Six Sigma in Project Management
Implementation of Six Sigma at Klesman Electric

Gizem Şebnem Sunal
Evangelia Evangeliou

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Abstract

In the business world the competition market and economical struggle have been increasing day by day, due to the time management established and continuously improved in communication a unique market focused on satisfying the changing customer needs for all types of processes is being created.

What the customers understand in terms of the suitable product anymore is the one which can adopt the changes in time easily, can be purchased at a competitive price and satisfy their needs. At this point in the competitive market created, all the responsible who take place in the supply chain should manage all the processes at a more detailed and controllable level and perceive all the improvement studies as a new project of these processes.

All the problems related with the government in terms of society, law or economics, all the improvement studies that needs to be performed are actually projects that should be completed from the very bottom to the top just as it is for companies which are also small societies. The one and only way of providing constant solutions passes through creating projects for which the specifications, current structure, objectives and the possible innovations have been well determined, the steps to be taken and the responsible to manage those have been identified and the actions related with the project have been scheduled. When we take a look at the developed countries for today’s world we see that they have overcome the economical war through industrial actions and have become countries that own successful companies leading the world market with the brands they have created.

Through this research it has been aimed to be able to provide information about the description and application algorithm of the worldwide project management philosophy. This is accomplished with the description of a project management tool which is six sigma in a market leading company.
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Evangelia Evangeliou

Gizem Sebnem Sunal

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Chapter 1

Introduction

In the globalizing world if there is a case now, it is the concept that in the removed borders people all over the world are an existing customer and a new market. There is a ruthless confusion in the sectors with increasing competition from day to day. Because there is a customer market with different cultures and different societies who wants more in cheaper price. Hence the companies need to satisfy customer needs and adapt to changes every day. Today companies seek to solve problems by a permanent method in order to provide improvements for their products. This can be done only taking every event as a project and concluding them with a known project management technique by analyzing deeply, showing the reasons of past problems and preventing new ones.

Today when we look at any sector we can see that profit margins fall to very low levels due to increased competition in the market. The only solution is to reduce the product cost. To increase the profitability of the current selling price or to increase the market rate by discounting in this price is targeted. In order to reach targets the product cost can be reduced by taking all steps as a process, identifying all problems with a project management technique, and solving them properly. At this point the chosen engineering method is very important. In other words, to look at every case in the perspective of project, choose the right engineering method and get a solution using mathematics and statistics brings permanent success.

A company success can be defined its projects which are done on time and within the budget and goals. The profitability and productivity of a company increase with an effective implementation of project management technique. Also the satisfaction of customers can be provided with project management. In order to meet customer needs new systems should be supplied and the project management is very important for that issue. Also Project management takes the responsibility of using the company’s budget effectively.

The solution of a case within the project management philosophy is to determine the different cases observed and to be improved chose the observation method, create and follow a calendar for that observation. Because of that we have several project management tools today. Companies choose the most suitable tool for their solutions in order to provide products with lower price and higher quality.
1.1 Scope of the Thesis

The scope of this project is basically to understand the project management and its benefits; Six Sigma Methodology and its importance for project management. For this reason a Six Sigma project from a Turkish company was investigated in this study. The case study can be summarized as; there is a product which nonconformity rate is above the target. So, the company lose money and time and also customer satisfaction rate is low. That means this problem creates risks to the company. As a result, they take it as a project and they use Six Sigma in order to solve this problem in order to reduce nonconformity rate and eliminate risks. After the completion of the project they increase the sigma value from 2.3 to 4.6 which means the rate of nonconformity decrease from %5.07 to %0.008. Considering this study it can be seen that how Six Sigma is important for a improvement process in the projects.

1.2 Research Question

To which extent Six Sigma can be a useful tool for the project management in order to reduce nonconformity rate and eliminate risks.

1.3 Research Methodology

The most appropriate methodology for this thesis is qualitative research as the collection of data is based on interviews and observations. In order to understand the data we collected we checked the initial assumption and discussed the major issues.

Qualitative research is mostly based on verbal things. So, the objective of this thesis is to qualify the data instead of to identify the data. In Silverman’s study (J. Jonsson, 2007), it is referred that interviews, observations, documents, photos e.t.c are the major sources for analysing qualitative data.

1.3.1 Interviews

One of the most important data gathering sources is Interviews. Interviews are taken place between two people at least, one of whom asks the questions and one or more who
answer them. There are many types of interviews. For this research structured and semi-structured interviews were used.

**Semi Structured Interviews**

Open questions were asked to the employees of the Quality Department of Klesman Company. They did not know the questions in advance. Also, the questions did not have any order, some of them could be removed if we judged that are not useful and some additional question could be added.

**Structured Interviews**

Most of the interviews were taken place face to face to the respondents. So, we had the opportunity to take notes, to discuss issues that we could not understand and make additional comments in order to understand the problem. These questions had given to the people of the quality department in advance in order to be enabling to prepare these answers.

**1.3.2 Observations**

In this thesis two types of Observations are used: direct observations and participating observations.

**Direct Observations**

In direct observations, the observer is not participating in the activities. The observations are made individually and independently. The observer is not a part of the system and the time for these observations is not too long. Some technological tools can be helpful in this kind of observation.

**Participating Observations**

In participating observations, the observer takes part in organization’s activities. He is a member of the organization and can collect data and information during the observations. The needed time is longer than this is needed in direct observations. In this case, the observer’s role is to make observations, and share thoughts with other employees.
1.4 Quality Assessment of the study

1.4.1 Reliability
Reliability of the study means how much reliable are the data and information we have collected for the completion of this research. (J. Johnsson 2007). In order to have a reliable research, we choose a case study that can be beneficial for future studies that want to have the same conclusion. The questions that were asked in interviews have been sent to the employees in advance in order to have time to think about their replies. So, we have the opportunity to take reliable and effective answers.

1.4.2 Validity
Validity of this research is accomplished by detailed planning and searching data and information especially via articles. For validity the interviewees had at least five year experience in the company. So, they had knowledge to reply the questions and give us the data that we needed. The summarized copy of the interviews discussions was sent to the Quality manager of the Klesman Company for validation. So, we tried to avoid misunderstandings. Also, the data that we included in the theoretical part of our thesis was from recent bibliography.

Chapter 1 (Introduction): In this chapter the introduction of this thesis and the research background are presented.

Chapter 2 (Project and Project Management): The second chapter defines the project and the characteristics of projects. The project management structure and algorithm were analyzed. Also project management areas, tools, project manager and his roles were mentioned theoretically.

Chapter 3 (Six Sigma Method): The second chapter covers the Six Sigma Method which is used all over the world today to improve the processes effectively and its utilization purposes.

Chapter 4 (Practical approach of Six Sigma): This chapter states a practical approach of Six Sigma. A Project of a big company in the energy sector is given with its initiation, improvement and conclusion parts which uses the Six Sigma to reduce problems.
Chapter 5 (Six Sigma in Project Management): Finally this chapter will answer to the most common question ‘How does Six Sigma relate to the Project Management’. In this part the differences between Project Management and Six Sigma will be explained and Six Sigma Process will be given according to PMBOK.

Chapter 6 (Conclusions): The conclusion of this thesis and recommendations for future research will be presented in this final chapter. The reader can understand how to test the theory in reality and how to make suggestions for future improvements.

Chapter 2

Project & Project Management

2.1 Definition of Project

People usually call all activities “a project”. The reason for this can be found by analyzing the etymologic of the word project. The word derives from the Latin word projectum and means "something thrown forward" [Encarta 2001, SAO 2001]. In order to describe what a project is, some different definitions will be referred.

PMI defines the project as a temporary endeavour undertaken to create a unique product or service” [PMBOK 2000].

By temporary, PMI defines that every project has a definite beginning and a definite end. The project ends when the project's goals have been fulfilled, or when it is obvious that the project's objectives will not or cannot be met. Temporary does not mean that the project has to be short in duration. In other words, the product created can be permanent.

Project Management Institute refers that a product or service can be unique if is different in some distinguishing way from all other products or services. For example, many malls have been developed, but each of them is unique to some degree. Each of them has different owner, different design, different location, different stakeholders and different
contractor. Of course some projects are more routine than others; some degree of customization is a characteristic of projects [Meredith & Mantel 1995], but the presence of repetitive elements does not change the fundamental uniqueness of the project work.

