MINIMIZING SLA TIME USING SIX SIGMA DMAIC METHOD IN A MULTINATIONAL COMPANY

BUSE BUDUR

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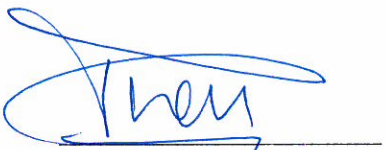
Dr. Öğr. Üyesi Pınar FALCIOĞLU (Tez Danışmanı)	Işık Üniversitesi	
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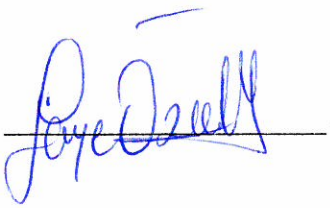
Doç.Dr. Gaye ÖZÇELİK	Bilgi Üniversitesi	

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ABSTRACT

Today, the sectors are affected by the rapidly changing economic conditions. For this reason, service industries face global competition. The biggest problems of these industries are decreasing profit margins and high quality service demand. In today's economy, the sales price is mostly determined by the market, not by businesses. For this reason, businesses that carries out their processes effectively and efficiently can compete in today's economic conditions. Companies try to implement various strategies and innovations to improve their service quality processes. The first coming to mind and the most powerful philosophy for process development is Six Sigma. The aim of Six Sigma is to reduce cost and waste, to provide high quality service, and increase efficiency.

Development methods were compared and as a result, DMAIC was chosen for the project. DMAIC is one of Six Sigma's most effective methods. Applying DMAIC is a good option for the development of the process, as the cause of the errors is not clearly visible in the processes. It is also a business strategy that helps to meet customer needs and expectations. Therefore, the Six Sigma DMAIC methodology has been applied to increase the quality of service provided to internal and external customers, to reduce time wasting and to increase the efficiency of the process. The steps of the implemented project are also explained in this thesis.

In the study, Six Sigma is generally mentioned firstly and then DMAIC method and its steps are explained. Then, the phases in the implemented project are explained. The applied techniques in the five phases of the DMAIC project are included. The project has been implemented in an international company from the service sector to develop processes and improve service quality. The team to which the project is implemented receives extensive demand during the day. The time of meeting each request is calculated and the global target is four hours on average. Team

performance can be calculated by drawing reports over a global system used by the company. The initial measurement shows that the average turning speed is seventeen hours.

As a result, with the implementation of the DMAIC project, the average turning speed is reduced to two hours.

Keywords: Servise Quality, Process Development, Six Sigma, DMAIC

ÖZET

Günümüzde sektörler hızla değişen ekonomik şartlardan oldukça etkilenmektedir. Bu sebeple, hizmet endüstrileri küresel rekabet ile karşı karşıya kalmaktadır. Bu endüstrilerin en büyük sorunları azalan kar marjı ve yüksek kaliteli hizmet talebidir. Bugünün ekonomisinde satış fiyatı daha çok işletmeler tarafından değil, piyasa tarafından belirlenmektedir. Bu nedenle, süreçlerini etkin ve verimli şekilde yürüten işletmeler, bugünkü ekonomik koşullarda rekabet edebilmektedir. Şirketler, hizmet kalitesi süreçlerini geliştirmek için çeşitli stratejiler ve yenilikler uygulamaya çalışırlar. Süreç geliştirmeye yönelik ilk akla gelen ve en güçlü felsefe Altı Sigma'dır. Altı Sigma'nın amacı, maliyeti ve israfı azaltmak, yüksek kaliteli hizmet sağlamak ve verimliliği arttırmaktır.

Geliştirme metotları karşılaştırılmış ve sonucunda proje için DMAIC seçilmiştir. DMAIC, Altı Sigma'nın en etkili metotlarından biridir. Süreçlerde hataların nedeninin açık bir şekilde görünmemesi sebebiyle ve sürecin geliştirilmesi için DMAIC uygulamak iyi bir seçenektir. Aynı zamanda, müşteri ihtiyaç ve beklentilerini karşılamaya yardımcı olan bir iş stratejisidir. Bu nedenle, iç ve dış müşteriye verilen hizmetin kalitesinin artırmak, zaman israfını azaltmak ve sürecin verimini artırmak için Altı Sigma DMAIC metodolojisi uygulanmıştır. Bu tezde de uygulanan projenin adımları anlatılmıştır.

Yapılan çalışmada ilk olarak Altı Sigma'dan genel olarak bahsedilmiş sonrasında ise DMAIC metodu ve adımları anlatılmıştır. Daha sonra uygulanan projedeki adımlar anlatılmıştır. DMAIC projesinin beş adımında uygulanan tekniklere yer verilmiştir. Proje hizmet sektöründen uluslararası bir firmada süreç geliştirmek ve hizmet kalitesini artırmak adına uygulanmıştır. Projenin uygulandığı ekip gün içerisinde

yoğun olarak talep almaktadır. Her talebin karşılanma süresi hesaplanmakta olup küresel hedef ortalama dört saatir. Ekip performansı şirketin kullanmış olduğu global bir sistem üzerinden rapor çekerek hesaplanabilmektedir. Başlangıçtaki ölçüm ortalama dönüş hızının on yedi saat olduğunu göstermektedir.

Sonuç olarak, DMAIC projesinin uygulanması ile ortalama dönüş hızı iki saate düşürülmüştür.

Anahtar Kelimeler: Hizmet Kalitesi, Süreç Geliştirme, Altı Sigma, DMAIC

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ABBREVIATIONS

DMAIC: Define-Measure-Analyse- Improve-Control

SIPOC: Supplier-Input-Process-Output-Customer

VOC: Voice of Customer

VOB: Voice of Business

CtC: Critical to Customer

CtB: Critical to Business

CL: Control Limit

UCL: Upper Control Limit

LCL: Lower Control Limit

SLA: Service Level Agreement

JIT: Just In Time

BPR: Business Process Reengineering

VST: Value Stream Transformation

CHAPTER 1

INTRODUCTION

The Business world is more competitive with the advancement of technology and increasing opportunities, and at the reached point, providing high quality service to internal and external customers puts forward the firms. Foundations have to be profitable by offering high quality at low cost to survive in the market. In other words, businesses that can carry out their processes effectively and efficiently can compete in today's economic conditions; Others cannot make their successes permanent in the short term.

This thesis explores methodologies to find the best method for process development and offers a solution to reduce errors. The steps of a development project carried out in an international company that attaches great importance to improvement will be explained in the thesis. The company always includes development projects in accordance with its strategy. Nowadays, Six Sigma attracts attention and is applied in many companies in order to increase profitability, efficiency and service quality.

In this study, the Six Sigma DMAIC method is followed to reduce defects in the company. At the end of the project, the relevant firm has taken its service quality to the next level and further strengthened its competition in the market. The DMAIC approach has been used to provide a better service quality to both internal and external customers. For a team that meets the demands of the customers intensely, the speed of the first touch to the demand is significant. Therefore, in order to provide a better service, the work process of the team should be examined. The initial turning speed is evaluated with weekly data as of April 2019, the starting point of the project.

