POLITECNICO DI MILANO

Scuola di Ingegneria dei Sistemi

POLO TERRITORIALE DI COMO

Master of Science in Management Engineering

APPLICATION of 6 SIGMA METHOD in PURCHASING PROCESS

Supervisor: Prof. Alessandro BRUN

Master Graduation Thesis by:

Gokce KURAL **Id Number: 787277**

Alperen OZ **Id Number: 781140**

Academic Year 2014/2015

ACKNOWLEDGEMENTS

Even though only our names appear on the cover, we owe this study to many people who contributed with their moral support. However, it is not possible to mention every of them.

Our gratitude is to our supervisor, Prof. Alessandro BRUN for giving us the opportunity to work on this subject. Additionally, we would like to thank to ROKETSAN A.S. and SPAK Consultancy staff for their experience, guidance and assistance duration of this work.

We are also grateful to our friends who helped us with their friendship and support all along the study.

We would like to thank to the staff of Politecnico di Milano and their smiley face during our education in Politecnico di Milano.

Above all, we are indebted to our families. Their patience, support and encourage make this study and master degree possible. This dissertation is dedicated to them.

Abstract

Nowadays, most of the companies are deal with the competitive environment in markets. Especially, different types of the products are presented to customer. Therefore, loyalty and satisfaction is being more critical concept for the companies. Especially, most of the companies try to improve their product quality, services, process and total profitability. Therefore, most of the companies apply different improvement methodologies such as 6 Sigma, CMMI etc. with these improvement methodologies, companies increase their value added activities and create new products or services which are meet the requirements of the customer.

6 Sigma is a one of the important techniques for process improvement and most important subject of the quality management. This methodology is used in the different type of the industries in the world. Since, 6 Sigma methodologies analyze the root cause of the quality problems and eliminate the defects and variance of the outcomes. In six sigma methodology, statistical tools and techniques are used so, improvements can be measured. With this specification, 6 Sigma is a perfect tool to observe continuous improvements in the companies.

Six sigma methodologies have unique organizational structure, six sigma projects are made by the teams and each member of the team has specific roles in the six sigma organizational structure (master black belt, black belt, green belt etc.). In six sigma methodologies two methods are generally used. One of these methods is called DMAIC (Define Measure Analyze Improve Control) and second one is called DFSS (Design for Six Sigma). DMAIC method is most widely known and applied model in six sigma methodology. In this study, DMAIC method main steps and details are explained.

In this paper, different sector six sigma applications are researched and some of the real six sigma cases are represented. According to given real case in the paper, defense industry six sigma applications are analyzed. Especially, improvement areas in the purchasing process of the companies were analyzed. All of these researches help us to understand main characteristic of the industry and implementation of the six sigma projects.

Consequently, this paper presents case study illustrating the effective use of Six Sigma to implement improvements about their problem in purchasing process. It describes in detail how the problem was defined and how the Six Sigma methodology was applied. It also shows how various tools and techniques within the Six Sigma methodology have been used.

Table of Contents

List of Figures

List of Tables

I. Introduction

In today's world, nothing remains as steady state. Each passing day, companies have started to develop their efficiency and effectiveness with advancing technology. All these processes point just one thing though, which is increasing the quality level. Ever since industrial revolution, firms meant to meet the expectations of customers. At the beginning, this concept just related with answering all demands. However, over the years this understanding has been changed like customers' prospect.

Beginning of the 20th century, keeping pace with the demand had begun falling short. People started to desire getting not only products but also products with good quality. In parallel with these circumstances, some scientists and manufacturer had realized the truth. Only the companies which modernize themselves with quality will survive. They started focusing on formulas, methods, disciplines to develop the level of quality. Eventually, it reflected to the businesses.

Starting with Shewhart, Juran, Deming, some specific quality methods had been developed since years. The most important of these methods is focusing the solving problems by using statistical and mathematical tools and it aims 3,4 defect unit per million. It's been called as '6 Sigma'. This method helps to companies to get them the highest benefit and profit from the program. First company applied this method was Motorola in 1980s and they had huge success from it. After that accomplishment the other world's leading brands such as General Electric, Allied Signal, DuPont, Honeywell also put this quality method on their to-do list. Even though initial investment seems lot, if we compare the benefits after the program, this money wouldn't matter near the profits the companies gain.