2.2 Why Project Management?

Project management plays an important role in the growth of a company. Since the early 1950s, it started to be pursued as a major discipline in the companies. It can be used widely in the fields of civil engineering, aerospace engineering and infrastructure development. Some of the advantages having a good project management team are the following.

Excellent product quality

Consumers look for low cost and high quality, while purchasing a product. Having a high standard of excellence in developing quality products can the company have a competitive advantage in the market. Six sigma training programs can help the project management team to improve the quality of the products. So, the main responsibility of the project managers is to contribute a lot in ensuring that the quality of products is consistently high.

Better communication

Bad communication among employees can create misunderstandings. This fact can have a negative impact in the growth of the company. In this case a project manager can be the person that will solve these misunderstandings. The arrangement of daily or monthly meetings by the project manager can make sure that everyone is fully aware about the project goals and his/her responsibilities.

Reducing risks

The project management team can identify the potential risks and uncertainties. In this way it can help the company to save valuable resources. Risk management principles can be used by the project managers to eliminate risks to a larger extent.
Strategic goals

A project management team helps the company to define the strategic goals and objectives. Strategic planning and strategic thinking are very important management tools for a project management team. In this way the company can invest more and come out with new ideas that can increase the profit margin and also reputation of the firm.

Crisis Management

Labour strikes or reduction of funds can cause crisis in a project. In these cases, project managers should handle the situation. The abilities of an accomplished project manager can make a huge difference in the outcome of the project.

2.3 Project Management

Project management is “the application of knowledge, skills, tools, and techniques to project activities in order to meet project requirements” [PMBOK 2000]. Also, Project Management Institute refers that project management is achieved through the use of processes such as: initiating, planning, executing, controlling and closing.

Furthermore, PROPS describes Project management as the management of an individual project – a non-recurrent, time limited and budgeted undertaking for which a goal has been set. A project is planned, managed and performed by a temporary organization tailored to the specific needs of the project [PROPS 1999].

The definition of project management in one organization is not necessarily the same as in another as each organization is different from the others. In smaller projects, the project management activities may be seen as the process of balancing the three main constraints: time, cost and function. But, as the scope of projects has grown to include almost all kind of activities, the project management body of knowledge has grown as well. Today, there are many bodies of knowledge regarding project management. The most known is standard PMBOK. PMBOK divides knowledge about project management in two sections:
• The project management framework
• The project management knowledge areas.

2.4 Parts of Project Management

Project management knowledge areas describe project management practices in terms of their component processes. According to PMBOK (2000) these processes have been organized into nine knowledge areas. The knowledge areas describe the main competencies that project managers must develop in order to find business solutions faster. The descriptions in this thesis only provide a short review of each knowledge area. When each of these areas applied to a project, all processes can be integrated, and a total view of the project work can be maintained. The nine knowledge areas are:

• Four core knowledge areas lead to specific project objectives: scope, time, cost, and quality.
• Four facilitating knowledge areas are the means through which the project objectives are achieved: human resources, communication, risk, and procurement management.
• One knowledge area: project integration management, affects and is affected by all of the other knowledge areas.

![Diagram of Project Management Knowledge Areas](PMBOK 2000)

Figure 2.1 – Project Management Knowledge Areas - PMBOK 2000
2.4.1 Project Integration Management

Project Integration Management comprises of the interfaces to the projects internal and external stakeholders. All the activities performed and results achieved by subprojects, subcontractors and project teams should be integrated and coordinated to alignment with the projects’ strategy and goal. The Project Integration Management consists of the following major processes: Project Plan Development, Project Plan Execution and Integration Change Control.

2.4.2 Project Time Management

Project Time Management or Project Schedule Management is the area of project that describes the management and control of project’s schedule. This knowledge area is also divided into several processes in developing the times schedule. These processes are: Activity definition, Activity Sequencing, Activity Duration Estimation, Schedule Development and Schedule Control.

2.4.3 Project Cost Management

Project Cost Management or Project Budget Management is the management and control of the project budget such as the costs for the use of resources and the project income. According to PMBOK the main processes of project cost management are: Resource planning, Cost estimation, Cost budgeting and Cost control.

2.4.4 Project Quality Management

Project Quality Management is the management and control of the project performance, and of the quality of the project outcome. The processes are referred by the PMBOK [2000] are compatible with ISO 9000 and other important standards. The most important processes for this area of knowledge are: quality planning, quality assurance and quality control.

2.4.5 Project Human Resources Management

Human Resource Management comprises the leadership in projects the management and control of the project organization. This knowledge area includes the processes required to make the people of the organization more effective. According to PMBOK [2000] the most
important processes for this area are: organization planning, staff acquisition and team development.

**2.4.6 Project Communication Management**

Project Communication Management or Communication Management in Projects, includes the management and control of the information flow at all levels of the project. Everyone participated in the project must be prepared to send and receive communication. The most important processes in this knowledge area are: communication planning, information distribution, performance reporting and administrative closure.

**2.4.7 Project Risk Management**

Project Risk Management or Uncertainty Management in Projects, is necessary since every project involves some dimension of uncertainty or risk which will affect project success. Risk Management suggests methods to identify the uncertainties and causes. The major processes for this knowledge area according to PMBOK (2000) are: the Risk Management Planning, the Risk Identification, the Qualitative Risk Analysis, the Quantitative Risk Analysis, the Risk Response Planning and the Risk Monitoring and control.

**2.4.8 Project Scope Management**

Project Scope Management includes the management and control over the requirements of the project. According to PMBOK [2000], Project Scope Management includes the processes required to ensure that the project includes all of the work required, and only the work required to complete the project successfully. It is concerned with defining what is and what is not included in the project. The five major project scope processes according to the PMBOK (2000) are: Initiation, Scope planning, Scope definition, Scope verification and scope change control.

**2.4.9 Project Supply Management**

Project Supply Management or Project Procurement Management is the management and control of relations with internal and external suppliers of resources and results in the project. PMBOK [2000] describes Project Procurement Management as a six-step process: procurement planning, solicitation planning, solicitation, source selection, contract administration, and contract closeout.
2.5 Project Manager

A project manager is the person responsible for managing a project from its inception to accomplishment. The responsibilities of project manager are planning, managing the people and resources and defining the scope and goals of project. Project managers must have the ability to create clear and objective targets and goals. The project manager has full responsibility and authority to complete the assigned project.

Also, the project manager is responsible for ensuring that everyone on the team knows his roles and the roles of other team members and acts upon the belief that all the goals will be achieved. Further, he has to encourage and advice all the team members in order to be more effective.

A project manager's position may end with the completion of the project, or it may be a semi permanent position for a limited time. There are many certifications offered in project management from many organizations. Some of them are Project Management Professional (PMP), Certified Associate in Project Management (CAPM) and Program Management Professional (PgMP).

2.6 Project Management Phases

The preparation of a project usually requires the division of the work into several project phases, which are known as the project life cycle. Each project has a life cycle. A beginning followed by a sequence of phases in pursuit of the project opportunity. Unfortunately, the cycle is not always documented and it may not be understood [Forsberg et al.2000]. Professional project managers usually have a standard project cycle that includes their preferred approach. There are three aspects of the project cycle that can be described as layers: the business layer, the budget level, and the technical level.

According to the PMBOK [2000], the project life cycle generally defines what tasks and assignments should be done in each phase and which persons are responsible for them. The descriptions of the project life cycle can be very general or very detailed. Detailed descriptions have numerous forms, charts, and checklists to provide structure and consistency. Detailed descriptions are often called project management methodologies.
Although many project life cycles have similar names on the phases and similar deliverables required, few are identical. Most have four or five phases, but some have nine or more [PMBOK 2000]. A project model can have many different phases. There are some phases that are common in every project. These phases are: project initiation, project planning, projects execution, and project termination.

A company can have different project cycles. It depends on what kind of project that should be accomplished. For example, one organization’s software development life cycle may have a single design phase while another’s has separate phases for functional and detailed design. In order to support the phases of the project, there are some process groups that participate within each phase. These phases can be seen in the picture below.

The five processes are often connected in many ways. But, there is no general way to define this interaction. Each company that uses project management methodology has to define it according to their own project management framework.