The aim of this thesis is to show the phases of the service level agreement, which has been reduced from seventeen hours to four hours with the help of the DMAIC method.

CHAPTER 2

LITERATURE REVIEW

According to review, there are many researches regarding to Process Development. It can be seen that Six Sigma is the best choices for this topic. Some articles are examined below. In these articles, DMAIC method is chosen. Starting from this point of view, DMAIC is chosen for the project which is mentioned in this case study.

- **Accommodation Sector**

  One of the article that used DMAIC method is "*Integrating the Six Sigma Approach in Service Sector and Practicability of the Six Sigma in Lodging Companies*" . It is a case study about Sheraton Hotel. Due to the increasing costs, a development project is needed. The hotel is addressed the problem by implementing the Six Sigma project. Cost is reduced with the personnel planning method. The Six Sigma method profits the business. As a result of the project, a profit of 177.43 thousand dollars is achieved. The variability in costs is also reduced to 30.44% . (Yüksel, 2008)

- **Food Sector**

  Another example in service industry is *"Process Improvement Methods and Six Sigma Practices A Business Case"*. It describes a study carried out in a company that distributes pizza. In this study, the main goal is to shorten the delivery time and reduce customer complaints. As a result of the DMAIC project, an average improvement of 2.2 minutes is achieved in the packaging time, in addition to this, a much better improvement in standard deviation is achieved. (Eren, 2017)

McDonalds reduced costs and time losses, and made more hamburgers at once based on customer needs with 6 Sigma. (Marx, 2005)

Maidstone Bakeries wanted to improve the quality while streamlining production operations at the same time. By identifying where the production losses are, they reduced the cost by 80% and increased the productivity. Thus, earned substantial money such as several hundred thousand dollars.(Marx, 2007)

- **Banking Sector**

Bank of America has developed products to meet the needs of their customers using Six Sigma tools. In this way, a financial increase of over 300 million dollars was achieved at the end of 2002. In 2004, this increase reached 2 billion dollars. (Przekop, 2005)

GE Capital increased on-time deliveries by 85% and reduced billing errors by 87% with Six Sigma. (Araslı and others, 2006)

JP Morgan Chase has achieved more than 400 million dollars in financial benefits with their Six Sigma projects, focusing on customer and service levels. (Marx, 2005)

- **Health Sector**

Özveri and Din çel observed that the number of patients doubled, the time of treatment starting and pre-treatment waiting decreased, customer satisfaction increased and polyclinic revenues increased 100% thanks to the six sigma they applied in a hospital in 2012. (Özveri and Din çel, 2012)

In 1997, General Electric Medical systems gained 40 million dollars thanks to Six Sigma. (Araslı and others, 2006)

- **Transportation Sector**

The other research name is *"Using Six Sigma Methodology to improve the performance of the Shipment Test"*. It also gives an introduction to the Six Sigma methodology. The test campaigns' ninety three of percentage are aimed to be completed on time. Finally ninety three of percentage of test campaigns is finished on time and project goal is fulfilled. (Bin, 2015)

Air Canada started to apply Six Sigma in 2002. Today, over 1800 projects have been implemented and the business has gained more than 450 million dollars in financial benefits. (Marx, 2005)

- **Production Sector**

"DMAIC Approach to Solder Printing Process in Printed Circuit Boards" focuses on improvement of printing process. The study 's aim is reducing defect rate, raising the current sigma level in the printing process in order to increase yield. The problem is addressed using Six Sigma approach with help of DMAIC methodology. Thanks to implementation defects reduces from 243 to 118 per million of opportunity by applying DMAIC methodology. (Gider, 2018)

A case study which is named *"Minimizing the Defect Rate Using Six Sigma DMAIC Method; A Case Study in Supsan AŞ"* is presented in Supsan for defect reduction. DMAIC approach is also found more suitable for this project. Valves are forged laterally after the DMAIC project. The thickness of the valves is done better. The time to enter the regime is shorter. The rate of waste is reduced from 4.34% to 2% thanks to DMAIC Project. (Aslan, 2016)

CHAPTER 3

SIX SIGMA

3.1 Defination of Six Sigma

Sigma, σ , is a letter in the Greek alphabet used by statisticians to measure variability in any process. Six sigma is a disciplined and data-oriented methodology that goals to reduce errors in all kinds of processes from the service sector to the production sector. Combining the elements of the work of many quality pioneers, Six Sigma aims for nearly error-free business performance. It provides very effective results with its proven quality principles and techniques. Mikel Harry who is CEO of Six Sigma Academy says that Six sigma is not an improvement program. It is instead a business philosophy that employs a step by step approach to reducing variation, increasing quality, customer satisfaction, and in time, market share. (Selvi and Majumdar, 2014)

Six Sigma attracts a lot of attention for companies around the world because this principle affects companies of all sizes. If companies apply Six Sigma technologies, they will see significant improvements in quality, production, customer service and profitability. The Performance and business processes of a company are measured by sigma level. If companies adopt that the service should be faster, they can increase customer value. This is the basis for a better relationship with customers. Companies acquire a measurement-based strategy that focuses on process improvement with Six Sigma improvement projects. The measurable and consistent clear results provide six sigma is without alternatives. Table 3.1 represents the sigma performance level for the current projects. Based on developed calculation it is possible to monitor on which sigma level a company operates at the current moment. (Sahno and others, 2013)

Table 3-1 : Sigma Performance Level

Sigma Level	Defects per Million	Yield
6σ	3.4	99.99966%
5σ	230	99.977%
4σ	6,210	99.38%
3σ	66,800	93.32%
2σ	308,000	69.15%
1σ	690,000	30.85%

3.2 History of Six Sigma

Six Sigma, a measurement methodology, traces to the early industrial era in Europe during the eighteenth century. First, Carl Frederick Gauss introduced the normal curve (1777-1855). Than, Walter Shewhart showed how a three sigma deviation from the mean required a process correction and six sigma has appeared. (Bhargav, 2019)

In the 1970s, a Japanese company took over a Motorola factory producing television sets in the United States, and the Japanese began to make changes to the way the factory works. The Japanese changed the facility's operations. (Bubevski, 2018)

In 1981, with their scientific method and persistent efforts, the yield controlled at approximately 95% and this result was got above expected. In 1987, Motorola's Six Sigma Quality Program was created by B. Smith. (Devane, 2004)

3.3 Methods Comparison

In this study, the methods are examined. As a result, Six Sigma DMAIC method is chosen to help minimize time waste in the process. The Six Sigma implementation provides competitive advantage for businesses in recent years. DMAIC is decided to implement because it is not clear what caused the problem in the process and the whole process should be observed.

