. In this respect, (TAGUCHI and CLAUSİNG, 1990) reported a classic example on the impact of process variations using the case Ford versus Mazda. Ford which owned 25% of Mazda, had ask the Japanese company to build transmissions for the cars that it sold in the United States. The transmissions were built with identical specifications and Ford was adopting zero defects as its standard. However, after the cars had been in the market it was observed that Ford's transmission systems was generating far higher warranty costs as compares to the transmission systems built by Mazda. The reason was traced to the fact the Ford's transmission had much higher process variability to the transmission built by Mazda. Sony Corporation reported a similar case for their televisions manufacture in Tokyo and San Diego. As a result the customer satisfaction levels for television manufacturers in Tokyo were much higher than the television manufacturers in San Diego. (KUMAR *et al.*, 2008,)

Another innovative approach to the Six Sigma methodology is the focus on customer from a quality system criteria perspective. The approach considers the following:

- Driver: Senior executive leadership guides the sustained pursuit of customer value and improvement of organizational performance via the Six Sigma methodology.
- System: Processes are well-defined and well-designed to meet organization's customer requirements as well as quality and performance requirements for the profitability of the organization.
- Measures of Progress: These are established on a results-oriented basis for channeling actions and delivering verifiable improvements not only to the customer value but also to the organizational performance. This performance is based on specific goals from the organization with the intent to ever improve value to customers. To pull this together the following four items are necessary:

    i) Senior executive leadership.
    ii) Customer focus.
    iii) Human resource development and management quality and operational results.

iv) Customer satisfaction.

- Customer satisfaction relative to other organizations.
- Customer retention.
- Product and service quality.
- Productivity improvement.
- Waste reduction and elimination.
- Supplier quality.

This organizational quality performance is further enhanced by a strong:

Information analysis: The drive here is to become a data-driven company for all decisions. Information analysis is a push to effectively manage and use data and information for an optimum decision. With the proper and appropriate information we can examine the scope, validity, and analysis of data used to improve operational performance. How do the data and information systems support improvement efforts toward customer focus? What about products or services? What's the impact on internal operations? These questions help you learn more about the organization's ability to improve operational and competitive performance. Of course, to do this, statistical tools are necessary.

Strategic quality planning: What planning process do you use in your organization? What long- and short-term plans are produced by a process within your organization? How is all the key quality requirements integrated into the overall plan? These questions help guide the initial steps of the strategic quality planning process. It is important to be sure the plans include mission performance goals. Also improvement plans should be included for enhancing performance in all key areas for both short and long term. (Stamatis, 2001)

Beside all these, the customer requirements should be clearly set. For a long time "quality" meant some type of conformance based on a set of customer requirements that, if met, resulted in a product that was fit for its intended use. The trick, however, was to have knowledge of the user's needs, wants, and expectations from both the internal and external perspective.

It is critical that these requirements be understood and reflected accurately in specifications for products, services, and processes. One of the fundamental principles is that "conformance to requirements" only leads to user satisfaction when there is alignment between user expectations and user requirements.

Six Sigma methodology focuses on prevention not correction. There is no doubt that prevention has more leverage when improving quality than correction does. Therefore, the efforts of quality should be focused on prevention, because the quality payoff is maximized when considered during early phases of developing a product or service. It is then that many problems can be prevented. Thereafter, the leverage of prevention is reduced as correction of problems a more costly procedure becomes the dominant mode. A key aspect of this concept is designing products and services that can be produced with high yield within the capability of the manufacturing or service process. (Soni , www.isixsigma.com)

Furthermore, Six Sigma methodology increases the performance by reducing the waste. In general, the typical waste items are given such as:

Typical Waste Items			
Material	**People's Time**	**Lost Sales**	**Capital**
Scrap Excess inventory Inspection equipment Test equipment Poor machine utilization Energy Lost or misplaced material Over or under specifications Excessive equipment	Rework Inspection Checking Clarifying Producing waste or poor quality Inefficient meeting	Poor quality product/services Not responsive to customers' needs Poor customer service Poor engineering	Investments Warranty cost Liability cost Idle equipment Depreciation

Figure 7: typical waste item in manufacturing companies. Adapted from (ANTONY et al., 2006)

Everyone involved with quality has figured out that the cost of waste in all sizes of organizations is significant. Whatever the exact numbers are, they illustrate the extraordinary opportunity for reducing costs through improvement of quality. Much of the high cost of poor quality comes from processes that are allowed to be wasteful. This waste is often chronic and is accepted as the normal cost of doing business. The conventional approach to quality is not to get rid of chronic waste but to prevent things from getting worse by "putting out the fires." Chronic waste of time, material, and other resources can be driven down by implementing continual process improvement. (STAMATİS, 2001)

2.2.1 DMAIC vs. DFSS

The performance of a company can be established by the level of sigma or DPMO it is dispatching during the process and/or by the behavior of financial indicators like the return on investment (ROI). In (RAVİCHANDRAN, 2007) can be seen a classification for the company competitiveness based on DPMO, divided in:

- World class (6 Sigma level or 3.4 DPMO),
- Industry average (5 Sigma level or 230 DPMO) and,
- Non-competitive (2 Sigma level or 310.000 DPMO)

However, this analysis represents the plain situation of efficiency of the organization performance, and doesn't really represent the effectiveness of it, unless it is correlated with a financial indicator. Since Six Sigma approach is based on DPMO and it plays the most crucial part during the process, (RAVİCHANDRAN, 2007) present a cost-based process weights for DPMO where a weighted DPMO helps to Six Sigma to better operate under financial argumentation, i.e ROI is included into the process. A further detail of the method, the reader is referred to (RAVİCHANDRAN, 2007).

Then, keeping the previous in mind, the main Six Sigma methodologies are concentrated in the application of continuous improvement methodology (DMAIC) or a design/redesign approach known as design for Six Sigma or DFSS which uses the IDOV methodology. DMAIC is the methodology used to improve already existing processes and is divided in 5 phases: define, measure, analyze, improve and control. On the contrary,

design for Six Sigma (DFSS), is used for new processes or when the existing processes are unable to achieve business objective such as customer satisfaction (CORONADO and ANTONY, 2004). In addition, DFSS focuses on delivering the right product at the right time and at the right cost through the Identify, design, optimized and verify methodology. (LİNDSAY and EVANS, 2005) ;(CORONADO and ANTONY, 2004)

Taking into account that DMAIC might guarantee a 4-5 sigma level, it is very difficult to get the ultimate level of 6 sigma; in which the necessity for a breakthrough is given by the implementation of DFSS in order to assure the strategic objective in particular processes or products (SNEE and HOERL, 2003); (CORONADO and ANTONY, 2004) imply that these two methodologies not only have the same focus and target the same objective but also share the critical factors to success and the impact on the performance of the company, for example, some of the best people, in different business functions, are freed up from their normal duties and trained, then, they focus on Six Sigma and later on the company will take advantage of them not only in particular Six Sigma projects, but also in the appliance on the Six Sigma mindset in other functions. The continuous implementation of Six Sigma projects, guide the company organization to focus on formal and structural deployment plans and emphasized in hard financial results playing along with strong leadership support.

At the end, the impact on the performance of the company will be, no matter the methodology or toolset or technique within it, the reduction of variation on the processes and this according to (BRUE, 2005) will traduce in saving cost, raising customer satisfaction, quality and growth, higher impact on employees and increasing the competitive advantages.

It is important to notice that companies reach successful projects if exist the decisive support all organizational levels, and stand clear of the procedure to do, having involve all the personal necessary to it (CHAKRAVORTY, 2009). The performance of the projects, in the other hand, is measure on the basis of financial results, mainly ROI factor (PYZDEK, 2003) and the method of (RAVİCHANDRAN, 2007) previously mentioned is a string

comparative decision-making rule when deciding which the impact of the performance of the company through Six Sigma methodologies.

2.3 Implementation of Six Sigma Techniques on particular cases

Using basic Six Sigma techniques, companies can refine their processes to improve their ability to demonstrate compliance and reduce time and resource costs along the way. But the first step is to understand, identify and prioritize risks. Here are a few tips based on tools used in compliance systems to help get started. (AN *et al*, www.isixsigma.com)

i. Evaluate and Understand Gaps

Since companies do not have endless resources, resources need to be applied according to the biggest benefit, or in case of compliance processes, the largest risk. In order to prioritize where additional Six Sigma process efforts are necessary, the company should gain an understanding of where the biggest risks and gaps exist.

Using this analysis method, the company prioritized the processes with inadequate controls and that posed significant compliance risks. Then, they launched several phases of Lean Six Sigma projects, beginning with the highest risk gaps, to streamline the processes with the right controls.

ii. Evaluating Potential Risks and Control Gaps

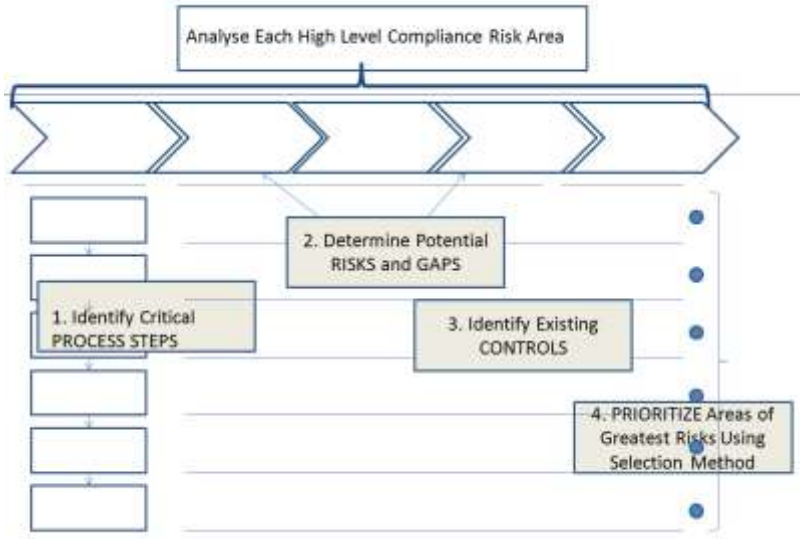


Figure 8: High level process analysis. Adapted from (AN *et al*, www.isixsigma.com)

iii. Apply Basic Process Map Analysis

Another tool to increase understanding of key compliance risks is process map analysis, one of the foundational tools of Lean Six Sigma. Process maps in all their various forms - including value stream mapping, swim lane, deployment, etc. - can help companies determine what parts of which process are necessary to accomplish their purpose, and which add cost and time but no value. (http://www.strategosinc.com/mppng1.htm)

Figure , for example, shows a schematic of a process looking at how to most efficiently handle cash funding to clients, which is subject to certain approval and controllership regulatory requirements. The team created the map and then looked for "over processing" (non-value-added processes, or in Lean terms, waste), including unnecessary handoffs and approvals, communication gaps, delays or wait time, and rework.

iv. Using a Process Map to Find the Waste

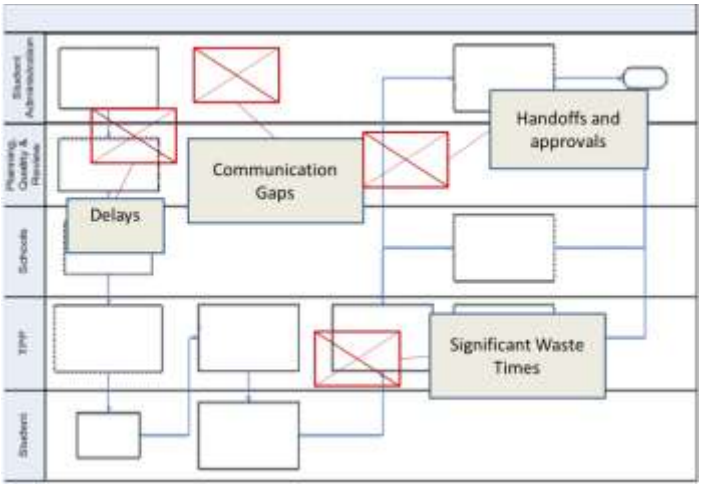
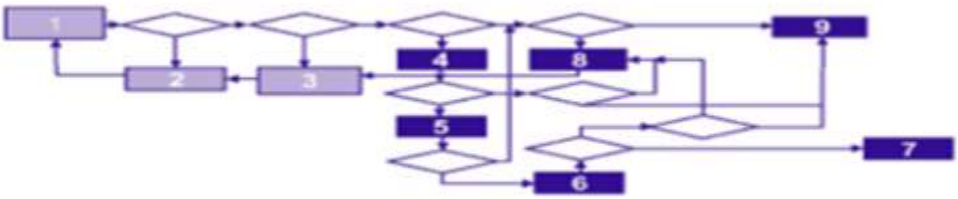


Figure 9: Process mapping to find waste. Adapted from (AN *et al*, www.isixsigma.com)

Another process analysis approach is to measure and analyze how time is spent in a process, focusing on the time spent on value-added (VA) versus non-value-added (NVA) activities. The method correlates process steps with a table that summarizes the time for each step, separating VA from NVA time.

v. Separating Value Added time from Non-Value-Added time



Process steps	1	2	3	4	5	6	7	8	9	10	11	12	13	Total	Total %
Est Ave. Time(min)	1	60	20	60	60	60	30	10	10					311	100%
Value-added	X	X	X											2	
Non value added														0	
Internal failure				X	X	X								0	
External failure		X												0	
Control/Inspection														0	
Delay	X	X	X	X	X									42	
Prep/set up				X										2	
Move		X	X				X	X	X					3	
Value enabling														0	
Total	1	0	2	4	1	1	1	1	1	1	1			49	

Figure 10: Value added Vs Non-Value Added activities. Adapted from (AN *et al*, www.isixsigma.com)

Taking the initial analysis from these tools, the team then continued with the detailed data collection and root cause analysis. The final process improvement efforts resulted in a decrease of late funding to customers from 41 percent to less than 5 percent and an increase in cycle time requirements from a sigma quality level from 1.2 to 3.2.

vi. Use Data Tools to Identify Risks

Two additional basic Lean Six Sigma tools that can be used to focus in on the highest areas of compliance risks are the Pareto chart and cause-and-effect diagram. Figures and are examples from a project that revolved around the required reporting of key vendor identification information to a federal government agency in order to avoid large penalty fines.