![Project management phases](http://www.brilligsys.com/PM.htm)

**Figure 2.2. Project management phases**

### 2.6.1 Project Planning

Project planning is part of project management. It is related to the use of schedules such as Gantt charts in order to plan and report progress within the project environment.

First of all, the project scope must be defined and the methods for the completion of the project must be determined. Following this step, the durations for the tasks that must be completed are listed into a work breakdown structure. The dependencies between tasks are
defined using an activity network diagram that it can identify the critical path. Float time in the schedule can be calculated with the use of project management software. After these processes the necessary resources can be calculated and costs for each activity can be allocated to each resource. So, we can estimate the total project cost. At this stage, the project plan is able to achieve the appropriate balance between resource usage and project duration according to the project targets. After its establishment and agreement, the plan becomes what is known as the baseline. Throughout the life of the project, progress will be measured against the baseline. Analyzing progress compared to the baseline is known as earned value management.

The project charter and the concept proposal are included to the inputs of the project planning phase. The project requirements, the project schedule, and the project management plan are included to the outputs of the project planning phase.

2.6.2 Determination of Project Environment

The project stakeholders include all individuals and organizations who are actively involved in the project, or whose interest may be positively or negatively affected by the project, whether or not it is completed successfully or terminated [PROPS 1999, PMBOK 2000]. Therefore, it is important that the project manager or the project management team identify all the stakeholders, and determine their needs and requirements. In some literature and project models, it is considered important that the project manager clarify the interfaces between different stakeholders and sign “contracts” with them in order to make them committed to the project. Commitment to the task and to teamwork is a very important management issue, but it is part of the project management knowledge areas and will be briefly discussed later. The stakeholders presented below are the most common ones and their function is important for a better understanding of this thesis.

**The Sponsor** is an individual or a group, within or external, to the performing organization that provides the financial resources for the project [PMBOK 2000]. In PROPS [1999], the sponsor is defined as the manager who is commercially and financially responsible for the project and its outcome. The project sponsor is the primary risk taker for the project and makes the important decisions based on the assessment of the project’s alignment with the
business direction [PROPS 1999]. For this reason, there is little difference in the definitions of the role of the sponsor.

**The Project Steering Group** is consisted of managers in the organizations who have the authority to take an active part in the decisions concerning the steering of the project, and that can provide the project with necessary support. The main responsibility of the steering group is to ensure that the organization’s support to the project manager in executing the project is coordinated, and that the project has access to people with the authority to provide the project with resources [PROPS 1999].

**The Project Manager** is the person that is responsible for managing the project [PMBOK 2000]. PROPS add that the project manager is responsible for managing the project towards its goal in accordance with an agreement made with the project sponsor [PROPS 1999].

**The Customer** is the most important external project stakeholder [PROPS 1999]. The customer is either an individual or an organization that will use the project’s product. There may be multiple layers of customers. For example, the customer for a new pharmaceutical product may include the doctors who prescribe it, the patience who take it, and the insurers who pay for it. In some application areas, customer and user are synonymous, while in others, customer refers to the entity purchasing the project’s result, and users are those who will directly use the project’s product [PMBOK 2000]. Customer satisfaction is a term often used in project management literature. In order to satisfy the customer, the project must understand who the customer is and what the customer wants.

**The Subproject Manager** is given the authority of the project manager to execute a subproject, in which he or she has the role of the project manager. The subproject can vary in size and can have a goal and a budget of its own. The subproject manager is part of the project management team in order to increase the alignment, and prevent sub optimization within the project [PROPS 1999].

**The Program Manager** is the single point of accountability for overall program management across multiple interdependent projects. He or she must ensure that the program is on time, within budget, and meets client requirements, which requires a high degree of cross-functional integration [Moore 2000].
The important role of the **Reference Group** is to advice all the people that are participating the project. Often, experts who can be internal or external are included in the reference group along with people who have an interest in the project and who are able to come up with useful ideas in order to help the project management team with technical decision [PROPS 1999].

**Project Team Member** is the team that is preparing the tasks of the project in each phase of this.

### 2.6.3 Organization of Project

The basic purpose for initiating a project is to accomplish goals. The reasons for organizing the task as a project are: to focus the responsibility and authority for the attainment of the goals on an individual or a small group [Meredith & Mantel 1995]. Further, the project organization implies a different and simplified decision making process to obtain cooperation that is adapted to the project task or scope and be more creative compared to the traditional line organization and make possible co-operation beyond organization and department borders. Therefore, a project has three steering functions instead of the line organizations two, since the project management function is added in between, partly to replace the “normal” steering function and the “normal” executing function. Thus, project management provides a shortcut in an otherwise hierarchical organization, resulting in visible management involvement and shorter lead-times between the delivery of a proposal and the decision to accept or reject it [PROPS 1999].

The project form also allows the project manager to be responsible to the client and to the surrounding stakeholders. Gaddis expressed it, as “The project staff will be a “mix” of brainpower, varying with the project’s mission” [Gaddis 1959].

### 2.6.4 Definition of Tasks

In Project management the first step is to determine the goals. After that Project is divided into parts considering those goals.

First of all the main tasks are determined and then each task is divided into sub-tasks. At the end the Project is defined with a series of scheduled and budgeted task. It is very hard to determine the tasks but it has a critical importance for the Project management.
After a successful task definition obtained activities should be clear, specific, scheduled, measurable and have goals. Thus those activities can be linked each other and the Project is completed using Project management techniques.

2.7 Project Planning and Management Tools

Programme planning creates the main frame of project. In the programming step, some Project techniques are used such as Gantt Charts, CPM (Critical Path Method) and PERT (Programme Evaluation and Review Technique). Using these techniques, the relations of activities composed the Project and their precedences are determined; the project time schedule estimated and beginning & finishing time are found out. Finally a detailed budget is prepared for the programmed activities and the employees are assigned.

The benefits of the project programming can be summarized like that;
- The relation of every activity with each other and also the whole project is shown.
- The precedences of activities are defined.
- Time and budget estimation are made for every activity.
- The critical points of the project are defined and the resources like time, money and human are used more efficiently.

When preparing the project programme, the activities’ and resources’ data, restrictions, estimations, calendar and goals of the project are used as a data. Calculations are done by using mathematical analysis, simulations and some software programmes. As a result the Project programme is obtained. Also programme management plan is obtained with some supportive details and requirements of resources are supplied. If there is missing resource
there can be some delays. However oppositely if there is over resource this time the cost increases and also there can be some delays again.

2.7.1 Investigation of Project Management Techniques

In this part the Project Management techniques were investigated. PERT and CPM consider the task’s dependencies and precedences relations. However, Gantt charts are used in some parts of large projects. Gantt charts are used to summarize the project but it needs to be completed other techniques.

2.7.2 Gantt Chart

A Gantt chart is a horizontal bar chart used for project scheduling. It can be used to plan time scale for a project and estimate resources that are needed for its completion. It is also very helpful for the planning and coordination of specific tasks of a project. It is ideal for small projects when the activities are not complex. But Gantt charts are poor management tools when projects are big and complex.

2.7.3 CPA (Critical Path Analysis)

Critical Path Analysis is a very useful management tool and can be used in larger projects. The Critical path technique can be helpful for the estimation of time management, for the collection of ongoing data for assessing progress and for the collection of information for decision making. It is a very useful tool as the required time for each activity can be determined and the logical sequencing of the project activities can be made. Also, we can have full identification of all activities that require time and resources during the planning process.

2.7.4 PERT (Project Evaluation and Review Techniques)

The technique of PERT can give better time estimation for a project. This can be achieved by accounting the risk and uncertainty when predicting task durations. The project manager can define an average completion time after the estimation of the worst, best and most probable duration of time for each duration. This can be achieved by calculating an
expected value for each of them. The average time of each activity can be used to configure the elapsed time of the project.