There are many methods used in defect reduction projects. These methods depend on the size and industry of the company. Among these methods, Six Sigma DMAIC method has data-based results. The DMAIC process includes defining the main problem, identifying root causes and improving them. It aims to have a long-lasting solutions. The Dmaic method is reliable and result oriented. Six Sigma also has customer focus and continuous improvement. In addition, Six Sigma reduces defects in process performance.

3.3.1 Kaizen

Kaizen is a methodology aims at short-term improvement. Also, Kaizen is a team-based development. In addition, Kaizen is used for urgent improvement issues and gives immediate results. Kaizen is a Japanese workplace philosophy that focuses on continuous improvements and is also a customer-focused strategy. This scientific approach uses statistical quality control and focuses on zero defects. That's why Kaizen puts emphasis on problem awareness and problem identification.

Kaizen has advantages such as developing to self-managed groups and consolidating teamwork. It also helps to lead understanding of change and realize the value of employee effort. On the other hand, Kaizen has the disadvantage of permanently changing the management system because it is difficult to return to the previous management system and it is difficult to apply to different contexts. It is an active

problem solving approach. Kaizen gives employees a sense of purpose and eliminates the need for inspection.

Kaizen has some limitations that should be considered before deciding on the application. Kaizen resets stratagies and approaches. For this reason, if they are not ready, it can be difficult and cause problems in the business. Companies must be open to change so that employees can easily express their opinions. Companies need to bring a change in their way of operating and mindset, but sometimes this is difficult and the initial problems created can be very bad for the business. There may also be problems adapting to a new management style. In this case, they cannot get the results they expected.

The team improves the process or problem in a specific area. The team meets to study stages such as discovery, analysis, brainstorming, and implementation. The team takes a tour to understand the initial process flow, the products produced, the machines used. The team collects data from the defect history, current situation, demand. In the last stage, the outstanding ideas are applied. Kaizen; is process centric and can identify what went wrong and reduce defects.

3.3.2 Jidoka

This method is human integrated automation and can be applied to all processes. It aims to stop the bad production or defects in production. The principle of this method is to stop the error and finalize it. Detecting the abnormality, correcting it, investigating the root cause, and taking action are Jidoka's steps. A company needs Jidoka because JIT cannot function effectively without Jidoka. Jidoka includes human judgment, assigns responsibility to the employee and optimizes quality. It also prevents equipment failures and provides high-quality products, increasing productivity.

3.3.3 Business Process Reengineering

Business process reengineering is a business management strategy and devised in the early 1990s. It focuses on the analysis of work flows in the company. BPR aims to improve customer service and reduce costs. Re-engineering focuses business objectives to reach. It encourages to reviewe the whole process in order to increase efficiency and reduce costs. All processes are followed by management. It allows the products to be delivered to customers quickly. On the other hand, there are some disadvantages like that it is very difficult to apply. Employees resist such big changes. For this reason, it is important to get support and approval from senior management. In addition, it may not be suitable for all processes or for all organizations.

3.3.4 Value Stream Transformation

Value Stream Transformation is addressed by realizing the need for change in the company. The application continues with a detailed analysis and future planning. It contributes to minimizing the time from the beginning of the process to its completion. It eliminates defects by increasing productivity, quality and efficiency. It provides a clear view of all processes involved in the workflow. It helps to identify waste, source and where changes need to be made. Also, VST helps identify the main problems and standardizes the process. On the other hand, VST cannot be success If the prodcts do not have same maps and transportation.

3.4 Six Sigma in Service Industry

The purpose of the Six Sigma methodology is to focus decreasing the instability and improving the process in improvement projects. It is a strategic implementation based on measurement. The Six Sigma methodology has been developed for perceptible products, mostly production-based. Later, there is also a need to improve the impact of this methodology in service.

Six Sigma in Service Industry; It is a business development methodology that maximizes stakeholders in order to reach the best point in customer satisfaction, cost, quality, process speed and capital. The Six Sigma methodology does not handle applications under two separate headings as the service sector and the production sector. Six Sigma can be applied successfully in both areas. It attaches importance to the business processes of the service companies as much as the production processes and strives for improvement. Whether it is a production or a service oriented business, perfect products and processes are seen to be the foundation of success. A product or a process should do what is right for the customer. This means that products or processes are created continuously and without error. In the Six Sigma consept, defect is described as anything that does not meet expectation of customers. (Antony, 2004)

However, in the service sector, the human factor, the perspectives of the employees, past application experiences, the structure of the work, relations, project management approach and error rates are different from the production sector. Due to this difference, the trainings and cases should be suitable for the structure of the sector. Research shows that even less than ten percentage of service processes are dedicated to satisfying customers. The rest of the time is spent doing jobs that are not required at all. When the factors that support the competitiveness in business life increase, It is seen that the areas waiting to be developed are also more. In this respect, the service sector needs Six Sigma and quality management tools at least as much as other sectors.

Six sigma is applied in many areas such as transportation, banking, insurance, health, food and accommodation which provides service. Internal and external customers are in one-to-one communication in almost all processes in the service sector. Therefore, it is seen that the human factor is involved in all processes. The service sector includes processes that are more likely to make mistakes, and have a very low tolerance to compensate for mistakes than other sectors. When the service is provided to the customer without any control, it causes internal and external customer dissatisfaction. Providing the service on time is very important for quality because it

is not possible to store or hold the service. It is essential to optimize the chain of demand forecasting, inventory management, marketing, sales management and after-sales support in order to provide the best service to customers and gain their loyalty. Six Sigma tools are a good way to analyze and optimize this chain because the companies that implement the Six Sigma try to approach as close to zero defect as possible by eliminating errors systematically.

The basis in determining the service quality is to decide what to measure. Financial results, service speed, customer satisfaction and response time are values that can be measured in the service area. 6 Sigma is successfully applied in the improvement of these processes. Using the 6 Sigma methodology to solve business problems can provide a significant improvement in results and an improvement beyond expected in service quality.