The Pareto chart in Figure helped the company prioritize where (in which business units) the most exceptions or control failures were occurring. This was then helpful in prioritizing where process improvement efforts should be focused. In this case, the company quickly identified three focus areas for further analysis. (BONACORSİ, 2002)

vii. Using a Pareto Chart to Prioritize

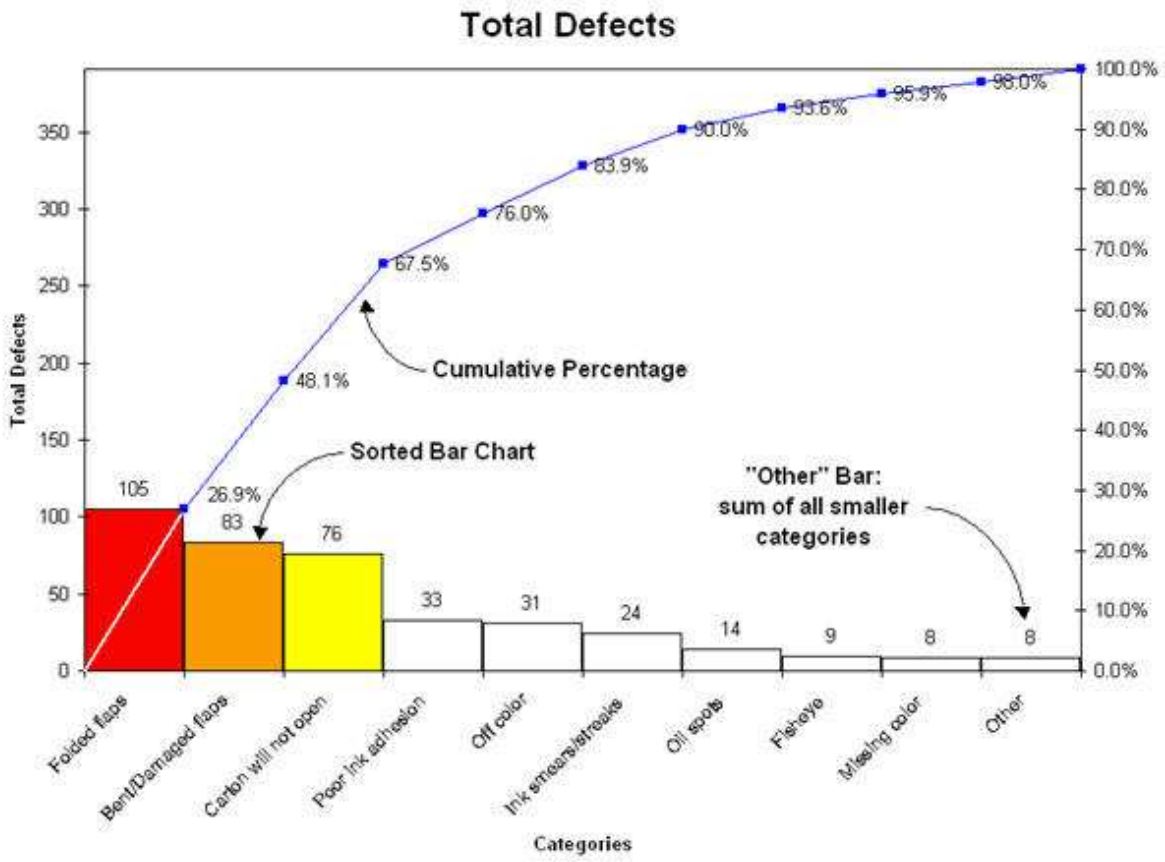


Figure 11: Pareto Chart as a prioritize tool. Adapted from (www.qaproject.org)

A cause-and-effect diagram (Figure 12) was also used to brainstorm potential factors or reasons for noncompliance or control failures. These then identified data that needed to be collected to validate the factors creating the greatest control gaps.

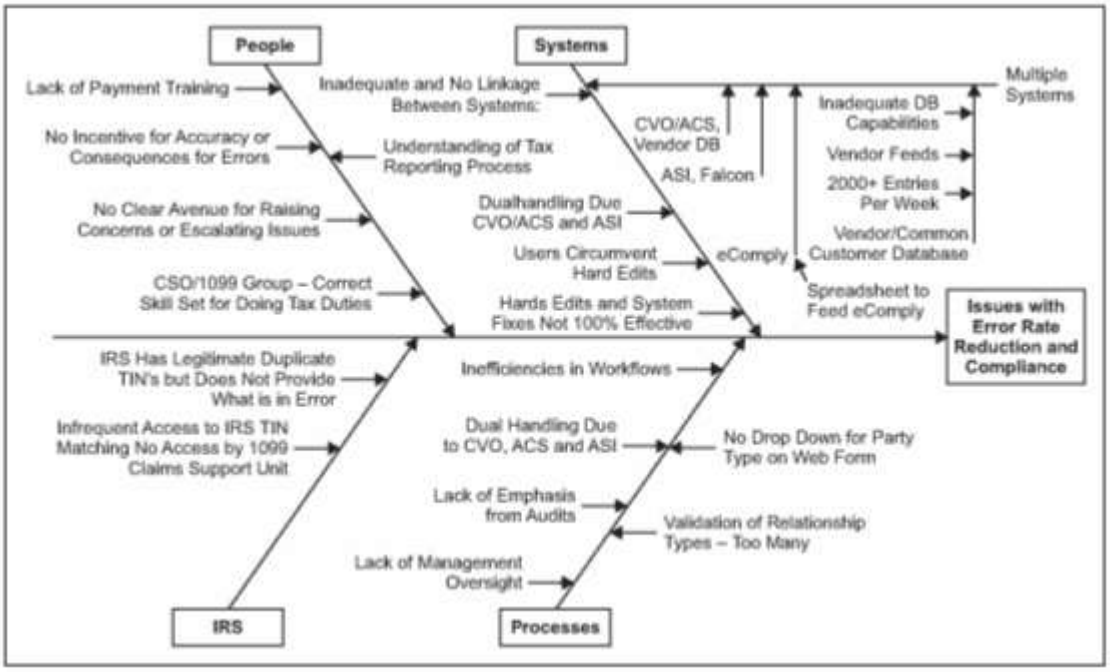


Figure 12: Cause and effect Diagram. Adapted from www.balancedscorecard.org

Many Lean Six Sigma practitioners are familiar with quality function deployment (QFD) as a product development tool used to convert customer needs into specific product design features. Even a simple QFD, however, can help in selecting appropriate controls and process features to accomplish business objectives, whether for legal or regulatory requirements or for business requirements. A QFD can be used to evaluate the importance of existing controls and to select effective new controls against business objectives.

Figure 13 shows how QFD thinking was used in the risk management function of a financial services firm. They used the tool to develop better ways to evaluate the credit-worthiness of potential customers by listing the business requirements down the left side of the page with existing and proposed metrics across the top of the page.

viii. Quality Function Deployment for Risk Management

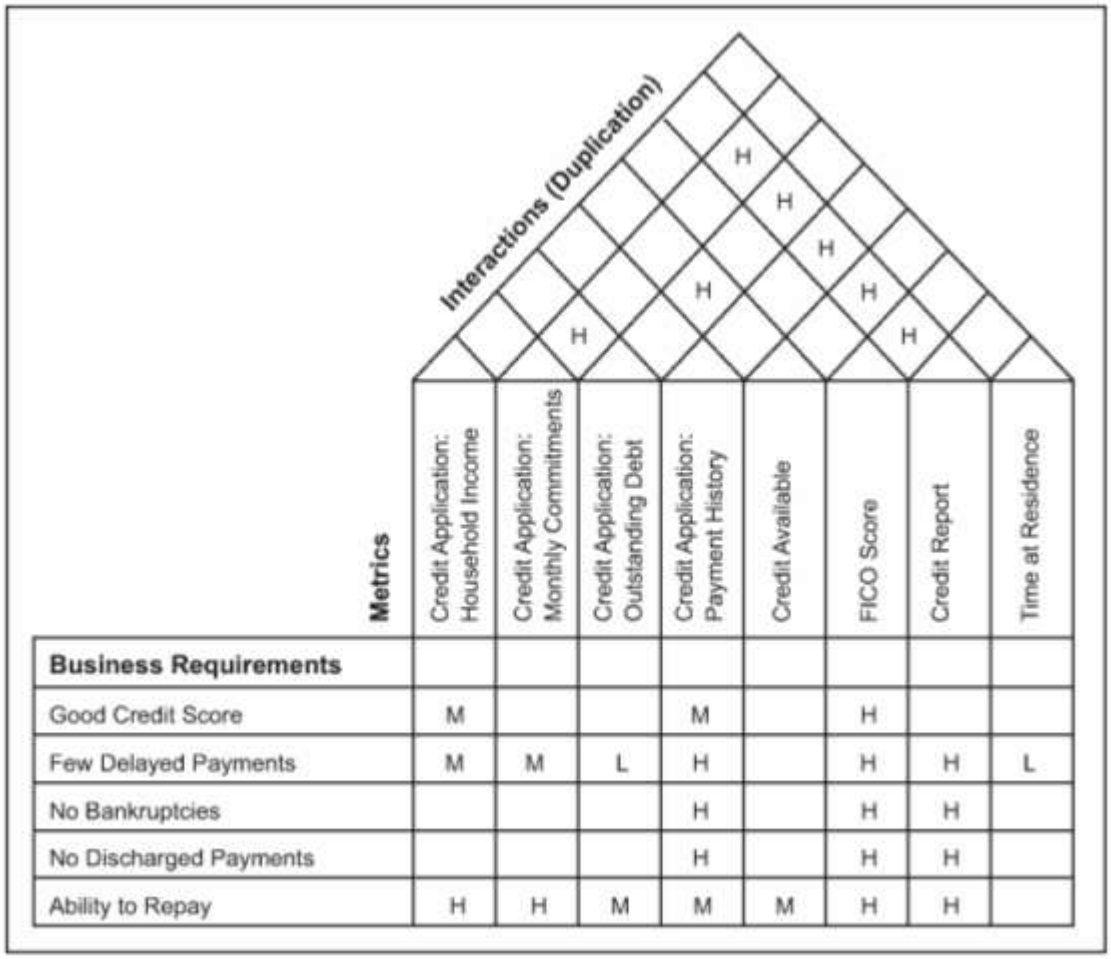


Figure 13: QFD. Adapted from (AN *et al*, www.isixsigma.com)

Each metric was then rated as High, Medium or Low in its validity for satisfying the business requirements listed down the side. Quickly, some metrics were determined to be of limited value and were thus removed from the credit assessment process as non-value-added. Examples of non-value-added data include net worth figures, which were often unreliable and not actually used in the credit decision despite being required of customers on application documents.

Then the top of the QFD was completed to determine if metrics were similar or redundant. Decisions were made regarding which metrics to retain as being more appropriate indicators of credit performance, and the metrics that were less appropriate or

redundant were eliminated. An example of redundancy was the data collected on application forms related to all outstanding credit instruments when the pertinent data was already available on electronic credit reports. The result of the exercise was a leaner credit evaluation process that was easier, faster and less expensive to perform and less burdensome to customers completing application paperwork. Cycle times to customers were shorter as well.

3. The Human organization of Six Sigma and their roles on performance.

For a Six Sigma deployment to produce the expected results, organizational roles and responsibilities must be clearly defined and aligned. If Executives and Champions are trained and Black Belts and Green Belts aren't, the probability of success decreases to virtually nothing. The reverse is true as well. None of these situations will produce the type of results that will occur when Six Sigma practitioners are placed in the correct support environment.