2.8 Project Control

The traditional view of Project Control, according to the PMBOK, has been cost and schedule during the project execution phase. Although this view cannot be always important in industry, an effective project controls process can be applied in a collaboration of its various sub-disciplines such as:

1) Planning Schedule & Project Reporting
   - Scope Management
   - Schedule estimation
   - Project deliverables
   - Productivity analysis and calculation

2) Earned Value Analysis & Management

3) Cost Engineering & Estimating
   - Cost Management
   - Cost control
   - Cost forecasting

4) Change Management & Controls
   - Change order control
   - Trend analysis

5) Risk and Delay Claims
   - Risk assessment and management
   - Delay claims Quantification

The development of a suitable Project Control system is an important part of the project management effort (Shtub, Bard & Globerson 2005). Also, it is recognised that planning and monitoring plays mayor role in the project success. There are many case studies
that can prove how useful is the control in the achievement of project objectives. It has been
proved time many times that Project performance can be improved if dedicated Project
Controls systems are in place.

Chapter 3

Six Sigma

3.1. Overview of the Six Sigma

Sigma (σ) is the 18. letter of the Greek alphabet. The word of ‘sigma’ represents that
the average value of the entire process. The capital letter of sigma is used as the summation
symbol (Σ). Besides, sigma (σ) is the symbol of standard deviation in statistics and statistical
process control which is a very important criterion.

Six Sigma is a statistical management (control) mechanism utilized in using zero-
defect strategy as an attainable target. In quality system, Six Sigma can be defined as
providing the highest quality service continuously according to customer requirements.
Another definition of Six Sigma is; It is a wide and flexible system to ensure and increase the
success of the work done. Six Sigma develops the process by analyzing the collected data and
primarily focuses on customer. Besides, the success of Six Sigma Management is due to the
application of design, measurement, analysis and control processes through the whole
production/service process not after completing the product or service. Six Sigma is not only a
technical programme, it is a management programme. In other words, Six Sigma is a business
and management strategy.

In Six Sigma, the collected information is expressed by numerical values and these
obtained results are evaluated statistically. Sigma value shows the frequency of the defects
(errors) have occured. The increase of sigma value towards to 6 means the reduction of
defects. A measurement of six sigma equates to only 3.4 defects per million opportunities
which is equivalent to a 99.99966% perfection rate. The target of 3.4 defects per million operations is can be achieved only a few company. While the level of sigma increases, the quality of product increases and the cost decreases. As a result of this the satisfaction of the customer is gained.

Table 3.1 shows a simplified one-to-six conversion scale.

Table 3.1. One to six sigma conversion table
(http://www.businessballs.com/sixsigma.htm)

<table>
<thead>
<tr>
<th>‘Process Sigma’</th>
<th>Defects per million Opportunities (DPMO)</th>
<th>‘Long Term Yield’ (basically the percentage of successful outputs/operations)</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>3.4</td>
<td>99.99966</td>
</tr>
<tr>
<td>5</td>
<td>233</td>
<td>99.98</td>
</tr>
<tr>
<td>4</td>
<td>6.210</td>
<td>99.4</td>
</tr>
<tr>
<td>3</td>
<td>66.807</td>
<td>93.3</td>
</tr>
<tr>
<td>2</td>
<td>308.538</td>
<td>69.1</td>
</tr>
<tr>
<td>1</td>
<td>691.462</td>
<td>30.9</td>
</tr>
</tbody>
</table>

Various definitions have been made of Six Sigma. Some examples are given below;

- Six Sigma is a name for the programme of a company’s improvement and renewal process.
- Six Sigma is a statistical and engineering method for the product and process optimization.
- Six Sigma is a programme aims to eliminate the defects for each product and process.
- It is a system to meet the customer needs/requirements.
- Six Sigma is a data driven approach to problem solving, as a business process, as a disciplined statistical approach, and as a management strategy. (Swink and Jacob, 2012)
- It is a wide and flexible system to ensure and increase the success of the company.
- Six Sigma is a strategy which requires a hard work and care.
Six Sigma is a result-oriented systematic methodology and appropriate for the improvements depend on the factors of variability, processing time and utility degree.

Six Sigma is an organized and systematic method for strategic process improvement and new product and service development that relies on statistical methods and the scientific method to make dramatic reductions in customer defined defect rates. (Linderman, Schroeder, Zaheer and Choo, 2002)

Quality Progress called Six Sigma a “high-performance, data-driven approach to analyzing the root causes of business problems and solving them” (Schroeder, Linderman, Liedthe and Choo, 2007)

Harry and Schroeder (2000), in their popular book on Six Sigma, described it as a “business process that allows companies to drastically improve their bottom line by designing and monitoring everyday business activities in ways that minimize waste and resources while increasing customer satisfaction” (Schroeder, Linderman, Liedthe and Choo, 2007)

Six Sigma is described as a disciplined and statistically based approach for improving product and process quality. (Schroeder, Linderman, Liedthe and Choo, 2007)

It is a management strategy that requires a culture change in the organization.

Six Sigma is an organized, parallel-meso structure to reduce variation in organizational processes by using improvement specialists, a structured method, and performance metrics with the aim of achieving strategic objectives. (Schroeder, Linderman, Liedthe and Choo, 2007)

### 3.2. Historical Overview

As it is well known the term of Six Sigma was first used at Motorola in the beginning of 1980s. However the roots of Six Sigma as a measurement standard can be traced back to Carl Frederick Gauss (1777-1855) who introduced the concept of the normal curve (http://www.isixsigma.com/new-to-six-sigma/history/history-six-sigma/).

When the origin of Six Sigma was reviewed it can be seen that people of Motorola - Bob Galvin (CEO), Bill Smith (VP and Senior Quality Assurance Manager) and Mikel Harry (Senior Engineer of the Government Electronics Group) – invented this quality improvement
process. In 1981, Motorola aimed to increase the quality 10 times using Six Sigma before the 1986 and 3500 employees were trained in order to get this target. At the end of the five years they obtained a budget improvement but not customer satisfaction and employee motivation. Hence they implemented a communication improvement programme and in 1987 Motorola started to use Six Sigma reaching its aggressive goal of 3.4 ppm defects. After that as Motorola said “Six Sigma provided a common worldwide language for measuring quality and became a global standard” and many high profile companies such as AlliedSignal (now Honeywell), General Electric (GE), and 3M have used Six Sigma to achieve significant results. Today Six Sigma is no longer just a defect rate measure. It is a process improvement program that has a statistics core, a rigorous improvement method, and a unique set of practices. (Zahang and Xu, 2008)

3.3. Goals & Tools

The aim of Six Sigma Methodology is to reach ‘zero defect’ rate in the process. Six Sigma Methodology defines ‘how to do’ rather than ‘what to do’ for the perfection model. Therefore it uses statistical techniques as easy and feasible tools in the process improvement.

Six Sigma is a customer-driven and data-defined system because of that it aims to increase the market share with maximum customer satisfaction. There are three points to succeed it;

- To meet the all quality expectations at the first time,
- To offer the reasonable price for desired quality,
- To offer the desired quality on expected time.

Considering these points we can say Six Sigma approach includes minimizing the variability, process time and the cost.

According to Anbari and Kwak (2006) the Six Sigma includes measured and reported financial results, uses additional, more advanced data analysis tools, focuses on customer concerns, and uses project management tools and methodology.

\[
\text{Six Sigma} = \text{TQM (or CQI)} + \text{Stronger customer focus} + \text{Financial Results} + \text{Additional Data Analysis Tools} + \text{Project Management}
\]
Therefore any Six Sigma project whether is DMAIC (Define-Measure-Analyze-Improve-Control) or DMADV (Define-Measure-Analyze-Design-Verify) also known as DFSS (Design for Six Sigma) uses tools. These tools come from statistical analysis and project management. Table 3.2 presents the tools and techniques used in Six Sigma.