The dissertation is designed with not only theoretical part but also a real case project implementation. In theoretical part, overlooking of quality and total quality management will be included in the first place. Understanding of meaning of quality and general idioms of it would help to get the concept of 6 Sigma, since total quality management is the father of 6 Sigma methods. Afterwards, detail of 6 Sigma has been explained to get the idea better. Why we should use 6 Sigma? What are the differences with classical procedure and application? How is it going to help the companies?

Onward section was held by starting with information about organizational structure of 6 Sigma. The people who work for applying method and relationships among each other, duties and responsibilities in the organization explained before passing through the critical success factors of 6 Sigma. After the explanation of essentials of the method, criticizing of the obstacles was a must to do

to see what can be done, simply because, all applications are not 100 % effective and useful for the companies. In that case, the possible rigors and barriers were indicated later on. Before passing the real case implementation stage, some of the methodologies of 6 Sigma was explained and the most used one defined in details.

On the other section of the study, some information for the sectors and sample applications of method in different industries were written as examples. Not only understanding the implementation but also seeing the characteristics of the industries would help to get the way how 6 Sigma is applied. Since our military company is active in the manufacturing sector and method will be enforced in purchasing department, information about those sections also added.

The last part starts include a real case project. In this project one of the military company purchasing processes was analyzed. According the analysis, DMAIC 6 sigma method was applied and bottleneck points and improvements areas were found. Every step of the DMAIC 6 sigma method was applied and results and outcomes have been indicated in the project. In the final part of the project, benefits of the six sigma project are presented. To sum up, 6 sigma DMAIC methodology improvements opportunities are observed in the real case project.

II. Overview of Quality and 6 Sigma

1. Quality

In today's our modern world, people are questioning about the quality of all products and services they get. That's because we hear or read many new concepts such as quality, quality control circle, quality engineering, quality management, quality systems, quality standards... All of these terms are focusing on "quality" and define its various aspects.

Quality term states in different meanings according to intended purposed use. The reason is that quality is multidimensional. This concept is also difficult to define in a few words, so different organizations and different experts put it into words in different ways.

- "degree of excellence, superiority in kind" by Webster and Oxford dictionaries

- According to ISO (International Standardization for Organization) 9000- Guidance on the terminology paper, quality is "degree to which a set of inherent characteristics fulfils requirement".

-Quality may be defined "the totality of features and characteristics of a product or service that bear on its ability to satisfy a given need" by EOQC (the European Organization for Quality Control) (Wojciech, Stanley, Robert and Bernhard, 2009 p 161)

- Philip B. Crosby: "Conformance to requirements." (Crosby, 1979)

-W. Edwards Deming: "the efficient production of the quality that the market expects" (Deming, 1986)

- Joseph M. Juran: "Fitness for use." (American Society for Quality, 2008)

Beside of these definitions we could also say that quality is the customer satisfaction, the efficiency, a life philosophy and a life style. When we mention about it, people generally think about the quality of goods or quality of service. However, product quality is the result. The other major components of quality which affecting this result, are leadership quality, equipment quality, management quality, work quality, service quality, system quality, communication quality, process quality, human quality, target quality.

If we apply the requirements through the process, gaining from quality will increase. Well, what are these returns? All the companies agree about these elements that they take an advantage from it.

- increasing of customer satisfaction
- increasing of market share
- increasing of profit
- improving of employee satisfaction
- decreasing of cost
- high global competitive capacity

Technology, changing conditions, diversified needs bring the different dimensions to the meaning of quality. It is because limitation of term is expanding day by day. However, in broad meaning of quality could be “providing of internal and external customer satisfaction”. In this description, not only people who buy the products/service (external customer) but also people who produce them (internal customer) are taken into consideration.