CHAPTER 4

SIX SIGMA METHODOLOGY – DMAIC

DMAIC is a method which is the main constituent of Six Sigma. Also, it goals to improve processes. This methodology is fundamental to Six Sigma process improvement projects. DMAIC is the term that used to describe the phases of the approach taken in a Six Sigma project for achieving continuous improvement. If the product or service under consideration is still at the early stages of development or major design changes are required, the five phases that are used become DMAIC (Define, Measure, Analyze, Improve, Control). (Salah and Carretero, 2019) DMAIC projects are applied to provide decreasing cost, time and defect. DMAIC consists of five phases. These phases are Define, Measure, Analyse, Improve and Control respectively. There are many tools available for every phase. In a DMAIC project, each phase should be implemented step by step and no phase should be skipped. See Fig 4.1. The define phase, which is first one, can always be returned and revised step by step. The DMAIC cycle is a disciplined, well-structured methodology used not only to locate the causes of defects within a service quality, but also to eliminate the root causes of defects and improve service quality. (Karakhan, 2017)

Figure 4-1 : Six Sigma - DMAIC Steps

4.1 DMAIC Phases

When applied for performance improvement of an existing product, process, or service, the Define-Measure-Analyze-Improve-Control, or DMAIC model is used. DMAIC is summarized in Fig. 4.2. (Pyzdek and Keller, 2010)

D	Define the goals of the improvement activity, and incorporate into a Project Charter. Obtain sponsorship and assemble team.
M	Measure the existing system. Establish valid and reliable metrics to help monitor progress toward the goal(s) defined at the previous step. Establish current process baseline performance using metric.
A	Analyze the system to identify ways to eliminate the gap between the current performance of the system or process and the desired goal. Use exploratory and descriptive data analysis to help you understand the data. Use statistical tools to guide the analysis.
I	Improve the system. Be creative in finding new ways to do things better, cheaper, or faster. Use project management and other planning and management tools to implement the new approach. Use statistical methods to validate the improvement.
C	Control the new system. Institutionalize the improved system by modifying compensation and incentive systems, policies, procedures, MRP, budgets, operating instructions and other management systems. You may wish to utilize standardization such as ISO 9000 to ensure that documentation is correct. Use statistical tools to monitor stability of the new systems.

Figure 4-2 : Overwiev of DMAIC

4.1.1 Define

In Define phase, the project is explained. The scope and purpose of the project is specified. Define phase should be created according to the requirements and expectations. The project limits and the mission of the project are designated at the end of the define phase.

This section contains the project charter and explains the Voice of the Customer (VOC), understands the process. Also, some tools which are SIPOC and Frame can be used to overview the process and scope in Define phase. Defines problem

statement and goal statement. It develops the process map, collects business requirements, develops communication plan and finalizes the project charter. This phase includes selecting projects, determining process parameter input, creating process flow chart, selecting project team members, creating execution plan. After determining which topic to work on, resources and milestones are engaged to complete these steps. The completed process map provides a visual throughout the project and also helps to more specifically identify the customer's needs and requirements for the particular process being developed. A clear statement of the project should be written, a basic timeline should be created and a business case should be developed.

As a result, this section begins with problem identification. The purpose and resources of the project should be defined. This part helps to understand the needs of customers, defines the target statement.

4.1.2 Measure

The subject of a DMAIC project should provide quantifiable data. In Measure phase, a data collection plan is developed and the existing process is measured but firstly baseline is determined. Then, the data is constituted validly and reliably. These valid and reliable data help monitor progress towards the goal defined at the previous phase.

As a result, the initial process at the end of this phase is measured and documented. Data are collected here to be evaluated during the analysis phase. It is important not to jump to solutions and results. Metrics are the basis for factual decision making.

4.1.3 Analyse

The analysis phase verifies the root causes of the problems. The aim is to determine the cause-effect relationships in the process by using the data in the measurement phase. At the analysis stage, many methods are applied to evaluate the data, and there are many useful tools at this stage. The combination of data analysis and process analysis is used to achieve root cause in projects. The reason why the problem exists appears in the Analysis phase. This part includes defining performance goals, identifying process capability and the sources of variation. Also, The aim of this stage is to determine and validate the root causation of the main issue.

In addition, fishbone technique can be used in this part. Thanks to this technique, negative factors affecting the process are seen more clearly. For each factor, two to three sub-refractions are created by asking the wh-questions. In this way, raw data are obtained and used for root cause analysis. Another element is the run chart. This graphic allows to detect trends, shifts or cycles in the analysis phase. The information obtained from the graph helps the project team to observe and focus the changes in the process.

All this information obtained in the analysis phase is used to improve the process in the next phase.

4.1.4 Improve

The Improve phase is the fourth phase in the DMAIC method. It focuses on solutions after the analysis phase. This section focuses on improving and optimizing service quality. This stage is where defects are eliminated or their effects will be reduced. In the improve phase, necessary studies are carried out to eliminate the causes of the defects causing the problem. At this stage, the team creates and selects a series of solutions to improve sigma performance by brainstorm. The best solution is chosen by the team to increase efficiency in the process. Results must be checked to find the

best solution. Solutions and customer needs are prioritized and selected, and then tested to see if the solution solves the problem. In addition, Run charts provide an overview of whether a solution has an impact on the process.

As a result, the improvement phase; develop process maps based on different solutions, choose the best solutions, implement solutions, measure improvement.

4.1.5 Control

Control is the last stage of DMAIC. This stage shows whether the activities and process improvements are sustainable. The aim is to ensure that the problem under consideration is not repeated and that the new process is further improved over time. The project team develops a plan at this stage to monitor and maintain the improved process. Actions determined and implemented in the previous stages should not lose their effect over time. This phase checks that the implementation will continue or not in the long term. The improved process should be followed. The proposed control phase length may vary from project to project, at least the Control phase takes several months. Once new routines have been applied, there is a risk that the methods will return to older applications. During the control phase, the documented new process conditions are checked by the control charts. Data of defects percentage and range indicates that the process is under control.

The last activity in the Control Phase is to close the project. Standardization and documentation of the new process, transmitting the details of the new process to others and closing the project are the results of the Control Stage.

4.2 Reason to Chose DMAIC Method

Six Sigma sheds light to companies on achieving specific goals and objectives. After comparing the methods, Six Sigma DMAIC that the most suitable method is decided for process improvement. DMAIC targets higher quality standards and lower defects related to customer needs. (Pykdek, 2000) It creates a culture of continuous improvement and changes the way of works by improving processes. Six Sigma enables employees to not only acquire new tools to solve problems, it also enables them to produce new approaches to problem solving by analyzing a process in a very methodical way. Six Sigma culture tries to collect input from different directions with the suggestions of the project leader and team members. Team members aim to find innovative solutions with brainstorming sessions. In Six Sigma projects, the DMAIC process is used to improve quality by reducing errors with data analysis. The Six Sigma/DMAIC Project will be the best approach, as in this thesis, if the aim of a company is to improve the process and increase customer satisfaction. Global competitiveness is almost impossible without Six Sigma. Every company can benefit by adopting Six Sigma concepts. DMAIC is the best way to eliminate and improve defects in the process. Six Sigma, DMAIC projects increase the company's performance and customer satisfaction. The quality is improved by analyzing the data. DMAIC identifies and resolves problems. It takes precautions to continue improvement. Thanks to the customer-oriented approach, efficiency is increased by reducing errors.

As a result, Six Sigma provides tools to improve services and improve quality. It is known as one of the important ways to develop competitive advantages to achieve excellence in quality. Six Sigma should be chosen to implement the project because it has many advantages among other methods. In addition, Six Sigma produces long-term success as it involves a cultural change.