### Table 3.2. Six Sigma Tools & Techniques

<table>
<thead>
<tr>
<th>Six Sigma Tools &amp; Techniques</th>
<th>5 Whys</th>
<th>Pareto Chart</th>
<th>Affinity Diagram</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cause&amp;Effect Diagram</td>
<td>Failure Mode and Effect</td>
<td>SIPOC Analysis (Suppliers-Inputs-Process-Outputs-Customers)</td>
<td></td>
</tr>
<tr>
<td>(Ishikawa Diagram / Fishbone Diagram)</td>
<td>Analysis (FMEA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Check List</td>
<td>Design of Experiments</td>
<td>Calculators</td>
<td></td>
</tr>
<tr>
<td>Business Process Mapping</td>
<td>Cost Benefit Analysis</td>
<td>Brainstorming</td>
<td></td>
</tr>
<tr>
<td>Control Chart</td>
<td>Sampling</td>
<td>Quality Function Deployment (QFD)</td>
<td></td>
</tr>
<tr>
<td>Correlation</td>
<td>General Linear Model</td>
<td>Kano Analysis</td>
<td></td>
</tr>
<tr>
<td>Histograms</td>
<td>Root Cause Analysis</td>
<td>Project Charter</td>
<td></td>
</tr>
</tbody>
</table>

### 3.4. Six Sigma Method

Six Sigma Method is a business philosophy that increases the customer satisfaction, reduces and prevents the defects in the process. The purposes of this method are to obtain maximum, even more than maximum customer satisfaction, to make business on time and to reduce operating expenses. Besides this method hepls to compare the improvements of works done by using statistic. As a result, companies using Six Sigma reduce the defects and improve their products/services continuously.

Today many companies work at an average of 3 sigma value. This means approximately 67 defects occur in per million opportunities. Table 3.3 shows the quality difference between 3 sigma level and 6 sigma level with very basic daily examples.
Table 3.3. Comparison of 3 sigma and 6 sigma (Arıtürk 2003)

<table>
<thead>
<tr>
<th></th>
<th>3 sigma</th>
<th>6 sigma</th>
</tr>
</thead>
<tbody>
<tr>
<td>Death of a new-born baby</td>
<td>40500 babies / 1 year</td>
<td>3 babies / 100 years</td>
</tr>
<tr>
<td>because of doctor mistake</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time of giving unhealthy water to the</td>
<td>2 hours / 1 month</td>
<td>1 second / 6 years</td>
</tr>
<tr>
<td>city water</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Time of telephone signal outage</td>
<td>27 minutes / 1 week</td>
<td>6 seconds / 100 years</td>
</tr>
<tr>
<td>Number of wrong surgery</td>
<td>1350 cases / 1 week</td>
<td>1 case / 20 years</td>
</tr>
</tbody>
</table>

It can be seen on the table that there is an important difference between 3 sigma and 6 sigma values. Six sigma reduces the failure rate significantly.

Six Sigma method run inside the company top to bottom considering the company’s hierarchy structure. Directions of the project are given by the senior manager to mid-level manager and he conveys to employees. Every Six Sigma project is managed by an expert project leader and the team consists of members who knows the Six Sigma process.

Some areas are given below that can be used in Six Sigma method:
- Reducing cost
- Increasing efficiency
- Increasing market share
- Reducing defects
- Changing culture of the company
- Improving product/service

Companies using Six Sigma method do not only produce high quality product but also ensure to work system efficiently. This system includes production, customer services, selling and after- sell services. In the organizations Six Sigma method can be used in a wide range beginning from stratejic planning, operations to customer service. Beside that it can be used in both whole organization and only one department.
3.5. Six Sigma Process

Six Sigma is a systematic, customer-driven, data-defined approach following two project methodologies DMAIC (define- measure- analyze- improve- control) and DFSS (design for six sigma) which are inspired by Deming’s Plan-Do-Act-Check Cycle.

3.5.1. DMAIC

DMAIC is a closed loop process that starts defining of the problem and includes a lot of activities until obtaining the solution. It is used to improve existing processes by eliminating unproductive steps. This methodology has five steps;

- **Define:** The problem, desired improvements, process (by mapping the business flow), application area, goals and customer requirements/expectations are defined.
- **Measure:** There should be a starting point to end the work. Thus, relevant data are collected by developing a data collection plan, defects of the current process are determined and satisfaction of customer is measured.
- **Analyze:** Collected data are analyzed using the data analysis techniques, causes of the problem are searched and sourced according to variation. Those variations are determined in the process and future improvement opportunities are noted.
- **Improve:** The process is improved to eliminate variations and a permanent solution is found out for the problem by developing creative alternatives.
- **Control:** Process is monitored and controlled for the future state to ensure the permanent solution.

Measuring, goal setting and culture change in the organization are a need to apply the Six Sigma. However the secret of success is flexibility and different applications for each company and process. Most important benefits of DMAIC were summarized below;

- The problem is measured by facts in the light of collected data not predictions.
- Customer is important even the company wants to reduce costs.
- The reasons of the problem have to be proved by facts.
- All process is considered and improved not only the faulty part of process.
- In Six Sigma the results have to be tested and improved.
- Outcomes of the process are observed and benefits are obtained.
- There is a continuous improvement application.

DMAIC methodology phases and used tools & techniques in these phases are presented in Table 3.4.

Table 3.4. Six Sigma DMAIC Methodology

<table>
<thead>
<tr>
<th>Phases</th>
<th>Development</th>
<th>Tools &amp; Techniques - Applications</th>
</tr>
</thead>
</table>
| Define       | ➢ Selection of the Project  
               ➢ What is the product/service to be improved?  
               ➢ What is the process?  
               ➢ Determination of parameters: Benefits to the customer and company, complexity of the process, cost | ➢ Six Sigma Measurement system  
               ➢ Customer complaints  
               ➢ Customer surveys  
               ➢ Employee suggestion system  
               ➢ Data system  
               ➢ Statistical assessments  
               ➢ Pareto Analysis  
               ➢ Cause & Effect diagrams |
| Measure      | ➢ What is the characteristics of product/service?  
               ➢ What is the factors effecting data collection?  
               ➢ -Data type  
               ➢ -Precision of measurement  
               ➢ -Sample size/number  
               ➢ -Measurement time & frequency | ➢ Design of Experiments (DoE)  
               ➢ Benchmarking  
               ➢ Brainstorming  
               ➢ FMEA  
               ➢ and so on… |
| Analyze      | The effects on the variable are analyzed. | ➢ Defects per million opportunities  
               ➢ Sigma values  
               ➢ Quality control charts  
               ➢ Comparison of the similar products and processes within/out organization |
| Improve      | ➢ Predictability  
               ➢ Variability  
               ➢ Targeted average values  
               ➢ Effection rate | ➢ Statistical techniques  
               ➢ Variability precautions |
3.5.2. DFSS

DFSS is a systematic methodology which is known also DMADV (define- measure- analyze- design- verify). The phases were depicted in Figure 3.1. The DFSS is used to create new product or process design with a six sigma criteria aiming minimum defect rate and maximum customer satisfaction. In other words, the DFSS methodology is based on new or innovative designs which targets perfection. Some important features of DFSS can be summerized as (Anbari and Kwak, 2006) :

- Customer- oriented
- Predicts design quality at the outset
- Integrates cross-functional design involvement
- Uses top-down structure
- Leads quality measurement and predictability
- Monitors process variances to see customer satisfaction.
3.6. Variability in Six Sigma

Variability is one of the most important concepts of Six Sigma. Because variabilities are the causes of defects in the process. Every process has variabilities but the important point is its nature and size.

Considering the variability, the upper and lower limits are determined. If product is not between these limits, defects occur. The purpose is to improve processes with low variability and average targets.

Variability shows up for different desired/uncontrolled results in similar situations. There are two variability: Known variability and random variability.

3.6.1. Known Variabilities

Known variabilities are larger than occurred in normal conditions. They can be prevented so they are manageable. If the variability is uncontrolled, this is taken as defect. If it
is desired variability, this means success or improvement. At the end ‘change’ is obtained. Thus the situation, parameters and the output of the system has changed.

3.6.2. Random Variabilities

The thought is that random composition of small effects of different causes makes random variability. The characteristics of this variability are;

- They are small and random differences,
- It can be measured by probability distribution model.
- System and system output does not change.

Chapter 4

Application of Six Sigma Project

4.1. Company Definition

This project has been done at Klemsan Electric Electronics Inc. in Turkey. It was established in 1974. Klemsan’s head Office is in İstanbul and it has a factory in İzmir, Kemalpaşa. Klemsan is the leader of the local market with its several regional offices and wide distribution network. It exports more than 60 countries including USA, Canada, Brazil, Germany, Italy, France, UK, Denmark, Norway, Finland, Romania, Saudi Arabia, UAE, Egypt…etc. It has nearly 60000 employees. Klemsan increases its production volume continuously and adds new products to its product range in order to meet customer needs.