1.1 History of quality

Quality is the well-known and accentuated notion from the beginning of the civilization. Primarily by B.C.2000, some assessments about the quality term could be attained in Hammurabi Laws in Babel. For instance, a construction foreman was responsible for the quality and solidity of the building that he built. If it collapsed, foreman got punished for it. Later on in Europe, craft and related trades workers became organized under the guilds. These chambers were in charge to make rules for the quality of service and the products. In that period of time, quality of the goods had been controlling by supervision committees and a significant mark was placed on the impeccable products. This way of the quality control checking continued until the industrial revolution at the beginning of 19th century. At that period, quality checking had been doing by similar way also in USA. However, this method was no longer valid after the revolution.

Consideration of the quality as scientifically started gathering speed and term of ‘process’ was incorporated into the quality implementations in the beginning of 20th century. In that way not only monitoring but also statistical methods came into use. Walter A. Shewhart (1891-1967) who is known as the pioneer of the statistical quality control had developed control charts by using his name. Before Shewhart, only finished products were subjected to control and products were shelled if they didn’t have intended features. In fact, Shewhart was thinking that all the processes are producing constant data. Therefore, he started to examine these data as statistically and ‘Statistical Process Control’ germinated.

After the WW2,some scientists such as William Edwards Deming (1900-1993), Joseph Moses Juran (1904-2008), Kaoru Ishikawa (1915-1989), Philip Bayar Crosby (1926-2001) and Armand Vallin

Feigenbaum (1922-2014) gave new point of view to the quality and made a contribution to the model of ' Total Quality Management' which was put forward by Henry Ford(1863-1947) in 1926 for the first time.

Deming, who was working with the Shewhart through '30s, went to the Japan in 1950 and played a big part in industrial progress which is known as Japan miracle. Deming as an edifier of the total quality management taught the idea of 'cost decreases by improving the quality and thus efficiency and the market share increases' to the Japan industry executives. After these trainings, japan managers and industrialists took a step ahead, unprecedentedly. Hence, Japan goods which were noted by being cheap-jack identified with the 'quality' and started having a command of world markets. For all of these reasons, an award which is called 'Deming Prize' is given every year in Japan.

In 1970s, especially automotive and electronic industries in USA came up against with high quality competition of Japan. Reaction of USA was changing the statistical based approach to the new mentality of Total Quality Management (TQM) which involved all the organization.

From the beginning of 21st century to nowadays, quality movement matured with the consideration of 'beyond total quality'. New quality systems have been developed over the fundamentals which structured by Deming, Juran and Japan executers. Over the years, quality has moved up through the production industry to the other sectors such as service, health, education and public.

1.2 Total Quality Management

This concept was showed up by Henry Ford for the first time in 1926; however, it didn't attract attention at those years. After the Second World War, TQM model again came into prominence and played a key role in the unforeseen growth of Japan which seized it.

Total quality management model aims to meet every single customer needs at top level. That is because it is targeted to be sure everybody in the company (from the top management to the lower level workers) gets actively involved in the process. In this regime, every employee's opinion matters for each operation. Hereby, everybody is incorporated into the quality improving process.

TQM intends to get down to a fine art not only in the industrial areas but also in the sectors which involving the society, such as education, health, management and service. In this way, PDCA (plan-do-check-act) loop is implemented. It means, jobs/process has planned before it get started, then prepared plan enforces. Data acquired in the implementation phase should be controlled and analyzed and necessary precautions have to be taken into consideration according the results of the control. The loop should be kept continue till getting the target outcome. As well as there are many

success stories with this method, new seeking for reaching the perfection is hold and another approach '6 Sigma' has been developed.

1.3 What is 6 Sigma?

Sigma, transliteration of Greek letter σ, means standard deviation in Statistics. Term of 'Sigma' is used to explain the mean deviation of a process or characteristic of a product. Sigma is a statistical measurement that demonstrates the process sufficiency. Accuracy of sigma is directly related to number of error per unit, number of defect in million and error probability.

Approach of 6 Sigma uses the 'defects per unit (DPU)' as a measurement instrument. Defect per unit (DPU=Defect/Unit) is an outcome after the evaluation of product/service as good-bad or accept-reject policy based on qualification standard. 6 Sigma aims to reduce the defect rates by identifying and eliminating causes of variation in applied process.