Champions have a much larger role in deploying Six Sigma or any other initiative than just removing roadblocks. Champions must be integrated into the business; select projects accurately, adjust the speed of the deployment as necessary, and take responsibility for implementation. (CARNELL)

3.1 The most Common Functions of Six Sigma Organization

The following will summarize the roles and functions of the typical Six Sigma project teams as was mention in chapter 1. The text is based on the book (STAMATİS, 2004). Later in 2.3.6 will be discussed the effect and need of each one of the member of the teams on the performance of the project.

3.1.1 Executives

The executives legitimize the changes about to happen because of the Six Sigma implementation methodology through their actions to:

- Establish the vision—why we are doing Six Sigma.
- Articulate the business strategy—how Six Sigma does supports the business strategy.
- Provide resources.
- Remove roadblocks and buffer conflicts.

- Support the culture change by encouraging others to take the risk and make the change.
- Monitor the results by defining the scorecard for six sigma and holding others accountable for the results.
- Align the systems and structures with the changes taking place.
- Participate with the black belts through project reviews and recognition of results.

3.1.2 Champions

The champions implement the changes as a result of the Six Sigma methodology by taking action to:

- Develop a vision for the organization.
- Create and maintain passion.
- Develop a model for a perfect organization.
- Facilitate the identification and prioritization of projects.
- Develop the strategic decisions in the deployment of Six Sigma around timing and sequencing of manufacturing, transactional and new product focus.
- Extend project benefits to additional areas.
- Communicate and market the breakthrough strategy process and results.
- Share best practices.
- Establish and monitor a team process for optimum results.
- Recruit, inspire and "free up" black belts—pick the best people.
- Develop the reward and recognition program for black belts.
- Remove barriers for black belts.
- Coach and develop black belts.
- Provide the drum beat for results by reviewing projects and keeping score through metrics.
- Develop a comprehensive training plan for implementing the breakthrough strategy.

3.1.3 Master Black belt

The master black belt (shogun) assists the champion and/or guides the black belt as needed by taking action to:

- Be the expert in the tools and concepts.
- Develop and deliver training to various levels of the organization.
- Certify the black belts.
- Assist in the identification of projects.
- Coach and support the black belts in project work.
- Participate in project reviews to offer technical expertise.
- Partner with the champions.
- Demonstrate passion around six sigma.
- Share best practices.
- Take on leadership of major programs.
- Develop new tools or modify old tools for application.
- Understand the link between six sigma and the business strategy

3.1.4 Black belt

The black belt serves as the project manager for the six sigma project. Fundamentally, the black belt is the individual who receives the change and makes sure that the change is institutionalized throughout the organization by taking some form of action in the following categories:

- *Mentoring*. Cultivate a network of experts in the factory and/or site.
- *Teaching*. Provide formal training to local personnel in new strategies and tools.
- *Coaching*. Provide one-on-one support to local personnel.
- *Transferring*. Pass on new strategies and tools in the form of training, workshops, case studies, local issues and so on.
- *Discovering*. Finding application opportunities for breakthrough strategies and tools, both internal and external.

- *Identifying*. Surfacing business opportunities through partnerships with other organizations.
- *Influencing*. Selling the organization on the use of breakthrough strategies and tools.

On the other hand, because the black belt is so important to the process, it is imperative that the individual who carries this title must have the following specific requirements and knowledge to be able to:

- Understand how to implement the breakthrough strategy application.
- Prepare initial project assessment to validate benefits.
- Lead and direct the team to execute projects.
- Determine the most effective tools to apply.
- Show the data.
- Identify barriers.
- Identify project resources.
- Determine appropriate and applicable input from knowledgeable functional experts/team leaders/coaches.
- Report progress to appropriate leadership levels.
- Present the final report.
- Deliver results on time.
- Solicit help from the champions when needed.
- Influence without direct authority.
- Be a breakthrough strategy enthusiast.
- Stimulate champion thinking.
- Teach and coach breakthrough strategy methods and tools.
- Manage project risk.
- Ensure the results are sustained.
- Document learning.

3.1.5 Green belt

The green belt is the individual who assists black belts with completing projects and applies the Six Sigma breakthrough strategy (DMAIC or DCOV) on the job. The specific details regarding the deployment and the role of any green belt is determined by each organization.

3.2 Skill Performance Assessment for Six Sigma Project Members

We started this chapter with the definition of performance. Therefore, this definition includes the'' what'' and ''how'' of performance. What needs to be achieved refers to the company's objectives. With regard to Six Sigma, these objectives are typically breakthrough process improvements and significant business benefits. A company should expect a Black Belt to close major competitive gaps by either enhancing the customer experience or generating positive economic profit. But also - in the longer term - cultural organizational change toward a data-driven decision-making process and customer-oriented organization can be achieved.

On the "how" side, performance-driving behaviors can be seen in four major areas (MONOPOLI and BUTHMANN):

- Task performance
- Leadership performance
- Interpersonal performance
- Ethical performance

i. Task Performance

Task performance refers to the technical project execution. This starts with selecting and scoping the right projects, ensuring Sponsor commitment and having sufficient resources available. During the project, high performance of tasks can be observed if the Black Belt selects the right tools from the Six Sigma toolbox to drive the right behavior during the project. In particular, tools that help to understand the root causes of the

problem, statistical and process analysis tools to verify these causes, and techniques to generate and select the right solutions are key to project success.

During the Control part and the project follow-up phase, a successful Black Belt prepares and conducts a proper handover to the process owner and follows up on the implementation of solutions to ensure that KPIs and the business case are achieved and the process owner's organization can easily implement and sustain the solution.

A company seeking successful Black Belts should look for a person with good analytical and project management skills. In terms of analytical skills, Black Belts should foster sound decision making based on data. They ask the right questions and keep asking questions. Having an affinity for statistics is important here but not statistical expertise because running statistical analysis is rather easy today given good statistical data analysis software.

In terms of project management skills, Black Belts should already bring project management experience to successfully deploy tools required to plan and assign tasks and timelines, define roles and responsibilities, hold team members accountable, effectively run meetings, resolve issues, move projects forward and complete the projects in an appropriate timeframe with the expected benefits.

ii. Leadership Performance

Successful Black Belts are results-oriented and strong in influencing people for results, developing team members, managing conflicts in the team and between other stakeholders, and leading change through strong listening, influencing and communication skills. High performers in the leadership category involve the key stakeholders early in the project and keep them up to date. They effectively communicate with the organization's leaders, and they consistently motivate the team to high-performance levels.

But leadership performance relates not only to project leadership. A high-performing Black Belt also inspires people to apply Six Sigma tools in their day-to-day operations and drives enthusiasm for Six Sigma within the organization.

iii. Ethical Performance

On a project level, a Black Belt ensures that project objectives are also the supporting social responsibility and customer-satisfaction targets of a company. Projects are therefore selected that improve the safety and reliability of products or services, increase courteous attention to customer queries and complaints, ensure adequate supply of products or services, provide full and unambiguous information to potential customers as well as reduce the potential dangers of pollution or disposal of waste.

iv. Exceptional Performance

Sometimes being a good performer is simply not enough: What is required is outstanding performance or unprecedented results. This means outperforming ourselves and going beyond our own limits. For a Black Belt, this would imply leading extremely difficult projects and at the same time managing really well the political and organizational implications of the role.

The keys to exceptional performance for Black Belts are:

- Clear project objectives
- Ongoing feedback by sponsor and relevant stakeholders, including project team members

  Sense of ownership about the goals
- Sense of control over the performance drivers and the results
- Commitment and involvement

A clear leading indicator of outstanding performance in Black Belt projects is an impressive combination of focus, concentration and self-efficacy that is called “flow.” To get to the flow area of performance, it is necessary for a Black Belt to lead a really challenging project but at the same time to be convinced to have the right competencies, as per the figure below (situation A4).

v. The Reasons for Excellent Performance

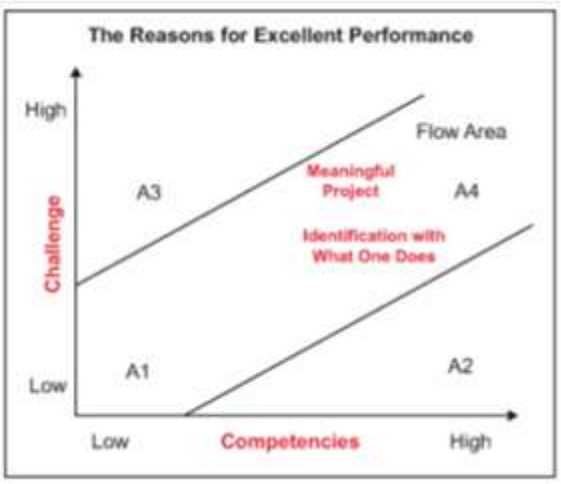


Figure 14: Reason for Excellent Performance. Adapted from (MONOPOLI and BUTHMANN, www.isixsigma.com)

All other situations undermine exceptional performance and call for action by the Black Belt's supervisor or coach (such as a Master Black Belt). Situation A3 is a threatening combination of high challenge and poor competencies, while A2 is the avenue of frustration, with high competencies wasted on a really simple challenge.

On the other side, Six Sigma Green Belts are critical to the process because they are the key to creating a culture shift. If the shift is attempted by training huge numbers of Black Belts, Black Belts will spend most of their time tripping over each other as they scramble to create the "number of projects" or "dollars saved" metrics imposed by management to motivate them.

Green Belts often face project delays and frustration resulting from conflicting priorities - day-to-day, business-as-usual duties versus Six Sigma project work. Although most companies communicate that Green Belts will spend approximately 25 percent of their time on projects, the reality is that this is usually in addition to their current workload. The best way to attack this problem is to assign Green Belt projects that address current opportunities for improvement within the Green Belt leader's current role or responsibilities

and to ensure Six Sigma-related goals are incorporated into their current performance management routines. (STROUD)

3.3 Six Sigma project performances as a function of the participants.

Undoubtedly, the success of Six Sigma relies on the people who are responsible for implementing it, but also for the ones that are responsible for support it and of course, the once in charge of apply it and give results.

But who is in charge of giving green light to the follow phase? In which basis give the freedom to continue?

Well, the green belts are the front field workers, and the executives give the push-on over the Six Sigma implementation, the Master Black Belt support and train Black Belt so at the end all the responsibility of the performance of the projects fall into the champion and bb.

Hoerl (Hoerl, 2001) said: "they the black belts are taught how to get an improvement project going, how to transition from phase to phase and how to close out the project", however, BB doesn't have the last word and they should report to champions, in other words, is him/her who monitors the project performance (Brue, 2005). Champions must understand the environment in which the project is carry on and follow the strategy and discipline of Six Sigma under the guidelines of the executives.

In other words, the performance of the projects is measure in first place by the Black Belt according to the objectives proposed during the selection of it, and the supervision of each phase agreeing the metrics selected. Then, the champion will corroborate the data and give the green light to continue to the next step. When? (Brue, 2005) connotes a regular oversight of the advances of projects in short term basis.

Therefore, the progress and performance of the on-going projects are directly proportional to the quality of work and analytic capacity of both, Black Bell and champions. Seems very subjective criteria to determine if a phase is complete successfully

and turn the page. As a result of the previous affirmation, the training and the skills take an important part foreseeing a high level of performance. There are several sources where both, the content of training and require skills, are studied and numbered; being that outside of the objectives of this dissertation, the authors suggest (Hoerl, 2001) and (Pyzdek, 2003) to go in depth on those topics.

III. Framework development

1. Goal setting and Methodology

Been reviewed the theory that surround Six Sigma methodology, it was noticed that there are still many facts to validate. The practitioner's literature is rich in many aspects about Six Sigma, but it seems to tackle a lot of subjects but they don't appear to have a solid ground. Some academicians have realized about it and have begun to do research covering some basis of the methodology. However, many are still to cover and the fact that Six Sigma is spreading up quickly and without solid basis is making a considerable among of implementations to fail.

Then, this thesis work is aimed to develop a framework which let the companies follow the Six Sigma initiative step by step and reduce the uncertainty of success due to lack of theoretical foundation in all important aspects of the methodology.

Following the previous statement, the objectives of this study are:

- To identify the key parameters for successful Six Sigma initiative deployment.
- To identify the main issues that increases the uncertainty of success in Six Sigma initiative deployment.
- To identify models on Six Sigma methodology.
- To elaborate a general framework for Six Sigma initiatives.

In order to meet the objectives, the methodology followed was simple. To reach the first three objectives, an extensive literature review was done and the information required is available on the previous chapters. In addition, an analysis of 3 cases of study was done aiming to identify critical successful factors and how those companies reduce the uncertainty when running Six Sigma projects.

Regarding the third objective, some Six Sigma framework methodologies were found and are shown on the succeeding numeral. Then, a consensus of the ideas was done and as a result a suggested framework can be seen in section 2 of the present chapter.