4.2. Problem Definition

When causes of problem were searched, the problem can be defined as;
The copper arc contact of the circuit breaker is welded with the sinter-end. The company cannot obtain the desired strength at that junction point and the nonconformity rate is above the target at the initial quality control part.

Several studies were done by the research&development and process engineers but they could not reach the desired quality.

The company has started a project with supplier to solve this problem and the preparation has began. They decided to apply Six Sigma management to this project. Senior management of the company has determined the budget, time and employees for this project.

4.3. Project Application

Considering the Six Sigma project management method mentioned in Chapter 2, the Project has started and the main approach DMAIC (Define- Measure- Analyze- Improve- Control) has been applied.
**4.3.1. Define**

**Table 4.1. Project Charter**

<table>
<thead>
<tr>
<th>Project Name</th>
<th>Improvement of SF1T1T2 Arc Contact welding process</th>
<th>Product</th>
<th>SF1 T1/T2 Zarf</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sponsor</td>
<td>Gökhan Kutluğ</td>
<td>Location</td>
<td>Kemalpaşa</td>
</tr>
<tr>
<td>Master Black Belt</td>
<td>Tümer Arıtürk</td>
<td>Senior Management</td>
<td>Patrick Fayen</td>
</tr>
<tr>
<td>Project Leader</td>
<td>Birol Arslantaş</td>
<td>Telephone number</td>
<td>+90 232 877 01 05</td>
</tr>
<tr>
<td>Team Members</td>
<td>Ali Topaloğlu, Zafer Koçyiğit, Ercüment Pekzorlu</td>
<td>Finans Expert</td>
<td>Ahmet Yeşil</td>
</tr>
<tr>
<td>Assistant Team Members</td>
<td>Hacim Kocademirci, Metin Aydoğdu</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Definition**

1. **Project Definition**
   Improvement of SF1 T1 T2 arc contact welding process

2. **Project Parameters**
   Kartal Otomotiv Kaynak Alanı

3. **Goals**
   - To reduce nonconformity at the initial quality control
   - To decrease the potential risks
   
<table>
<thead>
<tr>
<th>Measured</th>
<th>Main</th>
<th>Current</th>
<th>Target</th>
<th>Ideal</th>
</tr>
</thead>
<tbody>
<tr>
<td>%</td>
<td>5,07</td>
<td>5,07</td>
<td>0</td>
<td>4,6</td>
</tr>
<tr>
<td>%</td>
<td>5,07</td>
<td>5,07</td>
<td>0</td>
<td>4,6</td>
</tr>
</tbody>
</table>

4. **Results**
   - Reduction nonconformity
   - Risk elimination
   
<table>
<thead>
<tr>
<th>Fact</th>
<th>Potential 340000 euro</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gain</td>
<td>Risk reduction</td>
</tr>
</tbody>
</table>

5. **Customer Advantages**
   Customer satisfaction and Risk reduction

6. **Plan**
<table>
<thead>
<tr>
<th>Scheduled time</th>
<th>Actual time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Define</td>
<td>07.03.2012</td>
</tr>
<tr>
<td>Analyze</td>
<td>11.06.2012</td>
</tr>
<tr>
<td>Control</td>
<td>26.07.2012</td>
</tr>
</tbody>
</table>
Define phase includes the project definition, problem definition, desired improvements, benefits of the project to the company and customer. In this step the project leaders and team members are announced and admitted by the project sponsor, critical success factors are determined and project charter is prepared scheduling the finishing time.

Some estimations and assumptions are made in the define phase but these can be changed in next phases. If the standard deviation is too high, the project is investigated from the beginning. Because of that old data, if there are, and some reliable methods should be used while preparing the project charter.

Above Table 4.1 shows the project charter of applied Six Sigma Project in Klemsan Electric. The senior management has decided to start project by considering this charter. Those values has been taken as a reference for the starting point. Especially the saving value is a key factor to start this project. So stability of this chart is important.

When the Project charter was examined, it can be seen that the nonconformity rate of initial quality control value is 5.07 % or 50700 ppm. This rate is too high because the targeted value is 0.8 % (8000 ppm). As a result there are two reasons in the chart that develop the project;

1. To reduce nonconformity rate at the initial quality control for the pieces
2. To decrease the potential risks.

These are also the goals of the project and both of them related to each other at a main point: Customer satisfaction.

If the problem is solved, the outcomes of these goals can be commented like;

1. Reduction in nonconformity rate increases the satisfaction of customer who is the sponsor of materials. Also this eliminates the shipping cost of nonconforming product.
2. When the nonconformity problem is solved, the risks on the products (breakers) will be eliminated. So the company will decrease the risk factor and there will be 340000 euro return according to yearly budget.

As a result, sponsor’s service and technical quality will increase and the potential risk of the product will eliminate. There is no gain for the business but a potential loss of prestige will be prevented.
4.3.2. Measure

After the senior management takes the decision of Six Sigma Project method, define phase is completed and measure step is started. In this phase data are collected in order to go detail in the project.

In this project, for the determination of current situation of goals which are defined;

1. The initial quality control reports in the recent year were investigated.
2. The potential risk that will be created of returned results of those reports, amount of product and costs was calculated.

In order to determine the current situation of this project SIPOC (supplier- input-process- output- customer) analysis was used. This analysis can be seen on Figure 4.1.

Figure 4.2 shows the risk analysis done for this project. According to this analysis the nonconformity rate is 5.07 %. The macro examination of this nonconformity rate and budget gives a 340000 Euro potential risk.

The measurement phase shows the risk analysis of the current situation and details of process. Correspondingly the methods and statistical charts which are possible to use are determined. Sufficiency of data is controlled and new requirements are estimated.

![Figure 4.1. Project SIPOC Analysis](image)

### Project SIPOC Analysis

<table>
<thead>
<tr>
<th>S</th>
<th>I</th>
<th>P</th>
<th>O</th>
<th>C</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Supplier</strong></td>
<td><strong>Input</strong></td>
<td><strong>Process</strong></td>
<td><strong>Output</strong></td>
<td><strong>Customer</strong></td>
</tr>
<tr>
<td>Kartal Otomotiv</td>
<td>Copper arc contact</td>
<td>Induction welding process</td>
<td>Acceptable product of welding process</td>
<td>Core Unit</td>
</tr>
<tr>
<td>Schneider Plant</td>
<td>Sinter metal</td>
<td></td>
<td></td>
<td>Epoxy</td>
</tr>
<tr>
<td>Castolin</td>
<td>Welding rod</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Castolin</td>
<td>Decapan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kartal Otomotiv</td>
<td>Operator</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kartal Otomotiv</td>
<td>Induction bench</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TEDAŞ</td>
<td>Energy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Compressor</td>
<td>Air</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>JSKI</td>
<td>Water</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### For Parts

<table>
<thead>
<tr>
<th>Reference</th>
<th>Price of Purchase</th>
<th>2011 Consumption</th>
<th>Turn Over</th>
</tr>
</thead>
<tbody>
<tr>
<td>888204</td>
<td>5,266</td>
<td>21.550</td>
<td>112,630</td>
</tr>
<tr>
<td>759434</td>
<td>2,759</td>
<td>13.527</td>
<td>37,324</td>
</tr>
<tr>
<td>888129</td>
<td>3,000</td>
<td>19.000</td>
<td>57,000</td>
</tr>
<tr>
<td>891377</td>
<td>3,400</td>
<td>13.100</td>
<td>44,540</td>
</tr>
</tbody>
</table>

**1 Euro:** 1.850

**Total Goal:**

### For Products

<table>
<thead>
<tr>
<th>Product Type</th>
<th>Price of CCV</th>
<th>2011 Budget Production</th>
<th>Turn Over</th>
</tr>
</thead>
<tbody>
<tr>
<td>SF1 - T1 POLE</td>
<td>93</td>
<td>16,000</td>
<td>1,562,400</td>
</tr>
<tr>
<td>SF1 - T2 POLE</td>
<td>150</td>
<td>7.200</td>
<td>1,080,000</td>
</tr>
<tr>
<td>SF1 - T1 BREAKER</td>
<td>728</td>
<td>3.500</td>
<td>2,548,000</td>
</tr>
<tr>
<td>SF1 - T2 BREAKER</td>
<td>1,015</td>
<td>1.500</td>
<td>1,522,500</td>
</tr>
</tbody>
</table>

**Euro:** 6,712,900 Elimination Risk in Customer 340000

---

**Figure 4.2. Project Risk Analysis**
4.3.3. Analyze

The project with defined parameter and collected data is ready for the analyze phase. In this step the obtained data are examined, a data collection plan is determined for new data and statistical analysis of new and obtained data is done. So the project is based on a statistical floor.