On the other hand 6 Sigma as a project-driven management point of view is a business strategy to help gain a competitive edge and a performance target which meets the customer needs terrifically. 6 Sigma is a metric which indicates how well a process is performed for any of services or manufacturing procedures. Revaluation of the sigma value remarks the goodness of the process. Sigma measures the capability of impeccable working of process. If the number of sigma indication increases, costs and cycle time decreases and customer satisfaction goes up. The main parameter for 6 Sigma is 'error per product'. In this case product could be material, managerial form, time or range. It shows the deviation level from the zero error sites. If a process has 6 sigma quality levels, it means 3.4 defect pieces per million occurrences would be observed from all of the obtained service and products. 6 Sigma is a job philosophy which aims obliterate the defects with being processed of data. This is one of working smarter, not harder.

As mentioned before, 6 Sigma is applied in not only manufacturing industry but also service. It is an improvement tool applying to design, manufacturing, sales & SVC. It doesn't matter on which area it's been applied. In general terms, most successful implementation of 6 Sigma methodologies have some common characteristics. It makes the entire employee join the process. Using just relevant departments and people would be a mistake for the success of the program. Yet, also the management part has to be on board as the first priority. Another issue is that well-defined, measurable goals have to be described above all. Without specifying the targets, it couldn't be mentioned about the strong and effective implementation of 6 Sigma.

We can abstract some of the basic principles of 6 Sigma;

- Absolut Focus on Customer: Before we apply the method in entire organization, perceptive of the customer could be the first thing to do. Eventually, 6 sigma progress results are measured by customer delight.
- Data Management and Factual Approach in Decision Making: Even though many managers make a decision based on supposal or ideas, data and knowledge management should be taken considered despite of. After then, problems come up much more clearer and easy to identified/ analyzed.
- Process Focus Management: 6 sigma sets sight on entire process farther than focusing the final results.
- Proactive Management: Being responsive is no longer helpful to improve the process. We must be taking over responsibility, defining real targets and defining priorities from the beginning.
- Boundary less Collaboration: If all employees work in accordance with same purpose, there will be no boundary at all. It also helps to improve teamwork and across organization structure.
- Drive for Perfection, Tolerance for Failure: If a company wants to go a step further, they have to accept to risk coming with it. Otherwise, they will be in the infinite loop with the old projects and ideas. Learning lessons from the mistakes been done leads us to achieve the best solutions.

Despite of all the successful implementations of 6 Sigma, there are still some misunderstandings and myths about it. Contrary to what is believed;

- 6 Sigma is not a budget cutting strategy at all. Even sometimes it consumes more time and money than the normal while applying. However, the results are by far the best.
- It is not a program which includes signs, boards or slogans.
- In addition to those, 6 Sigma attentions are not just for the people. Measuring and analyzing of the process are crucial in order to all system work better.
- It is not a fighting with the errors, either. Detecting the mistakes and fixing don't solve the problem radically.
- It is not a just measurement. 6 Sigma wants you to pay attention also to your customer.
- 6 Sigma is not working only in manufacturing settings.
- It is not repackaged of Total Quality Management.
- It is not training and requires more than 'little effort'.

In the light of these; we can say 6 Sigma is not just one thing. It is a synthesis of technical, human and managerial part of the system.

1.4 6 Sigma and Total Quality Management

Total Quality Management is a management philosophy which aims at reaching the idea of 'zero error'. This inaccessibility of the target makes TQM to develop progressively. 6 Sigma, on the other hand, is a methodology to measure and improve the quality of process which also is one of the main focal spots of the Total Quality Management. Its objective is reducing the defect rate to the 3,4 pieces per million. 6 Sigma helps the company to compare its quality level among the others based on tangible data and indicators.

It wouldn't be wrong if it's said that 6 Sigma has been inspired by Total Quality Management. Since it is a much more developed model, it is not be surprising to be differences. Among the all of them, some of them are listed below;

- 6 Sigma is not result-oriented method likewise TQM. One of the main issues related with it is pointing at preventing defects and reducing the variability of the process.
- 6 Sigma includes methodologies and tools to solve the problem, whereas TQM is acting more like guidelines for the quality development.
- Since there are some tools to be applied the process, top-down management of the organization is way important than how it is with Total Quality Management applications.