Moreover, the framework was submitted to the review of a champion and general manager of a company which analysis is presented later. To finalize, after taking into account the suggestions received, the framework was optimized and send it over again to further consideration by a Master Black Belt.

1.1. Pre-defined frameworks on Six Sigma

During the literature review was found that there are many authors, which based on successful practices develop general suggestions when running a Six Sigma project. The models available focus on the execution phase of the projects. The DMAIC framework is extensively studied and is not difficult to find a widely accepted standard practices. However, the Six Sigma initiative is much more than a correct application of DMAIC or IDOV procedures, the need for a clear point in the readiness, implementation and track of results, understood as one comprehensive model is as important as the execution part.

Professor Brun (BRUN and FAN) developed a checklist aimed to measure the readiness of a company pursuing implement Six Sigma as a quality framework for service industry. On it, the management commitment, experience with improvement initiatives, performance measurement and customer orientation and availability of resources are evaluated by a series of yes/no question under a checklist proposal.

(CHAKRAVORTY, 2009) formulate a model for the implementation phase. The model is built of six steps, beginning with the development of strategic analysis based on market and customer and finishing with the implementation, documentation and revision as needed of the procedure; it also encourage to establish high level and cross functional teams, define the tools to use and detail processes and improvement opportunities. This model recreates a step by step to assure a good implementation practice. The suggested

framework incorporate these steps translating each issue in yes/no question assuring to cover the entire model.

Regarding the execution phase many authors propose checklists covering the DMAIC, some of them can be highlight in (PANDE *et al.*, 2000); (PYZDEK, 2003); (GUPTA, 2003); (BRUE, 2005). Nevertheless, these references address specific issues among the phase, considered the main one in Six Sigma projects, might differ slightly one to another. The suggested framework combines these differences creating an overall perspective.

(BERTELS and BUTHMANN) provide important critical successful factors for Six Sigma projects along different stages of the initiative; the ideas are shown as an evaluation model with 3 levels of measurement – low, medium and high- based on the grade of accomplishment and commitment in each issue. These ideas represent an important source of information because the basis of that model are years of experience implementing and running Six Sigma projects. Those ideas are included in the framework giving substantial support.

1.2. Checklist as an appraise tool.

Considering a framework as a group of standardize concepts, practice and criteria used together to overcome particular problems and help to reference and solve similar issues, the suggestion presented and developed in this study is a checklist. The checklist is a tool which provide practical guidance to the company, it give sound evaluation criteria and helps to not to forget about critical issues. In addition, the checklist aids to ease the reproducibility of planning, monitoring and guiding operations. In other words, it offers a sound way to reduce the uncertainty of the outcome.

The format of the checklist is develop based on yes/no question targeting the easiness to answer and help the user to reflect objectively about what is missing or what is not been accomplished.

The methodology used to create the checklist was based on the Evaluation Checklist Project by the Western Michigan University. The outline of checklist development is as follows:

- ***Focus the checklist task:***

The checklist is aimed to cover the critical steps of a Six Sigma initiative in order to reduce the successful uncertainty. This frameset is a comprehensive collection of CSF, easy to understand and follow and concrete. Although, it is a complete guide through the Six Sigma process, doesn't mean that once it is fully accomplish the Six Sigma projects will be pure positive achievements.

- ***Make a candidate list of checkpoints:***

The initial list of checkpoints was founded on those successful factors named on the literature review and those abstracted from the study cases analysis. Moreover, this preliminary list overcomes the list of likely reason to fail during Six Sigma, highlighted in the first chapter.

- ***Classify and sort the checkpoints***

The reasons of why six sigma projects fail were exposed under general division of themes thus, the candidate questions which form the first list were also divided into the same classes. Then, a descriptor of each category was added to the draft checklist.

- ***Define and flesh out the categories***

During the literature review and once analyze both, the existing frameworks and case of study, four main categories were established. These are: readiness, implementation, execution and results. These categories accumulate most perspectives from the consulted authors creating an extensive boundary in which companies can easily locate themselves and generate an action working plan. The explanation of these categories can be found in the succeeding index.

- ***Determine the order of categories***

The categories explained by themselves the position in which they should be evaluated. The first one is the readiness that will express if the company is ready to begin an implementation process for Six Sigma projects. In the second place, the implementation category is located. It will show the mandatory steps for the executives in order to look at the big picture and give the guidelines for the subsequent series of sigma projects.

- ***Obtain initial reviews of the checklist***

The draft version of the checklist was sent to Mr. OZTURK, who is the General Manager and Champion of EKOTEN TEXTILE A.S. His reviewed was positive but some suggestions were done.

- ***Revise the checklist content***

Taking into account the suggestion proposed by Mr. OZTURK, the content of the checklist was upgraded and revise.

- ***Delineate and format the checklist to serve the intended uses***

The checklist was formatted according to the recommendation claimed on the Checklist for Formatting Checklist belonging to the Evaluation Checklist Project of the Western Michigan University. Some of those items are:

- ✓ Provide a context at the beginning of the checklist specifying general directions.
- ✓ Use precise terms and consistent vocabulary and use as much as possible common words.
- ✓ Emphasize in active voice
- ✓ Group together similar items
- ✓ Use explanatory text if needed.

Furthermore, was decided not to use score or weight for the answers. The checklist is built to have positive answer in all the questions; a negative answer will represent a missing process during the initiative and the user is exhorted to focus its attention to

accomplish such item. Even though, the user can continue the projects, the procedures from a negative answer will decrease the possibility of a successful end.

- ***Evaluate the checklist***

This point will be skipped and will remain as a suggestion for later studies. A field-test is highly recommend at this point.

- ***Finalize the checklist***

The final checklist can be found in appendix A.

As was previously said, the checklist is divided in four main categories. The case of study showed an likewise methodology to execute the whole initiative in six sigma with positive results; other case of study wide-known like Motorola and GE experiences worked under the same scheme. The companies were ready to take the next step in quality framework and continuous improvements as a first issue. Then, the way the projects were implement and track follows a pre-established strategic that converge in some KPI and imperative objectives. This was follow by a standardize procedure for deploy the projects and was aligned with the human factor. Finally, the results of each single project were gather up analyze and joined up to examine if the approach used was giving the expected goals, not as a single result but as linked network of efforts.

From the last paragraph can be subtracted that 3 main phases must be fulfilled to assure successful Six Sigma initiatives, standardize procedure for execution, execution aligned with strategic objectives and repercussion of singles results into key performance indicators i.e., Execution and Results categories. However, the recently number of failed initiatives and the possible reasons for that to happen raise the concern about something is missing in the picture. Prof Brun and practitioners (Brun and Fan; Bertels and Buthmann) blame the companies for trying to go into Six Sigma without being ready for it. In addition, Prof. Chakravorty (CHAKRAVORTY, 2009) is concerned about when companies arrive to the moment of implementation and no standard is available.

Then, to create a complete framework, is necessary to include those argued worries and because of that, the readiness and implementation categories were added to the frameset.

Figure 15: Proposed overall model for the checklist.

The figure 15 is the proposal for the model that will be explained in section 2. The Six Sigma initiative according to it is a sequential, directly related and impossible to skip set of phases. Each one has the same weight among the whole life and the complete accomplishment of each one will traduce in an important decrease of successfulness uncertainty.

1.3. Targeted users and uses

Before continue to the explanation of each phase, it is important for the reader to understand the target-user aimed for this checklist. When running the Six Sigma initiative one CSF is the commitment of higher levels in supporting and empowering the employees and following the whole life-cycle of the initiative very closely. This checklist can be used

as a tool to trace, measure, implement and self-evaluate and in that order of ideas the main intended user is to be in executive level where actually the Six Sigma initiative is born, due the top-down approach. However, the checklist is formed by four parts, and the execution one is intended to be used purely to control by the executives i.e., the directly responsible for projects execution are black and green bells, then, the third part must be fill-up by them and collected by the executives to keep track on the job-shop floor projects and its perception on the initiative.

The checklist is very flexible and although, the main purpose was explained, some companies can use this framework as an reiterative evaluation-survey method in every level of the initiative, from executives to green belts including champions, master black belts and black belts; which information collected can be translate in punctual improvement efforts in different levels decreasing even more the uncertainty to success. If a company decide to use this checklist for that purpose, the question will be no longer evaluate with a simple yes or no, but a scale of 3 or 5 degrees is needed to understand the position and perspective of the testee.

Then, the 3 degrees scale might be accomplished using *High, Medium* and *Low;* in which *High* represents a prominent commitment or satisfaction to the question and Low the lowest. In a 5 degrees, instead, can be used a numerical scale from 1 to 5 in which 1 is the lowest level of satisfactory answer and 5 the highest.

2. Framework proposal

In the figure 15, can be seen the abstraction of the framework. In figure 16 is shown a discrimination of components for each phase. The approach implies a sequential order and the importance of completing a single part before going further is crucial, giving none particular value, in specific, to a single one. However, the readiness chapter has some special issue since it is the base of the beginning of the initiative and will replicate in further implementation rounds. Each part is explained as follows:

Figure 16: Details on the proposed model.

2.1. Readiness

How ready is the company to begin a Six Sigma initiative? To figure this question out is the main goal for this part, the first one, of the checklist. During the literature review was noticed several successful factors carried out to arrive to a happy ending and at the same time were noticed factors highlighted during failed implementation. These factors are shown as yes/no questions and are discussed later.

Then, the approach of this part is to make the company aware of how complex is going to be the initiative, how many steps need to be taken care of before proceeding and be mindful about the requirements that are basic to run the initiative and to keep it on the

line, in other words, we would like the company to discover what is Six Sigma in depth before spending time and resources in further stages when can be too late.

The focus of this part is based on the following assumptions:

- The Six Sigma initiative is an approach that involves the whole organization.
- It is focus on the reduction of process variation and as a synergy, will improve customer satisfaction and reduce cost.
- Far from being a fashion approach, it needs to be taken seriously and the commitment needed is not just good will but time, resources and continuous effort.
- It is worthy to implement if other quality management approaches have been previously or currently used, and further improvement is not easily reachable, and if previous implementation failed, a fully analysis of why did it fail and why it won't happen again must be done.
- Six Sigma may not be the right tool at the moment, a spread knowledge of the possible option for the company to implement might be done in order to assure that Six Sigma is the best you can go for at the moment and it will reach the expected results in the medium-long term.

To do this, we did a consensus of critical successful factors in both cases, successful implementation and in those were some critical issues were missed and the implementation failed. The cases of study were the first source of information then the literature review and complementing with Prof. Brun's research which approach is the base for ours, although, some ideas have changed a bit. He proposed 4 topics to evaluate the readiness of a company namely are: management commitment, experience with improvement initiatives, performance measurement and customer orientation and availability of resources. As was said previously, we wanted to stress more the readiness phase and go more in depth, so we expanded these four issues to ten as can be seen in the figure 15.

From those 4 topics used by Prof. Brun we took 2: management commitment and resource availability; from (ANTHONY and BANUELAS, 2002) we took cultural change, communication, organization structure, training, project management skills and link to strategic imperatives which is a fusion of 4 topics highlighted by them; link six sigma to

business strategy, suppliers, human resources and customer. Finally, we added a topic called full understanding, which is intended to be the first filter or the very first basic thing to do. This item is highly related to a topic used by Prof. Brun but the slight difference is that we don't want to focus only on the previous improvement initiatives but also consider a high understanding from the theoretical view of the methodology.

Each of the topics will be explained later on.

Figure 17: Details on Readiness phase.

2.1.1. Full understanding

The objective of this topic is to filter, in other words, to make understand the user of what is Six Sigma from the theoretical view. From recently failing Six Sigma implementation is abstracted that executives just decided to run it because of matter of fashion or benchmarking and not because it was the best solution to increase the capabilities in function of the customer for the current situation of the company. It is also important to notice by the user the implication of previous experience in quality improvement and understand on them what went wrong and what good and why to switch from one to another.

The questions are the followings:

- Has the company been involved in a Quality improvement approaches?
- Did the company get the expected results?
- Did the company standardize the improvement?
- Does the company understand Six Sigma as an approach to reduce process variation with strong focus on customer satisfaction?
- Do you think Six Sigma methodology will bring more success than the others?

2.1.2. Management Commitment

Both, practitioners and academicians agree that management commitment is a critical issue for the whole life-cycle of the initiative. Executives and managers should understand that their support is the solid ground of the process and that support is more that setting aside resources (however, is also a key ingredient). A clear example of commitment is when managers are convince of the initiative and before launching it are spreading through all levels knowledge of what and how is the company to improve by Six Sigma

methodology. A proactive behavior is needed and their persuasion skills are fundamentals to get people into the movement.

The questions to be asked are:

- Are managers focused more on company results and the project than the certificate?
- Does the top and medium level managers fully commit and able to set aside resources and time to carry out and support Six Sigma projects?
- Are the best people of your company aware of the objectives, procedures and benefits and commitment needed to carry out Six Sigma projects?
- Does the executive level know that his support is more important than ones coming from financial resources?