4.3 DMAIC Roles

4.3.1 Executive

Executives represent the most senior level of leadership according to Six Sigma hierarchy. They support the team and program at every step. Also, they guide towards a successful and profitable Six Sigma implementation. Executives oversee the Six Sigma process and provide support on methods. They also enable projects to add value. In additional they provide the necessary resources for projects.

4.3.2 Champion

The Six Sigma Champions works with Executives and plays a critical role at senior or mid-executive level. It is the Champion's task to adapt a company's characteristics such as its vision and mission to the Six Sigma plan to suit the company's goals. Another responsibility of a Champion is to ensure the successful progress of the process. They should prevent the resistance of the employees about changes, fix the problems within the team, and ensure that the project is completed on time and successfully.

4.3.3 Process Owner

Process Owners are responsible for the business process of the Six Sigma project. Usually they are a senior manager and support the Champion during the project. Also, sometimes can be the sponsor for the project.

4.3.4 Master Black Belt

Master black belts are true experts about Six Sigma methodology and tools. As experts who have the most project experience, they have knowledge of statistical analysis and contribute to the completion of projects. Master black belts train and mentor black belts and green belts related with six sigma. They also assist the

Champion in project selection and have responsibilities to the champion for the process to proceed as planned.

4.3.5 Black Belt

Black belts have some skills such as leadership, communication and problem solving. They support Green Belts in realizing their projects. Black belts actively participate in the process of development projects and determine the project boundaries. They also reports project progress to leaders and helps champions.

4.3.6 Green Belt

Green Belts are trained in the use of Six Sigma methodology and tools and play a supporting role in improvement projects. They get involved in Six Sigma projects before getting the certification. Green Belts are involved in projects part-time to assist the process, collect data, measure and analyze.

4.3.7 Yellow Belt

Yellow belts are team members in the six sigma process. Yellow Belt is an entry position that helps Green and Black Belts in projects. They take the introductory training of six sigma. Then, they work for suitable projects and contributes to continuous development.

4.4 DMAIC Tools

In the process of Six Sigma implementation, statistical methods have a great importance in determining and solving problems. There are many tools used in statistical process control and the following tools are most commonly used.

4.4.1 Histogram

Histogram is a technique used to provide visual information about the behavior of the process and to decide where improvement efforts should be focused. Histograms usually show the frequency of an event. It also calculates how often the problem occurs in the specified time interval. Thus, it provides to work up to a result by comparing the shape of the distribution with the shape of a known distribution. It is used to understand variability in processes and to develop theories about the source of problems. If customer requirements are displayed in a histogram, it is easy to see how much customer needs are or are not met.

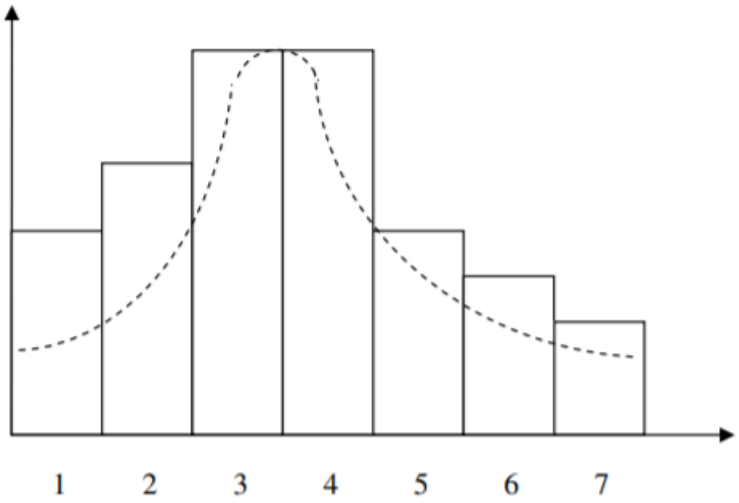

Figure 4-3 : An Example of Histogram

4.4.2 Flow Charts

Process flow chart is a schematic representation used to explain how the general process or sub-processes work. It is a visual representation of the process and helps team members to find solutions by identifying where problems occur. Process flow charts are visual representations of the path followed by a product or service in order to reveal deviations. In order to analyze the processes, flow charts should be prepared

firstly and measurements should be made to determine the current performance. The concept of flowchart present in production can also be applied in service. Generally, managers want to improve processes such as decreasing process cost and reducing waiting time. It helps to see the whole process and identify weak and strong areas. Flowcharts describe opportunities for improvement, inputs and variables in the process. It helps to reduce cycle time and errors by showing all steps of the procedure from start to finish. Flowcharts in critical processes document standard business procedures for projects.

Symbol	Name	Function
	Start/end	An oval represents a start or end point
	Arrows	A line is a connector that shows relationships between the representative shapes
	Input/Output	A parallelogram represents input or output
	Process	A rectangle represents a process
	Decision	A diamond indicates a decision

Figure 4-4 : Flow Chart Sembols

4.4.3 Brainstorming

Brainstorming is the combination of the personal opinions of a group of individuals to solve a problem. It aims to emerge many ideas by creating an atmosphere that facilitates participation. It is an activity that aims to reduce the variability in process performance. Brainstorming provides the group members who have different skills to produce ideas and solutions about a problem.

As in most methods, Six Sigma method uses brainstorming. The team can list possible measurements and improvement solutions by brainstorming method. In brainstorming, the subject is first explained to all members in a clear language. Some time is given to everyone for thinking and opinion of everyone is asked. One person takes note all the ideas described. Then, the most important ideas are identified and listed. This technique, which enables information sharing, plays a big role in solving problems. Brainstorming technique is widely used especially in problem solving processes. A common problem with brainstorming is that everyone thinks they are good at it, but work and discipline are required.

4.4.4 Pareto Diagram

The Pareto diagram allows the items that cause problems to be sorted according to their severity. It is an effective tool that helps to determine the actions to be taken. The Pareto diagram can be used in three dimensions. Error numbers in the left coordinate and error percentages in the right coordinate can be displayed cumulatively. There may be error types on the horizontal axis. This analysis clearly shows the most important error or factor. It provides a clear view of the situation before and after recovery by comparing the importance of the factors with each other.

According to the Pareto principle, 80% of the problem is caused by 20% of the causes. An example of using the Pareto diagram is to show customer satisfaction rates. All events that under investigation do not give the same effect on the result. Pareto

diagrams describe the problem that brings the highest cost and must be eliminated first. For this reason, it is frequently used in Six Sigma projects. Thus, the most effective point is focused on the project solution.