The main differences between 6 Sigma and the other similar programs are results can be measured, it is implemented through the all the departments and it changes the corporate culture. So, we can summarize the information above such as;

6 Sigma = TQM + Stronger Customer Focus + Additional Data Analysis Tools + Financial Results + Project Management

In order to get succeed with 6 Sigma methods, a solid infrastructure is needed. The companies which internalized of TQM can get very successful and satisfying results. At this point, it is needed to be known of 6 Sigma tools, deliberative support of managers, systematic propagation planning and organizational appropriation.

6 Sigma is not an alternative to TQM or the other quality systems, in contrast it is a methodology, which completes, integrates, supports and runs them together.

2. Evolution of 6 Sigma

6 Sigma is not a recent trend, in middle of 80s, Bob Galvin (Chief Executive Officer of Motorola) and Bill Smith (Quality Specialist in Motorola and he is known as founder of the 6 Sigma) has developed 6 Sigma to increase the reliability of product and decrease the defects. According to this, achievement bar at 99,6 % which was imposed by Shewhart, upgraded rate to the 3,4 defect per million and a new idea assimilated to achieve this target. In this model, errors are disallowed and high grade production is aimed for in every aspect. Motorola started to use the 6 Sigma technics in internal trainings hoping to improve the quality of cellular phone and pager systems. More than $ 45 million each year was invested for training, 40% of it devoted to quality.

One of the top 10 targets of Motorola in 1981 was enhancing a tenfold improvement in quality before the 1986. However, they were not contented with what they aimed in 1981 and in January 1987, they stated a new goal 'Improve product and service quality 10 times by 1989, and at least 100-fold by 1991.Achieve 6 Sigma capability by 1992.With a deep sense of urgency, spread dedication to quality to every facet of the corporation, and achieve a culture of continual improvement to assure total customer satisfaction' (Motorola Annual Report, 1988). For this purpose, Bill Smith defined the key element for the company: 'prevalent error reduction – defect per unit'. This method is used to measure the defect rate in all the business sector of Motorola, uniformly. Therewith, Motorola became the first company which won the Malcolm Baldrige National Quality Award in 1988.

After this huge success of implementation of the 6 Sigma in Motorola, many organizations started to apply this method. IBM was one of these first companies to chase this way. The other highlight in the 6 Sigma histories accrued when Jack Welch was selected as CEO of General Electric, in 1991. He remarked that 6 Sigma was the most uphill and extravagant target in the history of the GE. Company started to apply the 6 Sigma in 1995 and derived $ 2.2 billion profit between 1996 and 1999.

Beside of these pioneer companies, the others also saw the opportunities and started to implement the method in their companies. In below, some of the reported benefits and savings from 6 Sigma could be seen;

Company / Project	Metric / Measures	Benefit/Savings
Motorola (1992)	In-process defect levels	150 times reduction
Raytheon/aircraft integration systems	Depot maintenance inspection time	Reduced 88 % as measured in days
GE/Railcar leasing business	Turnaround time at repair shops	62 % reduction
Allied signal(Honeywell)/laminates plant in South Carolina	Capacity - Cycle time- Inventory – On-time delivery	Up 50 % - Down 50 % - Down 50 % - Increased to near 100 %
Allied signal(Honeywell)/Bendix IQ brake pads	Concept-to-shipment cycle time	Reduced from 18 months to 8 months
Hughes aircraft's missiles systems group/wave soldering operations	Quality / productivity	Improved 1000 % / improved 500 %
General Electric	Financial	$2 billion in 1999
Motorola(1999)	Financial	$15 billion over 11 years
Dow chemical/rail delivery project	Financial	Savings of $2,45 million in capital expenditures
DuPont/Yerkes plant in New York(2000)	Financial	Savings of more than $25 million
Telefonica de Espana (2001)	Financial	Savings and increases in revenue 30 million euro in the first 10 months
Texas instruments	Financial	$600 million
Johnson and Johnson	Financial	$500 million
Honeywell	Financial	$1.2 billion

Table 1: Benefits and Savings from 6 Sigma (Kwak, 2006)

The other worldwide companies (especially in automotive industry) also applied 6 Sigma methodologies. Some of them are Ford, Volvo, Whirlpool, Samsung, Kodak, Sony, Toshiba, Jaguar, Fiat, Pirelli, Citibank, Nokia, Shell, Hyundai and Ericsson. Estimated average 6 Sigma level in US is around 3-4 sigma.