Figure 4.3 shows the capability analysis of the product. The capability analysis is a statistical measure which shows the process performance thorough the $C_p$, $C_{pk}$, $P_p$, and $P_{pk}$.

- $C_{pk}$= Process Capability Index. Adjustment of $C_p$ for the effect of non-centered distribution.

Process capability and/or process performance is another way of Six Sigma to report the performance to the organization. $P_{pk}$ shows the how much variation the process exhibits and $C_{pk}$ shows how that variation effects the ability of process in order to meet customer needs. Both of them are calculated with same formula. And according to these values the sigma value of the process is determined.

In this process the strength of the arc contact was analyzed and $P_{pk}$ value was considered. When we looked at the graph we saw that the lower specification limit is 2800N for this process. So the statistical distribution area rate is 99.57%. Process sample number is 375, sample mean is 3600N and standard deviation is 587.69 within and 743.286 overall. In the overall analysis the nonconformity value is 140696 ppm. However for the process capability the desired value is 8000 ppm. In this analysis $P_{pk}$ value is 0.36 (using equation 1) and depending on the determined sigma value is 2.3. In order to reach desired level $P_{pk}$ value should be 1 (if $P_{pk}>1$ the process is capable) and then sigma value will increase around 4. The higher sigma value means better performance.

$$P_{pk} = \frac{Mean - LSL}{3\sigma} \quad (Eq. 1)$$
4.3.4. Improve

In this phase, design of experiment (DoE) method was applied to the inputs which are determined in the SIPOC analysis and the effect of these parameters on the strength was investigated. Considering these parameters the machines were set according to the desired values and the results of the process were followed statistically.

After the DoE the new samples were analyzed according to their strength again. This analysis is shown in the Figure 4.4. When we compared this analysis with the other one we saw that the $P_{pk}$ value has increased from 0.36 to 1.05. Also the sample mean increased from 3600N to 4589.77N while the standard deviation decreased from 587.69 to 466.912.

As a result when the analysis values was considered, the desired $P_{pk}$ value has been reached. Also the nonconformity value of overall system is 805 ppm which is the capability criteria of the process.
4.3.5. Control

In the control phase, the obtained improvement is proved by calculating statistically in order to show that it is a fact not a coincidence. The hypothesis test seen on Figure 4.5 proves the reliability of the improvement. If the P-value is smaller than 0.05, it proves statistically the variation is a real improvement not a coincidence. This test compares the T distribution and mean values. Control phase has a continuity.

**Figure 4.4. Process Capability Analysis (2)**

**Figure 4.5. Process Improvement Hypothesis Test**
When the new sigma value was calculated with the new data, it is seen that it increased to 4.6 from 2.3 and Figure 4.6 shows the comparison of two sigma value.

![Figure 4.6. Comparison of Sigma levels](image-url)
Chapter 5

Six Sigma in Project Management

5.1 Six Sigma and the Project Management Body of Knowledge

Interest in Six Sigma is growing rapidly within the professional project management community. The most common question coming from that group is something like “How does Six Sigma relate to the Project Management Body of Knowledge (PMBoK)?” Six Sigma and PMBoK presents some connections, similarities and distinctions.

Before diving into specifics, a little background is beneficial. The PMBoK is a well-established standard (published by the Project Management Institute) that is widely used by professional project managers in many industries around the world. This is also the basis for certification as a project management professional (PMP). The PMBoK consists of nine knowledge areas organized into five “process groups” as presented in Figure 2.

As specific connections are appeared, it is useful to identify and analyze on several different perspectives from which this topic can be considered.

5.1.1 What Is Meant by “a Project”?

This is not a question about the rhetorical or definitional sense. It is asked to point out an important distinction between a project that is being executed to develop a new product or process (or to enhance something existing) versus a Six Sigma project that may be concurrently executing in parallel with, and potentially intersecting with, the “product project.” The following diagram illustrates this distinction.

![Diagram of project types](image-url)

**Figure 5.1: What Is a Project?**
It is possible that several Six Sigma projects may be executing at the same time as a “product project” and may deliver results that impact or are used by that project. A Design for Six Sigma (DFSS) project could be chartered to better understand the requirements of a certain customer segment, with the intent to deliver that knowledge to the product project team at the appropriate time. Similarly, a process improvement DMAIC project might be initiated if it were recognized that testing capability was insufficient to deliver the required level of quality within the required time frame. Both Six Sigma projects could have results that impact other product project teams as well, and so are not simply tasks within the product project, but have a life of their own.

5.1.2 PMBOK as a Guide to Execution of Six Sigma Projects

At a conceptual level, many of the “management best practices” advocated by PMBOK and Six Sigma have a great deal in common (e.g., identify and communicate with stakeholders, have a plan, conduct regular reviews and manage schedule, cost and resources).

In the Six Sigma project world, most practitioners would likely argue that these types of activities are the province of the project sponsor/Champion and the team leader, typically a Green Belt or Black Belt. It is generally accepted as best to keep Six Sigma projects time limited (typically four months or so) and to execute them with small teams. Thus, it can be argued that appropriate management controls for projects of this nature may be primarily in the nature of individual results goals for sponsors/Champions and Belts. Six Sigma practitioners may resist additional oversight from a project office or other manifestations of professional project management.

In contrast, an argument can be made that professional project management finds its best application in larger, more complex “product projects.” In these cases, more formal and resource-intensive oversight by a mechanism such as a project office is appropriate. With large projects, individual results goals may not provide adequate control to ensure the best outcomes and accountability. In the balance of this discussion, “professional project management” is used to denote a larger, more complex project. It is not intended to suggest it does not apply to smaller efforts, or that all of the generalizations associated with larger projects will apply in smaller efforts.
In short, where it is well established that professional project management adds value to larger projects, it is not clear that the same is true for typically smaller Six Sigma projects. When Six Sigma projects truly follow the Six Sigma roadmap and faithfully conduct tollgate reviews, the additional overhead associated with project office controls and reviews may not be justified.

5.2 Six Sigma as an Aid to Professional Project Management

Application of professional project management is not the same with application of Six Sigma. Both disciplines share many common goals and purposes. Both try to reduce failures, prevent mistakes, eliminate costs, control schedules, and manage risk. Generally speaking, professional project management attempts to achieve these goals by encouraging sound practices on a project-by-project basis, often through the mechanism of a project office that provides templates and advice, promotes appropriate use of tools such as critical path method, and performs periodic project reviews.

Six Sigma is more typically oriented toward solution of problems at root cause and prevention of their recurrence, as opposed to attempting to control potential causes of failure on a project-by-project basis. Six Sigma’s toolset is more broadly applicable, than those commonly applied within the discipline of professional project management. Recognizing that project management is itself a process, Six Sigma is potentially applicable to its improvement.

Both sets of practices bring value and are best applied in conjunction with one another.
### Figure 2: Production Management Process Groups and Knowledge Areas
(Source: Project Management Institute)

<table>
<thead>
<tr>
<th>Process Groups</th>
<th>Initiating</th>
<th>Planning</th>
<th>Executing</th>
<th>Controlling</th>
<th>Closing</th>
</tr>
</thead>
<tbody>
<tr>
<td>4. Project Integration Management</td>
<td>4.1 Project Plan Development</td>
<td>4.2 Project Plan Execution</td>
<td>4.3 Integrated Change Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Project Scope Management</td>
<td>5.1 Initiation</td>
<td>5.2 Scope Planning</td>
<td>5.3 Scope Definition</td>
<td>6.4 Scope Verification</td>
<td>6.5 Scope Change Control</td>
</tr>
<tr>
<td>6. Project Time Management</td>
<td>6.1 Activity Definition</td>
<td>6.2 Activity Sequencing</td>
<td>6.3 Activity Duration Estimating</td>
<td>6.4 Schedule Development</td>
<td>6.6 Schedule Control</td>
</tr>
<tr>
<td>7. Project Cost Management</td>
<td>7.1 Resources Planning</td>
<td>7.2 Cost Estimating</td>
<td>7.3 Cost Budgeting</td>
<td></td>
<td>7.4 Cost Control</td>
</tr>
<tr>
<td>8. Project Quality Management</td>
<td>8.1 Quality Planning</td>
<td>8.2 Quality Assurance</td>
<td>8.3 Quality Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9. Project Human Resource Management</td>
<td>9.1 Organizational Planning</td>
<td>9.2 Staff Acquisition</td>
<td>9.3 Team Development</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10. Project Communications Management</td>
<td>10.1 Communications Planning</td>
<td>10.2 Information Dissemination</td>
<td>10.3 Performance Reporting</td>
<td>10.4 Administrative Closure</td>
<td></td>
</tr>
</tbody>
</table>

#### 5.2.1 Six Sigma and PMBOK Process by Process

**PMBOK Initiating Process** - This PMBOK process group relates most directly to “Define” in Six Sigma. This first phase or process includes preparation of a project plan and assignment of a project manager.