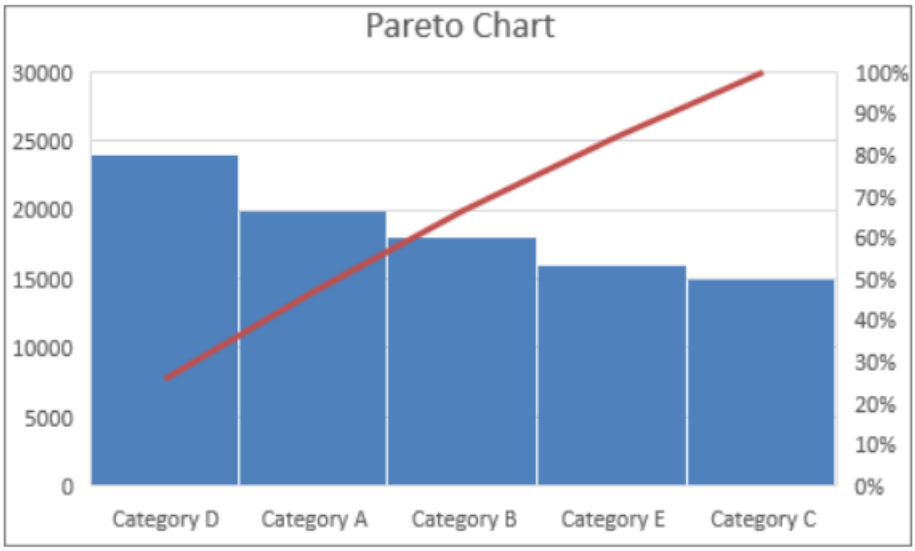

Figure 4-5 : Pareto Diagram

CHAPTER 5

STUDY IN COMPANY A

The company mentioned in this thesis is referred to as Company A because the project data are confidential. The mentioned company is an international company and industry leading at the same time. Customer satisfaction comes first for this company that continues its activities in the service sector. As a matter of the Company A 's strategy, customers are focus in every part of the process. Also, Company A attaches great importance to process development and plans studies and trainings to infuse the six sigma methods into each employee. Many improvement projects are carried out within the company, such as Gemba, 5s and DMAIC. Phases of a DMAIC project which aim to improvement and used methods in these phases are included in this thesis.

The project is implemented in a team that consists ten members to meet customer demands. This team, which has received the demands intensely, initiates the process by receiving the requests through a generic e-mail address. The DMAIC project was decided to be implemented because the late return to incoming requests caused customer dissatisfaction and the first touch to an e-maile is well behind the target.

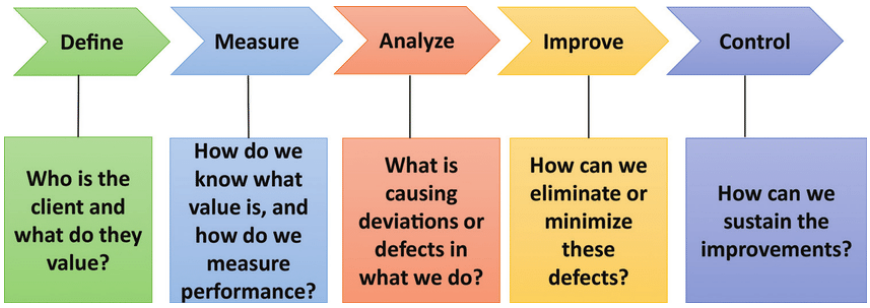

Figure 5-1 : DMAIC Template

5.1 First Phase

In the Identification phase, which is the first step of the DMAIC project, the problem and goal are determined. The goal in the project should always be to reduce the level of defect and increase efficiency. The team can be organized with people from different departments who will advantage gatherings in the project steps with their knowledge. At this stage, after the project charter is prepared, the scope for the process to be developed is determinated.

5.1.1 Project Charter

The project charter is a document that summarizes the project. The document includes the project team, business case, problem statement, and goal statement. The project charter is prepared by the project leader. The contract is very important for documenting the support received from the senior management of the Six Sigma approach, which will be implemented in the company. This Project Charter is intended to lead the project manager through the various activities when running a DMAIC initiative. It might serve other different purposes. These are to provide guidance and tool support for the project manager and team workers on the initiative and to be a communication tool for phase review and update meetings with stakeholders. The Charter provides corresponding guidance for the steps and activities to effectively use the DMAIC methodology on the job. It is the manager's responsibility to initiate the content of the project charter and to keep it up-to-date as the initiative evolves over time. The tools should be used and documented during the life-cycle of the initiative. Also, Project Charter includes business case, problem statement and goal statement.

- **Business Case**

  Business case shows the instant status of the process by numerical terms and it puts into words on why the project is implemented. A person looking at the business case should be able to see at which point the team is and why a development project is needed. In case of need, changes can be made above the business case in the later phases of the project. The business case on the implemented project is “Average SLA time is seventeen hours. The DMAIC project should be implemented due to customer-oriented action, reducing complaints and being above the global target. ” .

- **Problem Statement**

  Problem statement is a sentence that describes the problem in the process. It should include the targeted point with concrete numerical data. In the implemented project, the problem statement is "While the average return speed of the team to a demand is seventeen hours, the project should decrease to four hours until the end".

- **Goal Statement**

  Goal statement directly describes what the purpose is, with definite judicial statements, similar to the problem statement. The goal statement of the project is "A demand will be met in an average of four hours at the end of the project".

5.1.2 Scope

Since it is essential to be clear about the scope of the project, after the project charter is prepared, the scope in relation to the business case should be defined and started. Scoping is a vital part of the define phase and can have a long-term impact on a Six Sigma program’s ultimate success. (Lynch and others, 2003) SIPOC and In-Frame / Out-Frame are two tools that determine the scope of the project.

In the applied project, both techniques are applied. In the meeting with team members, the process is observed by applying SIPOC by sharing ideas. It is also decided what to include or not in the process of reaching the goal point by applying the In/Out of Frame technique.

As a result, minimizing the duration of the first touch to requests received after the study is decided. The resolution time of the request is excluded of the scope.

- **SIPOC**

  SIPOC is a table that allows you to see the flow of the process easily. It consists of the initials of five words. These words stand Supplier, Input, Process, Output and Customer. It is a high-level process map necessary to define the process in scope for the project by outlining the process in four to seven high level steps. SIPOC does not need to show any decisions points, only blocks indicating high-level activities. (Shankar, 2009)

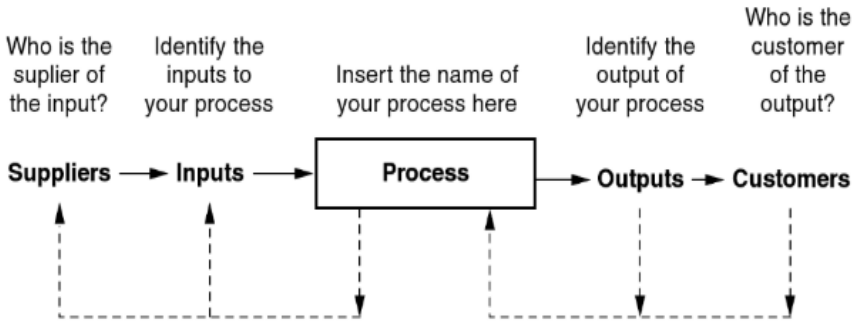

Figure 5-2 : SIPOC Flow

It helps to identify its starting and end point and creates an understanding of the process by highlighting who provides Input to the process (the internal or external supplier).