Even though companies all around the world had started to implement the new 6 sigma method in middle of 80s, applications were commenced quite late in Turkey. TEI (Turkish Engine Industry) is the first company applied 6 Sigma in Turkey. Since GE has the principal class of its shares, TEI also started to implement this method for all processes since 1996 after the GE's 6 Sigma expansion policy. In 1998, the second company applied 6 Sigma is Arcelik which is known as BEKO around the world. It is also the first domestic capitalized company did the implementation of 6 Sigma in Turkey. Company performed the method especially in the manufactured based process. Even though they confined the method to applying just in production in the beginning, they did reconfiguration the method that included all of the service processes since 2002.

There are some reasons behind the idea of setting the 6 Sigma in Turkey. We can mention about procuring of productivity growth, economic crisis in 2001, and requests from clients abroad, demands from the company partners abroad. Except of the TEI and Arcelik, the other companies as an example are Profilo, Borusan, Ford, Vestel, Bosch, Cimtas, Yesim Tekstil, Erkunt, Otokoc, Sabancı Holding Company, Calik Textile, Firat Plastic. Estimated average sigma level among companies in Turkey is between 2,5 and 3,5.

3. Why 6σ?

Beginning of the 20th century, 3σ had been thought as affirmed for the deviation. According to this, 99,6 % of the products was acceptable to have the feature on demand. However, when the surplus production capacity in parallel with development of technology and purpose of providing the customer delight were taking into consideration, this achievement seemed not acceptable.

6 Sigma strategies could be applied easily through the all business area such as design, marketing, purchasing, service, sales, and manufacturing. If the method is implemented to the system properly, the returns to the company will be in high numbers. Not only with the profit but also training people and meet the expectations of customer add the value to the company. Herein after, some of the advantages could be seen as a consequence of 6 sigma applications.

- Reduce the defect rate
- Reduce the product cost at the rate of 10-25 %
- Reduce the manufacturing cost in proportion of 10-40 %
- Improve quality of product, production and service
- Better understanding about the customer expectation and increase the customer satisfaction
- Increase the market share
- Increase the performance of quality and distribution
- More powerful and steady design
- Minimize the losses in entire process and therefore decrease the cost of loss
- Convert the complex systems to the basic systems
- Make clear output of business
- Improve the productivity
- Decrease the cycle time
- Positively cultural shift
- Speak the same language

In addition to those;

- Obtain the continuous success
- Procure the performance goals for everybody
- Increase the customer equity
- Improve the growth rate
- Increase the learning curve and information exchange

- Ease the strategic alteration

6 Sigma should be started by top management in the companies which have reached the specific quality level. It means 6 Sigma is needed to be integrated to business strategic plans. The important thing for the success of the company is bringing continuity about improvement and growth. Ergo, new tools to serve this purpose must be merged with Total Quality Management. Concordantly, 6 sigma approach needs to be adopted as TQM tool. If companies' conditions are tailored by TQM, implementations of 6 Sigma will become unavoidable.

In brief 6 Sigma exist to shift focusing problems from 'fixing' to 'prevent', to shift focusing on analysis from 'experience' to 'data base' and to reduce the cost of poor quality. Thus, customer satisfaction and so profit will increase.

3.1 Cost of Poor Quality (COPQ)

We might not get a second chance every time, that's because we have to do it in the first place. Cost of quality occurs when quality is poor. According to American Society for Quality (ASQ); the "cost of quality" isn't the price of creating a quality product or service. It's the cost of not creating a quality product or service. Every time work is redone, the cost of quality increases.

Costing of quality makes a company to define the performance of quality in language of 'money'. It means cost of poor quality allows us to convert things into money. American Society for Quality split it into 4 groups.