2.1.3. Cultural Change

Six Sigma methodology will create changes in the way things are done in the company. Some changes can be small and easy to understand, but others may be huge and highly differ from actual practices. When this occurs the company mindset should be flexible and permissible enough to allow the improvement became a reality. This is a critical factor, and the company need to be sure that its employees will adapt quickly and buy-in the improvement otherwise all the effort is in vain.

Question to be answered:

- Is the actual company culture able to receive mindset and procedural changes?
- Is your organization structure able to change in short term?

2.1.4. Communication

Not much need to be explained about this critical factor. If the company is not able to allow a fluid communication and keep everybody update and empower the employees to update as well, the methodology will face a roadblock that will leads a failure.

The question is:

- Does the company count with effective and efficient communication channels both vertically and horizontally within the organization?

2.1.5. Organizational Structure

This is a critical factor which is related to the cultural change and communication topic. Nowadays, and not only because of quality improvements implementation, companies need to adapt fast to the environment changes, unpredictive customer needs and tough financial times. Old and strict hierarchical structures have been changing for alternative options which enhance the performance and increase the reactive capacity. Usually, this means to go for horizontal approaches of the organizational structure as much as possible. Then, the critical factor in here is not opening the company for a big re-structuration but taking the necessary steps to go break rigidity and isolated process and take them into a more self-evolving structure.

The questions are:

- Is the organizational structure apt to support a major change in the way the organization operates?
- Can the organization work independently and cross-functional?

2.1.6. Training

Six Sigma methodology need to be execute by people that know the what, when, why and how to improve. Unfortunately, experience is not enough to make personnel competent to develop the methodology since it is analytical and mathematical approach training is a must. This process can be time and resource consuming but handle in the proper way, the company can find a maximization benefits. It is important for the company to understand the needs to fulfill and establish a standardize training program and this next to the correct selection of the employee (based on skills) and sufficient amount of people to be trained will help in the successfulness of the process.

Question to be asked:

- Is the company ready to train the best people in order to lead and carry out Six Sigma projects?
- Has the company found out a training program according to its necessities?
- Has the company figure out how many people will need to execute successfully the projects?

2.1.7. Link to the Strategic Imperatives

Link to the strategic imperatives aggroup 4 important critical factors: the consumer, the business strategy, the collaborators and human resources. Six Sigma methodology demand a correlation between them in order to shape the implementation. Six Sigma and the strategic imperatives play a mutually open relationship because both must aligned in order to success. Six Sigma will not be fruitful if the company doesn't know which are the critical to quality of the processes or if doesn't have clear what the customer wants. On the other hand, the company will not enjoy the opportunities of apply Six Sigma if doesn't coordinate and stand clear the way for Six Sigma projects.

To know well the inside of the company and environment in which is performing is as important as to know how Six Sigma works and putting together both perspectives is a critical successful factor.

- Are customer satisfaction surveys carried our regularly?
- Are results from the survey used to guide further quality improvements?
- Does the company understand Six Sigma as an approach based on statistical thinking and linked to key business processes?
- Does the company have cleared the KPI/CTQ to measure and how to measure them?
- Does the company know how to prioritize projects based on business processes and customer satisfaction?

2.1.8. Project Management Skills

Keeping in mind that Six Sigma projects are run parallel to day-to-day work and usually it need cross-functional activities, the personnel who owns the projects must have the proper skills and knowledge to work out smoothly the projects. Remember that not everybody is a project manager and that position must be satisfied properly otherwise, single projects will not be able to overcome struggles. Then, is a critical factor to have the proper people in the proper place.

The questions are:

- Does the company count with people able to lead inter-department projects?
- Is the number of team members available to run the projects?

2.1.9. Resource Availability

Finally, but not less important is to be careful to set aside the resources to support the intangibility of the process. It is needed to be sure that all factors are lined up and add value to each other. For example, is non-sense if you train people in specific tools on a specific platform, but when running the projects they don't have either the tools or the platform.

The question is:

- Does the company have the resources to support the Six Sigma Initiative?

2.2 Implementation

Being covered the readiness part, which means the company is certain to go for the next step in the Six Sigma initiative, the implementation of the strategy and roadmap for the subsequence set of projects; was developed a questionary was based on the implementation model proposed by (CHAKRAVORTY, 2009).

This part of the checklist help to decrease the uncertainty of companies when arriving to the point of "let's start" in which they don't have a complete guidance to follow and this will create erroneous path that will directly conclude with a failure.

It should be clear that the implementation phase must be carry out by the company when all the basic theoretical ground is revised and in depth, it knows what is going to begin; once the company has taken all the preparative for putting the hand on-the-job this set of questions tells the route the process owner must handle the implementation and assure a standard guideline.

These set of question are sequential and look for assert a macro analysis of the current scene of the company and then, draw a micro decision map aiming at clear factors, crucial for the company performance and competitiveness and finally, implement the projects.

The set of question is shown as follows:

- Is there an active sponsorship engagement?
- Do you have enough belt-people trained to carry out the projects?
- Is there a broad organizational awareness of the Six Sigma initiative and benefits?
- Have the company created high-level cross- functional teams to drive improvement initiatives?
- Does the teams carried out a strategic analysis based on customer and market?
- Does the team link the strategic analysis with the company business processes?
- Does the team construct a high-level process mapping and identified on it, the improvement opportunities?
- Does the team prioritize improvement projects and carried out a project sequence in order to assure key performance processes improvements, including CTQ and financial factors?
- Are the overall improvement tools identified?
- Have the company form low-level improvement teams for execute the improvement projects?
- Is there a detail plan for low level improvement teams?

2.3 Execution

The execution phase is likely to be the most studied one in Six Sigma programs and as a prove is enough to go to the literature in which both, practitioners and academicians, have shown extensively construct different theories and approaches.

Even though, they are several approaches, they converge in the same core with small differences; the most common is DMAIC in Six Sigma and nowadays rising fast is IDOV in DFSS. This study focused on DMAIC perspective because it is the basic position in Six Sigma initiatives. As a suggestion, the modification of this part of the checklist can be done including the DFSS framework widen the spectrum of application.

Regarding the construction of the set of question, as was mentioned previously, a consensus of several frameset was done, taking into account the (PANDE *et al.*, 2000);

(STAMATİS, 2004); (PYZDEK, 2003); (BRUE, 2005). The ideas shown by each author are classify into the Define, Measure, Analysis, Improve and Control boundaries. According to it, the execution checklist was divided into the same context.

It is important to notice that the application of this part of the checklist is a bit different from the others due the level of involvement, it is to say, executives and high-level users might not be directly involve with the development of projects carry out in the shop-floor, but the low-levels belts. Then, this part must be filled up by project owners, i.e, black belts or green belts, but collected by the initiative owner to identify how good or bad is the performance. Doing this, executive can follow objectively progress and improve weak points and make low-level participants of strategic decisions.

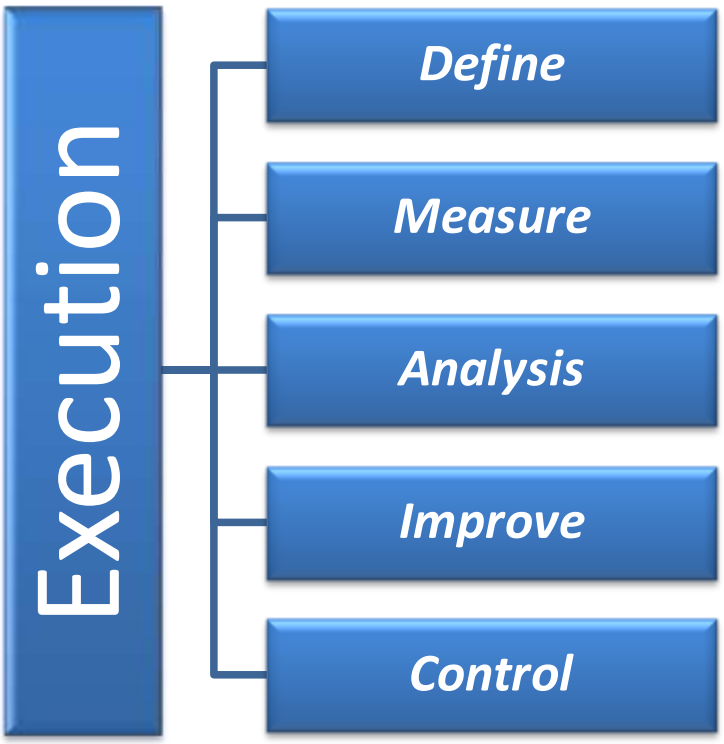


Figure 18: Execution phase.

The set of question can be seen as follows:

i. Define Phase

- Are the CTQ and KPI of the process identified?
- Have you prepared team charter and work plan?
- Have you prepared the high level process map?
- Have you defined the problem/opportunity statement?
- Have you defined the goal statement?
- Were project scope, constraints and assumptions known by team members?
- Have the important stakeholders been identified?
- Do you have measurable customer requirements in the plan?
- Has everyone reached consensus on team guidelines?

- Have all the operational definitions been identified?

ii. Measure Phase

- Did you use six sigma tools?
- Was the data gathered accurate?
- Have you determined what you want to learn about the problem and process in where you want to get the answer?
- Have you identified the types of the measures you want to collect and have a balance between effectiveness/efficiency and input/process/output?
- Have you identified the types of the measures you want to collect and have a balance between effectiveness/efficiency and input/process/output?
- Have you made a clear reasonable choice between gathering new data and taking the advantage of existing data collected in the organization?
- Have you tested your operational definitions with others to ensure their clarity and consistent interpretation?
- Have you clarified the stratification factors you need to identify to facilitate analysis of you data?
- Have you developed and tested data collection forms or check sheets which are easy to use and provide consistent and complete data?
- Have you identified an appropriate sample size, group quantity and sampling frequency to ensure valid representation of process?
- Have you prepared and tested the measurement system, including training of collectors and assessment of data collection stability?
- Have you used data to prepare the baseline process performance measures, including promotion defective and yield?

iii. Analysis Phase

- Have you examined the process and identified potential bottlenecks, disconnect and redundancies that could contribute to the problem?

- Have you conducted a value and a cycle time analysis locating areas where time and resources are devoted to tasks not critical to customer?
- Have you analyzed data about the process and its performance to help stratify the problem, understand reasons for variation in the process and identify potential root causes?
- Have you evaluated whether our project should focus on process design or redesign, as opposed to process improvement and confirmed our decision with the project sponsor?
- For process improvement, does developed root cause hypotheses to explain the problem we're solving?
- Have you investigated and verified your root cause hypotheses so that you are confident that you have uncovered one or more "vital few" root causes that create our problem?
- Do you need a special metric which is convenient to you case?
- Have you found the source of variation?
- Is software being used enough for the analysis?

iv. Improve Phase

- Have you created list of innovative ideas for potential solutions?
- Have you used screening techniques to further develop and qualify potential solutions?
- Have you created a "solution statement" for at least two possible proposed improvements?
- Have you made a final choice of our solution based on success criteria?
- Have you verified your solutions with your sponsor and received buy-in and go-ahead?
- Have you developed a plan piloting and lasting the solution including a pilot strategy, action plan, result assessment, schedule etc..?
- Have you evaluated results and confirmed that we can achieve the results defined in our Goal statement?

- Have you identified and implemented refinements to the solution?
- Have you created and put in a place a plan to expand the solution with refinements-in a full implementation?
- Have you considered potential problems and unintended consequences of the solution and developed preventive and contingent actions to address them?

v. Control Phase

- Have you compiled results data confirming that your improvement design has achieved the Goal defined in our DMAIC team charter?
- Have you selected ongoing measures to monitor performance of the process and continued effectiveness of our solution/design?
- Have you determined key charts/graphs for a "process dashboard"?
- Have you prepared all essential documentation of the revised process including key procedures and process maps?
- Have you identified an "owner" of the process who will take over responsibility for our solution/design and for managing continuing operations?
- Have you developed (with the process owner) process management charts detailing requirements, measures and responses to problems in the process?
- Have you updated storyboard documenting the team's work to date and key learnings?
- Have you forwarded to senior management other issues or opportunities which we were not able to address?

2.4 Results

Finally, the last part corresponds to gather the fruits of the whole program. In here, some critical issues must be done in order to realize if all the effort achieve the expectative. This part should be carried out continuously, for example after a predetermined group of projects are finished, so an outlook of the performance can be made up.

Important issues in here are corroborating the complete use of mechanism around the life-cycle like the correct and effective use of communication channels, successful use of Six Sigma tool previously define, active participation of people with a high level of commitment, punctuality among others. As in the others stages, the complete list of critical successful factors can be extracted from the questions.