**PMBOK Planning Process** - The Six Sigma thought process and tools have many intersections with this process group. The PMBOK areas most closely related and the most prevalent Six Sigma connections to each may be summarized as follows:

- **Project Plan Development, Scope Planning, Scope Definition** - “Requirements failures” are one of the most common problems encountered in project planning. Six Sigma’s DFSS brings a rich toolset to address these issues, including Kano classification, needs/context distinction, KJ analysis, and other language processing tools that help to reveal latent and unstated requirements – sound planning begins with a clear understanding of the voice of the customer.
• **Project Time and Cost Management** - Six Sigma tools also help to prevent “expectations failures” caused by poor estimates and inadequate exploration of prioritization and feature selection issues. Six Sigma brings tools such as analytical hierarchy process, conjoint analysis and concept selection scorecards that promote fact-based conversations between the project team and the customer. Proper use of this set of Six Sigma tools will eliminate the occurrence of political decisions about schedules and budgets that commit project teams to run the proverbial “three-minute mile.” (The world record stands at about 3:40.)

• **Quality Management** - Six Sigma’s emphasis on predicting and managing “capability” together with tools such as defect containment scorecards promotes understanding and managing the economic consequences of escaped defects. Six Sigma tools such as combinatorial methods and Markov chains can be applied to improvement of testing processes.

• **Risk Management** - Six Sigma tools such as Monte Carlo simulation (if not already being used) can find application within the context of professional project management.

**PMBOK Execution Process** - Six Sigma can complement product project execution primarily in the areas of risk management and in optimization through application of tools such as design of experiments, which can be used to find “what’s best” solutions.

**PMBOK Controlling Process** - Six Sigma complements Controlling in two primary ways. First, as it solves problems at root cause, it tends to prevent problems from reoccurring. Second, in the final step of the DMAIC improvement process (Control), controls and responses to special cause variation are institutionalized so that reaction to control issues is both rapid and sound.

According to the above, it is clear that Six Sigma can complement and extend professional project management, but cannot replace it. Both knowledge areas make important contributions to successful business outcomes.

**5.3 Necessary Qualifications for a Six Sigma Project Manager**

If someone wants to work as a Six Sigma project manager, there are some qualifications that it is necessary to have. First of all, he must have a [Six Sigma certification](#). This certificate must
indicate that he can perform the methodology at the Green or Black Belt Level. There are different levels of certification. To become a manager, he will need more than the basic Yellow Belt. It is also important to have a college degree, industry experience, management skills, and project experience.

Some people have worked in their business positions without a higher education. However, to obtain and keep a managerial position, they will need to make themselves better candidates than anyone else. Getting a four year college degree is a beginning. However, a graduate education will put you even further ahead to start.

It is impossible for someone to work in the Six Sigma field without some level of certification. This happens because he does not know the practices and procedures to follow as he is not well trained. When he enrol in Six Sigma Training, he can understand better the total amount of useful information in order to achieve his business success. After this training, everyone is able to know how to solve problems and come up with solutions for the employer or clients.

If someone has experience on an actual Six Sigma Project, he can put that on his resume. Sometimes a trainer will help the trainee to work on real cases studies during his training. But in the real world, people want to know that you can affect change on actual business processes. If someone has the experience and can achieve a marked improvement, this is another way to increase his advantage.

As a project manager you will be required to work with a team and even supervise it. If you have any managerial experience, it will help to fortify that you can do the job. Every team needs a leader. If someone does not have experience as a leader, he has to try to take leadership courses and ask for leadership responsibilities at his current position.

It may seem obvious, but someone needs to know how to effectively use a computer. He will need to know more than just basic operating procedures. It is good to understand all computer software that will be used to document and report his quality findings. He does not just need to be computer literate, but proficient.

One cannot simply get certified and expect to obtain a Six Sigma project manager job. There
are many attributes that are needed to get the position. These are managerial skills, computer knowledge, higher education and degree, industry experience and project experience. It is important that you stand out to the person doing the candidate selection. These qualifications will get you noticed. If you have them, you are one step closer to getting hired.

Effective project management is a huge benefit to any business, and incorporating the principles of Six Sigma into the project management process is a great way to increase overall project success rates. Too often projects fail because the system that designed to implement them was not properly organized from the beginning.

Chapter 6

Conclusions

In the first chapter of this Thesis includes the introduction of this thesis and the methodology that we used for this. Also, the methods that used for qualitative assessment of this thesis referred to this chapter. Reliability and Validity definitions are referred in order to explain the reliability and validity of this thesis.

The second chapter defines the project and its characteristics. Further, the project management areas, tools, project manager and his roles were described theoretically. It is also, referred the importance of project management and how it can be applied in order to be a useful tool for each company.

The third chapter gives the information about the worldwide Project management tool Six Sigma, its theoretical structure and application algorithm. This strategy is a result of quality search. Quality is the first step of success and becoming a market leader so it has a big importance. Because of that Six Sigma is attracting the attention of the companies. Today the main problem of the companies is not being successful, is keeping the success. The most important thing is for Six Sigma, it brings long term improvements. Also this method
emphasizes the importance of customer in every step. The priority is customer satisfaction for Six Sigma.

In the forth chapter, there is a application of Six Sigma Project. According to this Project, a process has a nonconformity rate 5,07% and 340000 Euro/ year potential risk has been improved and nonconformity rate has been decreased to 0,008% with a 4,6 sigma level.

And finally the chapter five answered to the most common question ‘How does Six Sigma relate to the Project Management’. In this part the differences between Project Management and Six Sigma were explained and Six Sigma Process was given according to PMBOK. Moreover characteristics of Six Sigma Projects and Six Sigma Project Manager were stated.

Competition is the main purpose for every company. To stat in the market can be done only offering the desired product/service with the highest quality and lowest cost. Because of that, companies should solve faced problem with a suitable method and Six Sigma is one of the strong method.
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**Six Sigma: a goal-theoretic perspective**

Kevin Linderman*, Roger G. Schroeder1, Srilata Zaheer2, Adrian S. Choo3

*Curtis L. Carlson School of Management, University of Minnesota, 3-150 CarlSMgmt Building, 32-19th Avenue South, Minneapolis, MN 55455, USA* Received 18 April 2001; accepted 2 May 2002

**Six Sigma: Definition and underlying theory§ Roger G. Schroeder a,*, Kevin Linderman a,1, Charles Liedtke b,2, Adrian S. Choo c,3a Curtis L. Carlson School of Management, University of Minnesota, USA b Strategic Improvement Systems, LLC Excelsior, MN, USA c Lally School of Management and Technology, Rensselaer Polytechnic Institute, USA Available online 22 June 2007**

**Six Sigma and Information Systems Project Management: A Revised Theoretical Model**

Wei Yong Zhang, Department of Management, School of Business, Virginia Commonwealth University, Richmond, VA, USA Xiaobo Xu, Department of Management Information Systems, School of Business and Management, American University of Sharjah, Sharjah, United Arab Emirates 2008

**Critical success factors of Six Sigma implementations in Italian companies**

Alessandro Brun Department of Management, Economics and Industrial Engineering, Politecnico di Milano Via G. Colombo, 40, 20133 Milan, Italy 2011