The SIPOC also identifies the customers whose complaints are the reason for starting this project (the Customer or the Business).

Process can be be designed as can be seen in the Fig 5.2 and Tab 5.1.

Table 5-1 : SIPOC

Supplier	Input	Process	Output	Customer

- **In/Out Frame**

  In/Out of Frame is another tool to refine the scope of the project or define roles. It supports to identify all elements that the project needs to address or which responsibilities are part of the role.

  In the team meeting, the topics that are aimed to be improved are written in a frame. Topics that will not be included are written outside the frame to ensure visual visibility.

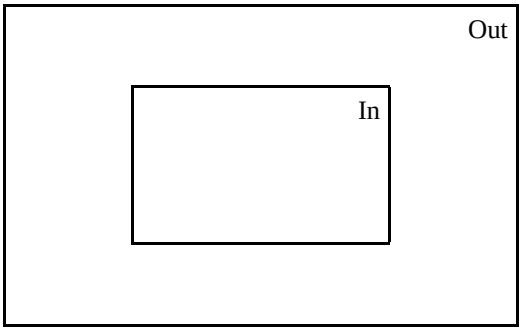

Figure 5-3 : In/Out Frame

5.1.3 VoC to CtC Matrix

In the last part of the Define phase, what is critical to the customer is determined. After the scope is clear, its time to understand the customer requirements. Customer orientation is one of the most important things in this whole process. (Ellis, 2016) The Voice of the Customer – VoC (or the business) needs to be collected and translated into what is Critical to the Customer – CtC (or the business). In the project, It should be needed to focus on determinated CTC / CTB.

To summarize the VOC / VOB and analyze customer / business requirements, the VOC - CTC Matrix is created. Then it transalates to CtC / CtB. First, how VOC/VOB is gathered is described. After that, what the problem is for the customer and the customer's need which is the key problem are written. Finally, what is critical to the customer is determined. It is important to be specific when determining CtC. A good CtC sentence can be expressed as "Every… must be ...".

In this study, Critical to Customer is "Every request must be answered within 4 hours".

Table 5-2 : VoC to CtC Matrix

Sources for VoC/VoB	Voice of Customer (VoC) / Voice of Business (VoB)	Customer/ Business Needs	Critical to Customer (CtC) / Critical to Business (CtB)

5.2 Second Phase

In the Measure phase of the study, the sigma level is calculated to evaluate the process performance according to the defect specifications determined in the Define phase. After the definitions are determined, what the defect is based on these specifications is determined. When the defects are compared, the Sigma level gives statistical insight into what is the root cause in the service process.

The data that provided by the system where the team meets the demand is organized and used for this study. It is important to determine the time period and frequency of measurement. The used data in the project is measured on a weekly data basis from April to July. Then the baseline is created with the available outputs. The control limit (CL), lower control limit (LCL) and upper control limit (UCL) are calculated and the run chart is created for the baseline.

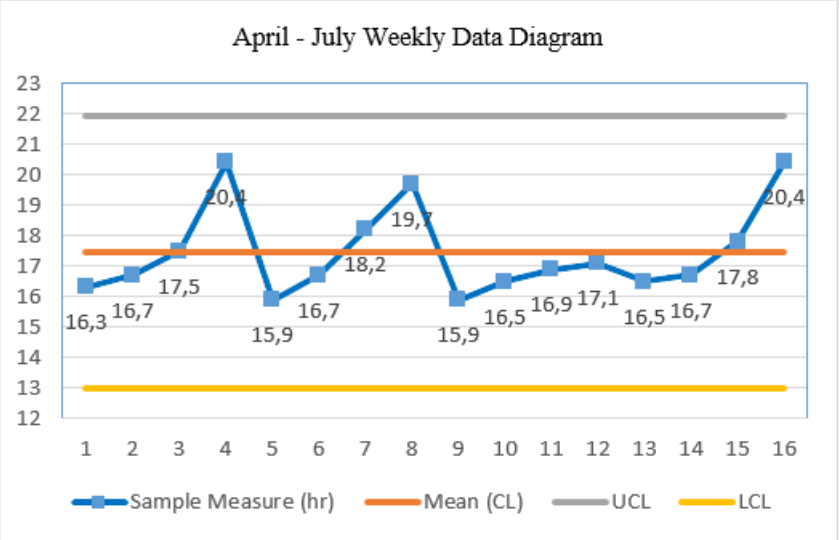

Figure 5-4 : April-July Weekly Data Diagram

5.3 Third Phase

At this phase, the root causes are analyzed and confirmed. Compared to the Define and Measurement phase, the Analysis phase is a place the action performed. For getting to the bottom of the issues and confirming root causes, meetings and brainstorms are required. The reason for not meeting the customer requirements to the desired extent is queried. In this phase, root causes are detailed.

5.3.1 Fishbone Technique

Fishbone technique is a good option for finding root causes. Brainstorming is done together with the team and/or specialists to find possible root causes and sub-causes using the fishbone technique. Further details can be explored using the Five Why Techniques to find real causes.

While applying the fishbone technique, the main reasons are thought through measurement, human, environment, machine, method and material, and the sub-reasons are addressed by Why questions. Why the CTC cannot be reached is written as a diagram. In this study, after the fishbone technique, twenty-two main reasons emerged from the question which is "Why can't the first touch in demand be achieved in an average of four hours?"

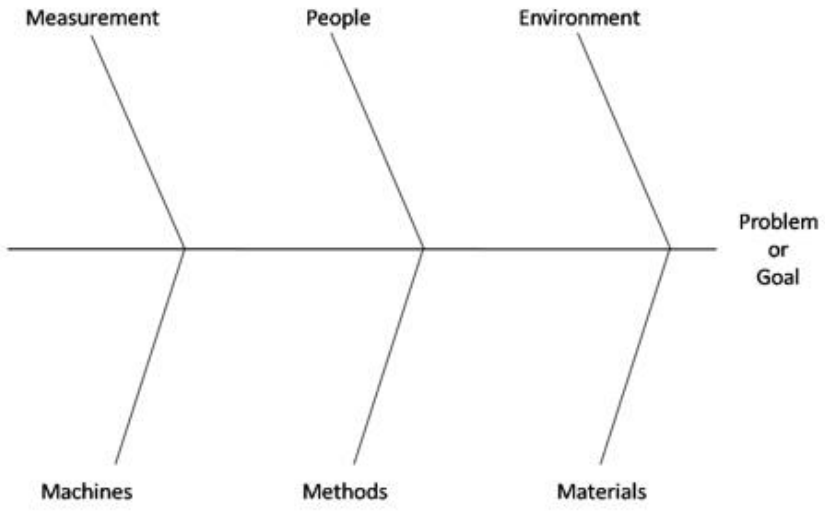

Figure 5-5 : Fishbone Technique Diagram

5.4 Fourth Phase

During the Improve phase, solutions are produced for the root causes determined in the Analysis phase and their feasibility is evaluated. Potential solutions need to be produced once accessible root causes have been identified. The team assembles and brainstorms to exchange ideas like the fishbone technique. Then, the determined solutions for the root causes are evaluated. The Effort-Benefit Matrix is a good method when deciding on the implementation of solutions. Thanks to the Effort-

Benefit Matrix, an overview and an indication of which solutions are the most promising are obtained.