- Are the managers, executives and low-level workers aligned with the methodology?
- Did team members meet and review the project as needed?
- Are the communication channels working smoothly?
- Did the teams use efficiently Six Sigma tools?
- Did you do any meeting without feedback?
- Did the project delivered meet the anticipated results?
- Is project finished time coherent to the one determined in the beginning?
- Are the results reciprocating on the KPI/CTQ established?
- Are the improvements easy to adopt by the process owner?
- Do results replicate over time?
- Does the project sustain over time?
- Did you cover the lost time, money?
- Have you celebrated the hard work and successful efforts of the team?

3. Assessing the checklist

Now, with the checklist put together (a sample formatted of the checklist can be found in appendix A) the next step is to proposed how the company can get a "yes" in all the questions. Accordingly to the format of the checklist the assessment of the checklist continue the same structure.

3.2 Assessing the readiness

The proposal for the assessment of the readiness is made of 5 steps as can be seen in the figure 19. If a company can fulfill or is already using these steps is very likely to be ready for Six Sigma implementation. In figure 20 is shown some important factors inside of each step.

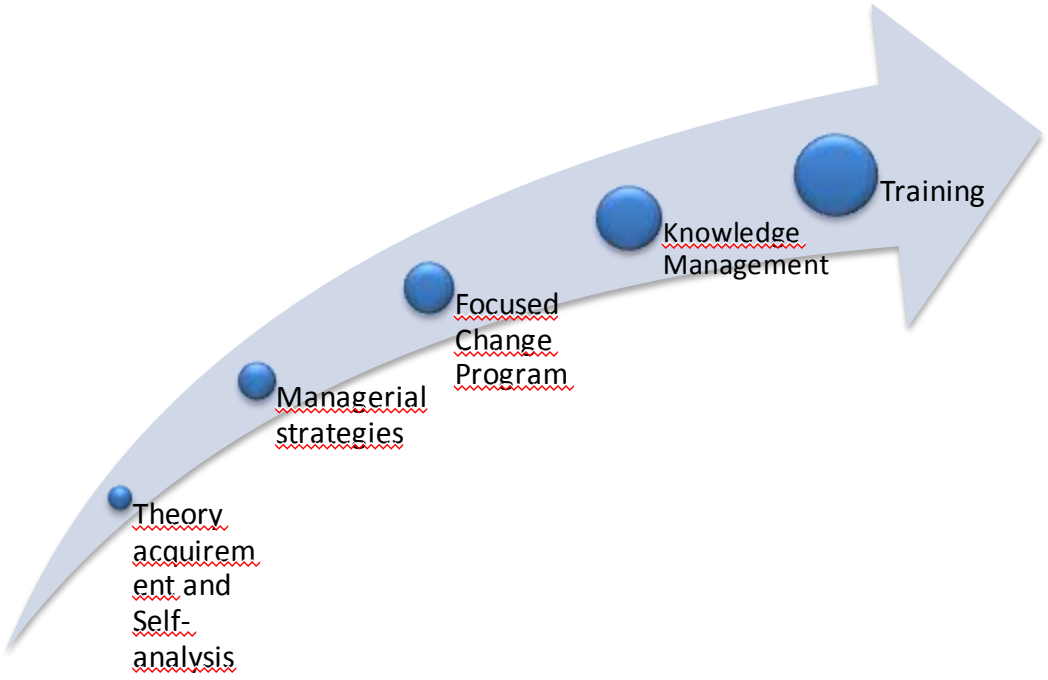


Figure 19: Assessing readiness.

From figure 20 it is not difficult to understand that getting ready for Six Sigma implementation is not an easy task, but is not impossible either. The steps and subtask are a set of management theories that are no longer only on books, instead is necessary to apply them to keep competitive. However, these steps are not something new, for example, using ICT as the engine and the frame of communication.

Even though, some companies might see this proposal very challenging due several factors like elderly of the structure and personnel, which means that a single structure have been used for a long time generating a dependence and a rigidity of processes in the employee that have been working there for many years. However, achieving that challenge will open the possibility to more options for current and future situation that environment can bring.

It is important to notice that some of this steps, like training, need to anticipate as accurate as possible the short and medium-term needs of the company. This because usually this kind of activities are time and resource consuming, which means that they can be easily affected by a shortage of any kind, in other words, trying to save, both resource and time, the company persuade to train as less people as possible and during the shorter time as possible; this might sound reasonable because the possibility of save in tangibles is easily notice, but this also might bring deficits in the benefits in the medium term and induce more losses in money than those that were saved before, and trying to correct this mistake must put in risk the whole implementation process and previous effort.

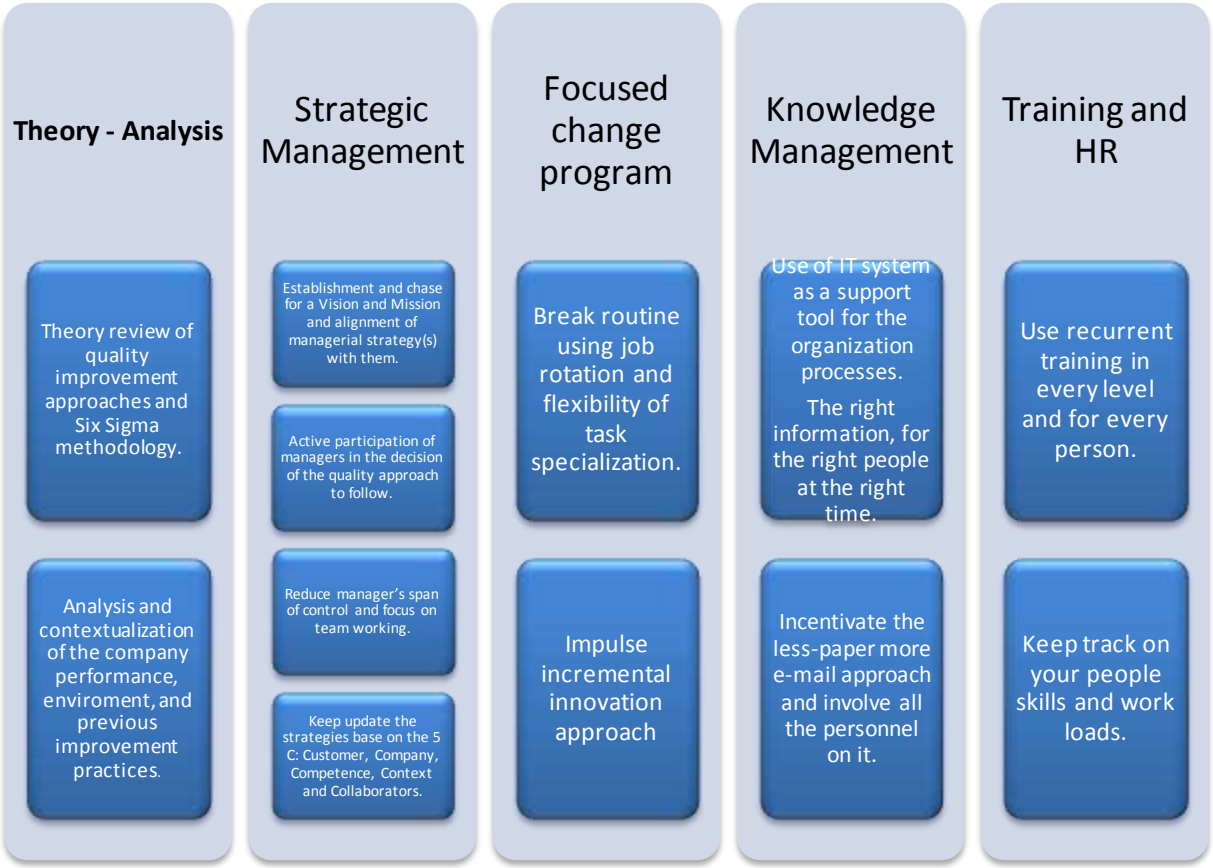


Figure 20: Details on assessing readiness model

3.3 Assessing the implementation

The procedure to guarantee a successful implementation of Six Sigma projects is easy to follow. The figure 21 is an adaptation of the implementation model of (CHAKRAVORTY, 2009). On this set of steps can be seen a high dependency with the performance of the readiness part. For example, the first step, perform strategic analysis, can be redundat if the management strategies are working as they should and the needed information to begin the implementation might be already gathered. The customer and market are not something that a company needs to do for six sigma implementation but for the every day survival.

The second and third steps are related to the training and HR in the readiness. Choosing improvement tools from those that have been trained to use and keep in mind the amount of people that is trained and available to engage new projects.

The last step is in charge of keeping track to all the projects and need to work as a close loop with the result checklist in order to introduce the feedback receive in that section.

Figure 21: Assessing implementation phase. (Adapted from CHAKRAVORTY, 2009)

3.4 Assessing the execution

The execution part in the checklist enjoy of the largest number of questions. However, we don't have a specific model to fulfill the checklist but a series of suggestion. All this, because several models to build up successful executions can be easily find on the literature and there is no-sense to add one more.

However, the following suggestion may be useful when choosing a performance practice:

- The key ingredient for a good execution is a good training in good people.
- There are several training options on the market but there is no standard about the content of the course given. In fact, there are some training companies that customize the training set according to the customer necessities and this is the best option if you don't want to handle the training by yourself. Using this option you can assure a standard training for all your employees.
- Train your people with the tools that you are going to use and enhance the skills that you need.
- It is important to keep a number of belts for each level so their workload is not so low and not so high. The number or the relation of champions, black and green belts is a big deal, however is not the aim of this study but is highly suggested to keep yourself update on this and corroborate the performance of your people.
- The checklist for the execution gives you critical successful factors for achieve your goals, analyze them and be sure to add them in your training courses.
- Develop standard formats for the milestones, meetings and phases, but keep the number as minimum as possible. Remember to use ICT support to follow the advances and retrieve the feedback. When using both, standard guidelines/formats and ICT, everyone in the company can keep update about other projects and can easily update theirs, and for the executives is much easier to gather the information of overall performance.

3.5 Assessing the results

Finally, to assess the result part of the checklist it is proposed a small model of 4 steps and you can see in the figure 22. This model is very easy to follow and automatize if the ICT tools are available (they should be) and is also very related to the last step of the implementation model. The 4 steps are aimed to realize if the projects are getting the expected results and presenting the feedback resulting of the execution, thus, is needed to gather all the information about singles projects and converge them into one.

To measure if the initiative is successful, the projects results must reciprocate into CTQ and KPI previously determinate. Then, it is important to do both, assure that the improvement are sustained over time, meaning the process owner has actually, implemented the improvements and communicate and celebrate the results with all the employees; in this way, the morale can be enhance and commitment will increase.

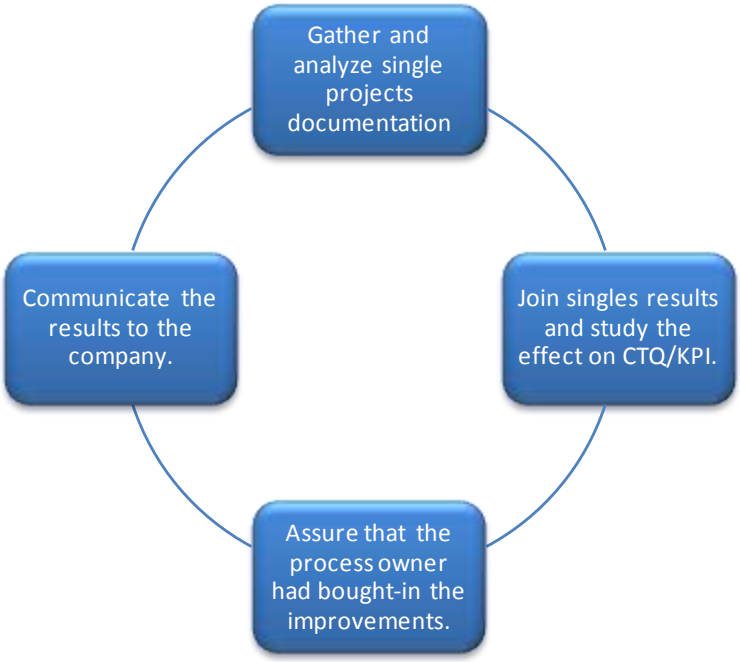


Figure 22: Assessing the results phase

IV. Framework Review and review analysis

1. Checklist review through study cases

As it was mentioned in the beginning, the aim of this work is to come up with a checklist which can be used by the Six Sigma initiatives as a guideline. During the preparation of the questions in the checklist, it is really significant to determine which questions should be asked and in which order according to their sequence in the process.

However, since it is decided to be applied among all Six Sigma initiatives, the questions should meet all the steps, in the other words, it should be a complete checklist.

In order to have an idea, to understand the concept, chemical sector was preferred to focus in which a lot of Six Sigma projects have been done. Three companies were chosen; Viracon, Dupont and Dow Chemicals. By considering these three companies and their specific projects mentioned below, the purpose was to prepare the checklist by catching the mutual points, underlining the specific cases and their solutions including the methods.