5.4.1 Effort – Benefit Matrix

An effort-benefit analysis is the most commonly used technique in assessing and selecting the solutions that will be implemented. Thanks to this technique, the benefit of each solution and the expendable effort when the solution is suitable are seen simultaneously. Effort-Benefit Matrix evaluates the solutions according to their effort of implementation and benefit towards the solution. Ratings are adjusted after the solutions are visualized. Based on the matrix, the solutions that point to the higher benefit and the lower effort should be applied. According to the results of the analysis, it is decided which solutions to be applied. Then, SIPOC method is created again for the new process based on the changes. See Table 1.

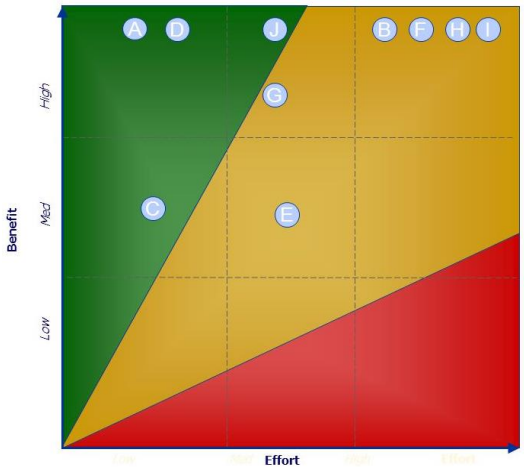

Figure 5-6 : Effort-Benefit Matrix

5.5 Fifth Phase

The Control phase is the last part of the project where the performance of the new process is monitored. After applying the solutions, the team is trained, processes are changed and performance needs to be monitored. In this study, a new process is

observed during three months. During this period, how much the results are improved and their continuity are evaluated by weekly data study. A new run chart is created with new data to see continuity. The new graphic is arranged according to August-October data. It is observed that the target fell further below in the run chart created at the end of the project. While the first touch time is targeted as four hours, the performance decreased to an average of two hours at the end of the project.

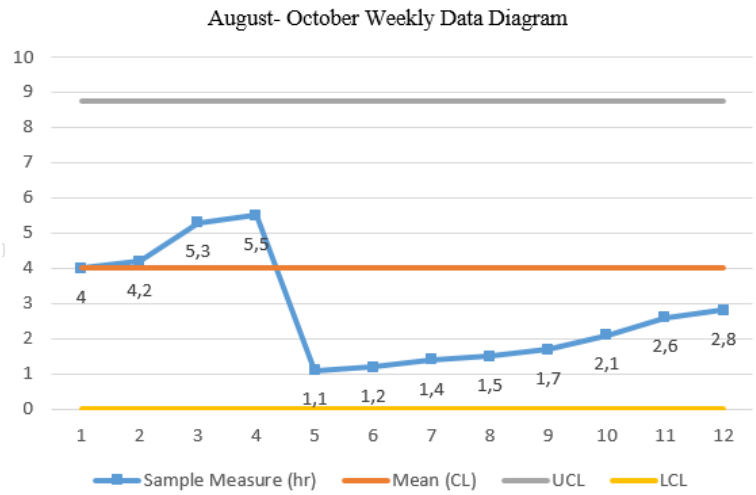

Figure 5-7 : August-October Weekly Data Diagram

CHAPTER 6

CONCLUSION

Companies should improve their service quality far and away the best in today's competitive world. In this sence, Six Sigma is regarded as a recent quality improvement initiative that has gained popularity and recognition in many industries around the world. The origin of Six Sigma comes from quality engineering, which is traditionally based on strong statistical methods. (Mast and Lokkerbol, 2012) After literature reviews about Six Sigma, it seen that DMAIC is the most used technique to improve service quality.

In this thesis, Six Sigma terms, the development of Six Sigma and DMAIC methodology is emphasized. Six Sigma applications in the literature are exemplified. In addition, the flow of an implemented DMAIC project and some tools and methods used in its five steps are included. The project has been implemented at an international company in the service sector, and the team to which it is implemented meets customer demands. In this respect, this study, which aims to minimize the SLA time, has been achieved with the DMAIC Project and the results obtained from the project have been shared.

The first part of the project is the Define phase. At this stage, the problem and goal are described. A project charter is prepared, showing the business case, problem statement and goal statement. This charter is a document that summarizes the project and shows the customer voice. The focus of the project is to meet the demand late. The business case in the implemented project is “Average SLA time is seventeen hours. The DMAIC project should be implemented due to customer-oriented action, reducing complaints and being above the global target". The problem statement is

"While the average return speed of the team to a demand is seventeen hours, the project should decrease to four hours until the end". The goal statement is "A demand will be met in an average of four hours at the end of the project". The scope is also determined at the Define phase. In this study, SIPOC and IN / OUT Frame techniques are used to determine the scope. As a result of the study, resolving the demand is excluded. It is decided that the first touch should be made within four hours on average to the incoming requests.

Then, in the other phases, the process is improved with techniques and brainstorms. As a result of the studies carried out with the project team, the SLA time, which is 17 hours on average at the start, is reduced to 2 hours on average. This has provided to a result below its goal.

6.1 Thesis Generalization

The study was carried out both conceptually and through field research. The purpose of this research is to show that 6 Sigma, which is new in the service sector compared to the production sector, is applicable and useful in the service sector as well as in the production sector, by considering a six sigma application in a company. As the conclusion of this research, It was decided that the most useful method is Six Sigma DMAIC and also DMAIC method is successful in the production sector as well as in the service sector are supported by literature research and a case study.

The generalization of the thesis should answer following question:

The study has been implemented in a team that meets customer demands in a multinational service company, in Turkey. If the same study is applied to a team that meets customer demands in a different company or in a different country, would the desired result be achieved?

6.2 Future Work

The root causes that were eliminated due to some limitations during the improve phase can be re-evaluated and the their value added can be measured. Also, as well as focusing on the target and company productivity in a process improvement project, employee motivation and pressure on the team can be included in the process.

CHAPTER 7

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BACKGROUND

Buse Budur was born on August 16, 1994 in Mersin. She started her undergraduate education at Işık University Industrial Engineering in 2012 and graduated in 2017. Then, she started her master's degree at Işık University Executive- Master of Business Administration in 2017. She has also been working at an international Express transportation company since 2018.