1.1 Viracon

Viracon is a company which works in the glass business. The case of this business is about the silicon filling which has a big impact on the glass fabrication. If the silicon filling is not clean enough, that problem may cause three main problems;

- Glass units will not adhere together as designed.
- Air filtration may ensue.
- Structural integrity may be compromised.

In this business case, the company wanted to know if Six Sigma would make any difference in their process. They tried to understand The Six Sigma methodology and how it differs itself from what they have always done. They inquired whether Six Sigma is a

temporary method for them to overcome the problems or it is a cultural change. It is also emphasized how important to choose the right tool and proper application. At the end, the question was if all those improvements are realized by their customer.

First, the problem definition is the key step of the Six Sigma projects. The problem was defined with all the aspects and the statement was tried to change from a problem to an opportunity.

Then, team was determined; how many people included, from which part of the organizations. It is quite significant, people's qualification working within the team, their technical knowledge and abilities are adequate to run the project and the team was formed by taking into consideration all these items.

In the further parts, the Six Sigma tools applied properly. First IPO (Input, Process, output) Model applied to see the whole frame with the factors which have a probability to cause the problem. Following, fishbone, process flow and value stream mapping were done.

After understanding the process in detail, the next step was to collect data. All the defects by quantity were collected in each process and then presented as a graph. Maximum defect quantity had been sourced from cleanliness which also can be seen in pareto diagram.

Then, they tried to figure out where the source of variation is.

Regarding to the all information collected and analysis done through the models, the first DOE and saw the responses. Statistical information was used to check mean, standard deviation, Cpk, USL, LSL...On the other hand, the process stability was evaluated so they could focus on more where periods have much variance and the noise comes from.

After nine years with the same application, the improvements were done. The new settings are supposed to reduce the variation. Then, the second DEO was done to complete the first group improvements. At the end of the project, the situation before and after Six Sigma was compared and as a result;

- The standard deviation decreased from 0.091814 to 0.021181

- Sigma level increased from 1.0377 to 4.3059

With the new settings, again the sustainability was checked in terms of hours, days, and months.

In this business case, the importance of all these are underlined;

- The definition of the problem,
- The selection of people to work in the team according to the their qualifications,
- Six Sigma methodology and its differences from others,
- Cultural change,
- The proper usage of the tools,
- Data collection and its analysis,
- The control of system's stability,
- Statistical information to check the improvements,
- The control of sustainability of improvements.

1.2 Dupont

Dupont's business case is about the sustainability in terms of the reduction in waste and emission from the operations being done in the factory. Like many manufacturing companies, company grows by making more and more stuffs which has been proportional to the amount of raw materials and energy used. This means that day by day, it causes more pollution.

Instead of believing zero-sum mentality, the company believes that if they can use creativity and scientific knowledge effectively, they are able to provide a strong return for their shareholders and grow their business- all while meeting the human needs of societies around the world and reducing the environmental footprints of our operations and products.

The company will follow environmental and social benefits but the underlying rationale, which must always remain in focus, is that in the global economy, sustainability will generate tremendous economic value.

In order to meet all these needs, the company developed a three-pronged strategy focused on integrated science, knowledge intensity and productivity improvement. Then they devised a new way to measure their progress quantitatively so that they would not have to rely on qualitative or anecdotal method.

Although the company was far from achieving sustainable growth, they have been successful in pushing the understanding, the acceptance and the application of Six Sigma Project by doing it deeply into their business operations, making it a comprehensive way for Dupont to do business. Dupont has set various stretch goals for 2010, including a reduction of greenhouse gas emissions by two-thirds while holding their energy use flat (using 1990 as a base year). They also plan to increase their use of renewable resources to 10% of their global energy needs.

Three-pronged Strategy

i. **Integrated science*;*** by the combination of physics and chemistry to create new materials.
ii. **Knowledge intensity*;*** their objectives are to develop less material-intensive means of creating economic value and to place greater emphasis on using technology, knowhow and information systems to manage the creation of material value more sustainability.
iii. **Productivity improvement;** they have adopted Six Sigma methodology, a stringent approach that strives to reduce manufacturing defects to just several per million. At the end of last year, they had 1,100 black belts and 1,700 green belts working on 4,200 projects.

In one of the case of Dupont was able to increase production rate of its plant in Buffalo, New York by 10% without any capital investments. The result is $26 million in

additional revenue last year. Maybe, for the first time, this number might not seem huge for a company with $ 30 billion in sales but Dupont has thousands of such projects and they are adding 200 new ones each month. Although, their projects using Six Sigma methodology are responsible for savings of more than $1 billion a year , and these efforts to improve productivity invariable result in less waste, both in energy and raw material.

After they implemented three pronged strategy, there is a new way needed to quantify whether their business were becoming more sustainable. They developed a new metric which they customized for Dupont called "shareholder value added per pound of production" or SVA/lb. SVA; as the shareholder value created above the cost of capital which is 10% to 12%for corporations in the United States. The higher the SVA/lb.the greater knowledge intensity in creating economic value.

In Dupont case, the importance of all these items is emphasized;

- The clear definition of goal,
- The understanding and the acceptance of Six Sigma,
- The importance of Six Sigma and its place in their strategy,
- The number of Black Belts and Green Belts in the organization and their adequacy to run Six Sigma Projects,
- The number of the projects that they have done monthly, which shows magnitude of Six Sigma within the company,
- The savings through Six Sigma Projects,
- Development of a new metric on their own which is needed to control the sustainability in Six Sigma Project.

1.3 Dow Chemicals

The Dow Chemical Company is a leading science and technology company that provides innovative chemical, plastic and agricultural products and services to many essential consumer markets. In 1998 Dow chose to implement Six Sigma methodology to accelerate the company's rate of improvement in quality and productivity. A trial of Six Sigma in two of Dow's global businesses convinced management that the value proposition was well worth the effort, and in September 1999 the company launched a corporate-wide program to incorporate the Six Sigma methodology into all of its businesses and functions.

The company's 1999 annual report stated that by the end of 2003, Dow expected its Six Sigma implementation to deliver revenue growth, cost reductions, and asset utilization totaling $1.5 billion in earnings before interest and taxes (EBIT). At the close of 2002, Dow achieved its $1.5 billion cumulative financial goal—a full year ahead of schedule.

This case is about four projects and their results which have been done at Dow facilities in Texas and Lousiana;

- Stream trap Improvement
- Polycarbonate Unit Energy Reduction
- Styrene Unit Energy Envelope
- Angus Site Energy Reduction

For each project, the problem was defined clearly for Six Sigma implementation to improve product quality and energy performance. Then DMAIC method was done for all the projects and given by detail. After doing all improvements and controls, all four projects realized savings as a result of the Six Sigma process implementation. Key cost savings identified by four projects are as follows;

- *Steam Trap Improvement Project:* $220,000 savings to date in the first year.

- *Polycarbonate Unit Energy Reduction Project:* $240,000 savings to date. Savings expected to reach $500,000 per year.
- *Styrene Unit Energy Envelope Project:* 80 MMBtu per hour energy reduction.
- *Angus Site Energy Reduction Project:* $474,000 savings to date. Savings expected to
  reach $600,000 per year.

What Dow Business case added our checklist are the following;

- The importance of clear identification of problem statement,
- The importance of DMAIC method in Six Sigma application,
- DMAIC application method in detail and its usage,
- How big amount of money companies save money in cost through Six Sigma methodology.

2. Checklist review through experts

2.1. Expert presentation - Ekoten Textile A.S.

Ekoten Textile is the biggest and the most prestigious knitted fabric manufacturer in Turkey. The company belongs to Sun Group which was the export champion of Turkey in 2009. It is among the biggest five hundred industrial corporations (ISO 500) declared by Istanbul Chamber of Industry. (http://www.ekoten.com.tr)

Ekoten Textile, is one of the important suppliers of leading brands in the world such as M&S, NEXT, BENETTON, MIROGLIO, DECATHLON; and the company continuously invests in human resources in order for product development and for increasing the quality and efficiency.

The company is located in Torbalı/Izmir which is a big industrial area since 2000 and they have 356 employers. In 2005, they started to implement Six Sigma Methodology

in order to improve their production system. All the certificates and training programs were given by Matris Consultancy (http://www.matrisas.com). Currently, there is one Champion who is the General Manager of the company, one Master Black Belt as a Six Sigma Project Coordinator. There are eight black belts and from these, two of them are working full time. On the other hand, there are 4 green belts and moreover, there are five people attending to green belt training program.

Until now, Ekoten has twenty two black belt projects, fifteen green belt projects and some improvement projects for short term. As a consequence, all those projects saved 600.000€ at the end of 2008.

The champion is Aydin OZTURK, as mentioned before, who is the general manager of Ekoten textile. He is a textile engineer graduated from Ege University/Izmir in 1995. He had his champion certificate in 2006 by Matris Consultancy.

The other person who contributed our thesis by giving the feedback is Deniz KOKSAL. She graduated from chemistry department in 1996 and completed her education by the Master in textile engineering department. Currently, she is the master black belt and six sigma project coordinator of the company. She also got her Master Black Belt certificate in 1996 by the same consultancy.

2.2.Review details and analysis

In the third chapter, the whole checklist is given which can help companies to walk through their ways to success. We tried to catch all key points that have an important impact on the projects in terms of performance. However, the checklist was prepared by using the theoretical perspective that's why it was sent to Mr. Ozturk who is the champion and also general manager of EKOTEN TEXTILE A.S./ TURKEY to verify and see how successful it is in practice.

Regarding to the feedback that we received, it is declared that this framework is completed enough, applicable and prepared by taking into account many aspects of a Six Sigma initiatives. In additional, he emphasized some points being checked first in the company, which are extremely important for sustainable success. Those items may differ from one company to another in terms of priority. According to the points, we wanted to improve the checklist but since the questions related to these suggestions, have already taken a part in the checklist, new questions weren't added. The number of the related questions to the feedback in the checklist is shown in parenthesis. These were mentioned below.

The educational level of the organization is quite crucial that's why all managers working (low-mid-high level or from foremen to tech directors) in technical departments must have enough education on Six Sigma. It is suggested that the managers from mid-level to high must be black belt and the foremen and shift managers, etc... should be green belt. (*Readiness; 3.2 /7.1 /7.2 Implementation; 2)*

Even though, people working in Six Sigma organization are well educated, this is not enough merely and it still needs support of top management. They should endorse the team and believe the projects and theirs expected successes and benefits. (*Readiness; 3.1/3.2/3.3/3.4 Implementation; 1 Results; 1)*

In order to run a successful project, there should be enough number of *Full-time Black* and *Green Belt* who are only responsible for the projects. After working like two or three years as full-time technicians and engineers, they can work as managers in the mill by the experience gained during those years. (*Readiness; 2.3/3.2/9.1/9.2 Implementation; 3)*

Within the organization, there must be at least one Master Black Belt who is in charge of helping the teams to work with proper methodology. (*Readiness; 9.1/9.2)*

The management should be informed about the projects periodically by presenting the project status thus it is easier also to keep people motivated. (*Readiness; 3.2/ 9.1 Results; 2)*

SPC and other main tools of Six Sigma Methodology must be used in the daily life of production. They should be applied practically and shouldn't remain as a theoretical knowledge. (*Implementation; 8 Execution; 2.1 Results; 4/5)*

It is significant to understand that Six Sigma is a methodology whose aim is to improve the process and not to make the system more difficult by bringing obstacles. If the project will not solve any problem, it is meaningless to analyze it, if it will not be analyzed; it doesn't make sense to gather the data so unnecessary data collecting should be stopped immediately. *(Execution; 2.2/2.3/2.4/2.6/2.9/2.10/2.11/2.12)*

Sometimes, because of the inefficient tools or systems used in the projects, the solution is not sustainable even though the problem has been solved. That problem pushes people to go back to the previous case which creates many difficulties. That's the reason how important to choose the right tools during the projects. (*Implementation; 8 Execution 1.3/2.1/3.9/4.2 Results; 4)*

Another important tool is FMEA (Failure Mode and Effect Analysis) which is considerable in the development phase. It is used to prevent the potential problems before they occur. (*Implementation; 8 Results;4)*

As a result, the feedback focus on two different aspects; organizational and methods used for the Six Sigma projects. Six Sigma can improve the bottom line of an organization if implemented wisely. An organization can get more with less using Six Sigma; for example, it can use fewer runs and samples and obtain more information. However, if the techniques are not used wisely, there is a considerable danger that the program will be counterproductive and frustrating. Organizations can sometimes get so involved in how to count and report defects that they lose sight of the real value of Six Sigma-orchestrating process improvement and reengineering in such a way that they achieve significant bottom-line benefits through the implementation of statistical techniques. Six Sigma efforts need to be orchestrated toward achieving Smarter Solutions (Smarter Solutions, Smarter Six Sigma Solutions, and S4 are service marks belonging to ForrestW. Breyfogle III).

On the other hand, people working within the team, take a big responsibility on the performance of the Six Sigma projects so organizational part is a big deal for initiatives. They need to complete their performance with the Six Sigma training program and be supported by the top management.

V. Conclusions and suggestions

Since Six Sigma is taking its place in the companies in an unavoidable way and its awareness is becoming more and more popular day by day, the companies will try to do their best to reach a higher sigma level. In order to do it, they are trying to improve their systems by doing many projects on weak parts of their systems. That's one of the reason, why companies are focused on the improvement projects and their assessments at the end to see how successful they are. By this reason, this work is done by the aim to assist companies in terms of their self-assessments of their projects and to company them as a guideline on their way which ends by success. During the chapters of this study were highlighted two ideas: the increasingly number of failing Six Sigma implementation and the lack of a standard framework which support the initiatives.

The critical successful factors for the Six Sigma methodology are mentioned and also, the reasons of why many initiatives are not reaching a happy end. Both perspectives are reflected in the proposed checklist in which, the general model follows 4 steps: readiness, implementation, execution and results. it is emphasized that having a good organization, the best training program or being able to finance everything are not enough individually . As a consequence, many conditions should be available together to come up with a project by expected results.

The presented framework is expressed in a single but comprehensive checklist, and can be count as one of the first attempts of the academia to bring together particular efforts under the same umbrella. In addition, it is suggested to follow simple's steps to assure the assessment of the checklist smoothly. Thus, the reader can find both, the self-assessment evaluation and the route to achieve it.

This research was done on empirical basis with an initial review from two intended users. The review show a positive response about the checklist, however, it brings up an important point, the fact that users would like to or are tempted to put more effort in some topics than others; this is not wrong, it matter of subjectivity and highly depend on the

environment; nevertheless, the correct accomplishment of all topics, in one way or another, is the real critical factor for successfulness.

For further studies that may came out after this, it is suggested to go for a sample application of the checklist and have more in detail critique that can proportionate more feedback about the checklist. In addition, execution this checklist in parallel to a new Six Sigma program in a company is necessary.

It is also recommended to aware companies that explicitly require guideline for executing Six Sigma programs of the existence of this study, in order to break the wall between practitioners and academicians and in that way, help to put in practice this idea aiding practitioners to improve their performance.

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Appendix

Appendix I: A checklist to evaluate the performance in Six Sigma initiatives.

A CHECKLIST TO EVALUATE THE PERFORMANCE IN SIX SIGMA INITIATIVES

Description: This checklist is a tool for the Six Sigma initiative owner aiming to help to reduce the successfulness uncertainty by describing step-by-step what you might have done based on critical successful factors of best practices and theory background. The procedure is simply to answer yes/no question which honestly response will highlight strength and weaknesses in your road to achieve your objectives.

The checklist is divided in 4 parts which must be accomplished in the order establish. Each part reveals issues that are highly suggested to be accomplished before going further and each question belong to a set of topics that need to be covered to easy the procedure and increase the performance during the life-cycle of the initiative.

Objectives:

- To increase the successfulness rate of Six Sigma projects.
- To enhance the implementation's performance of Six Sigma initiative.
- To set a theoretical and practical awareness of critical successful factors.
- To self-evaluate your knowledge and background in quality improvement approaches.

Instructions:

- Answer honestly and consciously each one of the question.
- Follow strictly the question sequence.
- Self-evaluate after you finish each part and take actions to enhance your performance.
- The execution checklist (part 3) is aimed to be answered by project owners and be collected and analyzed by the initiative owner.

Notes:

- All the question have the same weight.
- It is a timeless tool.
- This is a self-evaluation tool.

If you answer NO in any question(s), it doesn't mean you are going to fail, but it is necessary to focus your effort to improve the issue and assure better performance. If you answered everything YES, it does not mean you will success in your Six Sigma initiative but you are enjoying a high performance rate and are most likely to achieve your goals.

I. READINESS

If you answer ***YES*** in all the following question, please continue with the next chapter. You are doing well. Otherwise please read the suggestions that you can find after the questions.

1. Full understanding	YES	NO
1.1. Has the company been involved in a Quality Approaches?	☐	☐
1.2. Did the company get the expected results?	☐	☐
1.3. Did the company standardize the improvement?	☐	☐
1.4. Does the company understand Six Sigma as an approach to reduce process variation with strong focus on customer satisfaction?	☐	☐
1.5. Do you think Six Sigma methodology will bring more success than the others?	☐	☐

If you answered NO in the question 1.1:

- It is highly suggested to review the different options in quality improvement approaches. It is possible that Six Sigma is not the right tool for you now. However, if you are convince to go further please continue answering the checklist.

If you answered NO in the question 1.2:

- It is recommended to execute a depth analysis about why the previous or current quality improvement approach didn't get the expected results making sure that both, they won't happen in the Six Sigma initiative and Six Sigma is able to get the expected results.

If you answered NO in the question 1.3:

- It is highly proposed before going further, to review extensively and in depth the theory behind Six Sigma.

If you answered NO in the question 1.4:

- It is highly advice before going further, to review extensively and in depth the theory behind Six Sigma. If you don't believe in the methodology it is probable that the initiative will fail.

2. Management Commitment	**YES**	**NO**
2.1. Are the managers focused more on certification than company and project results?	☐	☐
2.2. Does the upper and medium level managers fully commit and able to set aside resources and time to carry out and support Six Sigma projects?	☐	☐
2.3. Are the best people of your company aware of the objectives, procedures, benefits and commitment needed to carry out Six Sigma projects?	☐	☐
2.4. Does the executive level know that its support is more important than the one coming from financial resources?	☐	☐
3. *Cultural Change*	**YES**	**NO**
3.1. Is the actual company culture able to receive mindset and procedural changes?	☐	☐
3.2. Is your organization structure able to change in the short term?	☐	☐
4. *Communication*	**YES**	**NO**
4.1. Does the company count with effective and efficient communication channels both, vertically and horizontally, within the organization?	☐	☐
5. *Organizational Structure*	**YES**	**NO**
5.1. Is the organizational structure apt to support a major change in the way it operates?	☐	☐
5.2. Can the organization work independently and cross-functional?	☐	☐
6. *Training*	**YES**	**NO**
6.1. Is the company ready to train the best people in order to lead and carry out Six Sigma projects?	☐	☐
6.2. Has the company found out a training program according to its necessities?	☐	☐

8. Link to the Strategic Imperatives	YES	NO
8.1. Are customer satisfaction surveys carried our regularly?	☐	☐
8.2. Are results from the survey used to guide further quality improvements?	☐	☐
8.3. Does the company understand Six Sigma as an approach based on statistical thinking and linked to key business processes?	☐	☐
8.4. Does the company have cleared the KPI/CTQ to measure and how to measure them?	☐	☐
8.5. Does the company know how to prioritize projects based on business processes and customer satisfaction?	☐	☐

9. Project Management Skills	YES	NO
9.1. Does the company count with people able to lead inter-department projects?	☐	☐
9.2. Is the number of team members available to run the projects?	☐	☐

10. Resource Availability	YES	NO
10.1. Does the company have the resources to support the Six Sigma Initiative?	☐	☐

II. IMPLEMENTATION

If you answer ***YES*** in all the following question, please continue with the next chapter. You are doing well.	**YES**	**NO**
1. Is there an active sponsorship engagement?	☐	☐
2. Do you have enough belt-people trained to carry out the projects?	☐	☐
3. Is there a broad organizational awareness of the Six Sigma initiative and benefits?	☐	☐
4. Have the company created high-level cross- functional teams to drive improvement initiatives?	☐	☐
5. Does the teams carried out a strategic analysis based on customer and market?	☐	☐
6. Does the team link the strategic analysis with the company business processes?	☐	☐
7. Does the team construct a high-level process mapping and identified on it, the improvement opportunities?	☐	☐
8. Does the team prioritize improvement projects and carried out a project sequence in order to assure key performance processes improvements, including CTQ and financial factors?	☐	☐
9. Are the improvement tools identified?	☐	☐
10. Have the company form low-level improvement teams for execute the improvement projects?	☐	☐
11. Is there a detail plan for low level improvement teams?	☐	☐

III. EXECUTION

1. Define Phase	YES	NO
1.1. Are the CTQ and KPI of the process identified?	☐	☐
1.2. Have you prepared team charter and work plan?	☐	☐
1.3. Have you prepared the high level process map?	☐	☐
1.4. Have you defined the problem/opportunity statement?	☐	☐
1.5. Have you defined the goal statement?	☐	☐
1.6. Were project scope, constraints and assumptions known by team members?	☐	☐
1.7. Have the important stakeholders been identified?	☐	☐
1.8. Do you have measurable customer requirements in the plan?	☐	☐
1.9. Has everyone reached consensus on team guidelines?	☐	☐
1.10. Have all the operational definitions been identified?	☐	☐

2. Measure Phase	YES	NO
2.1. Did you use six sigma tools?	☐	☐
2.2. Was the data gathered accurately?	☐	☐
2.3. Have you determined what you want to learn about the problem and process in where you want to get the answer?	☐	☐
2.4. Have you identified the types of the measures you want to collect and have a balance between effectiveness/efficiency and input/process/output?	☐	☐
2.5. Have you identified the types of the measures you want to collect and have a balance between effectiveness/efficiency and input/process/output?	☐	☐
2.6. Have you made a clear reasonable choice between gathering new data and taking the advantage of existing data collected in the organization?	☐	☐
2.7. Have you tested your operational definitions with others to ensure their clarity and consistent interpretation?	☐	☐
2.8. Have you clarified the stratification factors you need to identify to facilitate analysis of you data?	☐	☐

2.9. Have you developed and tested data collection forms or check sheets which are easy to use and provide consistent and complete data?	☐	☐
2.10. Have you identified an appropriate sample size, group quantity and sampling frequency to ensure valid representation of process?	☐	☐
2.11. Have you prepared and tested the measurement system, including training of collectors and assessment of data collection stability?	☐	☐
2.12. Have you used data to prepare the baseline process performance measures, including promotion defective and yield?	☐	☐
3. Analysis Phase	**YES**	**NO**
3.1. Have you examined the process and identified potential bottlenecks, disconnect and redundancies that could contribute to the problem?	☐	☐
3.2. Have you conducted a value and a cycle time analysis locating areas where time and resources are devoted to tasks not critical to customer?	☐	☐
3.3. Have you analyzed data about the process and its performance to help stratify the problem, understand reasons for variation in the process and identify potential root causes?	☐	☐
3.4. Have you evaluated whether our project should focus on process design or redesign, as opposed to process improvement and confirmed our decision with the project sponsor?	☐	☐
3.5. For process improvement, does developed root cause hypotheses to explain the problem we're solving?	☐	☐
3.6. Have you investigated and verified your root cause hypotheses so that you are confident that you have uncovered one or more ''vital few'' root causes that create our problem?	☐	☐
3.7. Do you need a special metric which is convenient to you case?	☐	☐
3.8. Have you found the source of variation?	☐	☐
3.9. Is software being used enough for the analysis?	☐	☐

4. Improve Phase	YES	NO
4.1. Have you created list of innovative ideas for potential solutions?	☐	☐
4.2. Have you used screening techniques to further develop and qualify potential solutions?	☐	☐
4.3. Have you created a ''solution statement'' for at least two possible proposed improvements?	☐	☐
4.4. Have you made a final choice of our solution based on success criteria?	☐	☐
4.5. Have you verified your solutions with your sponsor and received buy-in and go-ahead?	☐	☐
4.6. Have you developed a plan piloting and lasting the solution including a pilot strategy, action plan, result assessment, schedule etc..?	☐	☐
4.7. Have you evaluated results and confirmed that we can achieve the results defined in our Goal statement?	☐	☐
4.8. Have you identified and implemented refinements to the solution?	☐	☐
4.9. Have you created and put in a place a plan to expand the solution with refinements-in a full implementation?	☐	☐
4.10. Have you considered potential problems and unintended consequences of the solution and developed preventive and contingent actions to address them?	☐	☐
4.11. Have you updated storyboard documenting the team's work to date and key learning's?	☐	☐
4.12. Have you forwarded to senior management other issues or opportunities which we were not able to address?	☐	☐

IV. Results

If you answer ***YES*** in all the following question, please continue with the next chapter. You are doing well.	YES	NO
1. Are the managers, executives and low-level workers aligned with the methodology?	☐	☐
2. Did team members meet and review the project as needed?	☐	☐
3. Are the communication channels working smoothly?	☐	☐
4. Did the teams use efficiently Six Sigma tools?	☐	☐
5. Did you do any meeting without feedback?	☐	☐
6. Did the project delivered meet the anticipated results?	☐	☐
7. Is project finished time coherent to the one determined in the beginning?	☐	☐
8. Are the results reciprocating on the KPI/CTQ established?	☐	☐
9. Are the improvements easy to adopt by the process owner?	☐	☐
10. Do results replicate over time?	☐	☐
11. Does the project sustain over time?	☐	☐
12. Did you cover the lost time, money?	☐	☐
13. Have you celebrated the hard work and successful efforts of the team?	☐	☐