- Preventive Costs: *Market/customer surveys, design review, procedure writing, studies...*
- Appraisal Costs: *Internal audits, test, inspection, safety/security checks, process controls…*
- Internal Failure Costs: *Scrap/rework, redesign, supplier problems, accidents, lost sales…*
- External Failure Costs: *Product recall/returns, lawsuits, complaints, reports of failure…*

Internal and external failure costs are equal to the 25-40% of the total sales, while appraisal covers 10-50% and prevention costs are 0,05-5% of the sales.

Cost of poor quality can be calculated not only total for the company, but also per product or per department. Calculation period could be monthly, in every 3 months, annual etc. according to circumstances. Each company should find the best reporting time and range as per features they have.

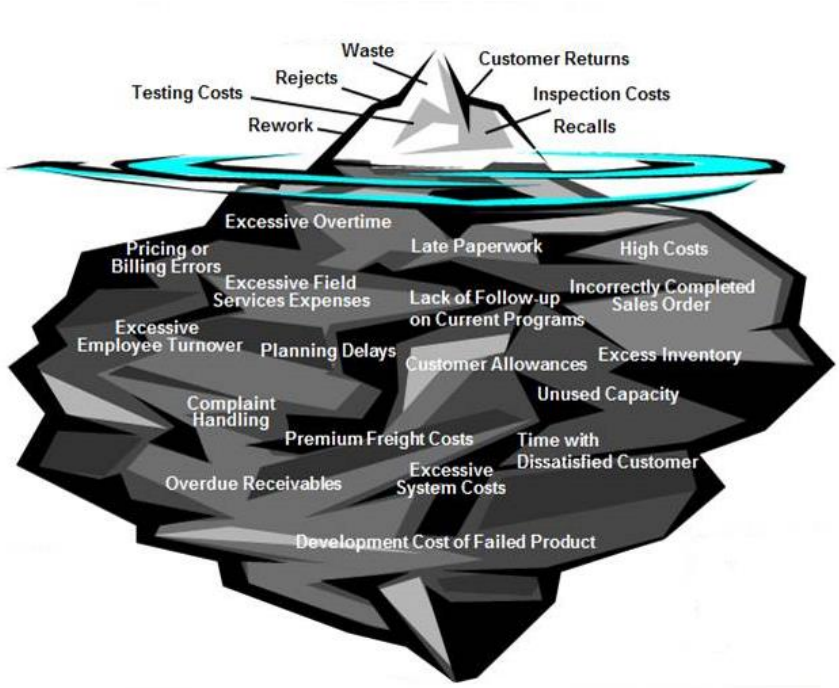


Figure 1: Cost of Poor Quality / Juran Institute, Inc)

In the iceberg shape, cost of poor quality explanation can be seen. While tip of the iceberg represents the small portion of the causes for COPQ, bottom part shows the majority of COPQ. Costs are such as waste, rejects, recalls, customer returns can be observed and they are visible to the company. However, the others which place bottom of the iceberg are called hidden causes and they are not easily identified. Unfortunately, they cause the almost 15-25 % of the sales. Below, it can be seen how much percent of the sales profit are wasting for the poor quality cost. This ratio is around 4-5 % of total sales for the top of the iceberg.

As it's been seen from the examples, there are huge differences between 6σ and 3σ in terms of the cost of poor quality.

Cost of Poor Quality(COPQ) as % of Sales	Defects per million (PPM)	Process Sigma Level
30-40 %	308.537 (non-competitive)	2
20-30 %	66.807	3
15-20 %	6.200	4
10-15 %	233	5
< 10 %	3.4 (world class)	6

Table 2: Sigma Levels

Reducing the COPQ is the best way if a company wants to improve its profit. In this term, companies have to switch their quality management approach from 3σ through 6 Sigma.

3.2 3σ – 6σ Comparison

Traditional 3 sigma applied companies lose its clients and customers continuingly because of the low quality and the opponents surpass this company in price oriented rivalry. Quality problems tried to be solved with increasing the number of tests and controls. Eventually, recession of the defects could be observed but cost start rising as a consequence.

Customers have a certain place in terms of quality. If the quality is not enough for them, they don't buy the products. When the quality is improved, cost will increase and customers can't pay the new price in this condition.

For a typical 3σ business, profitableness becomes max in cases where total cost of poor quality is 25% of the total sales. However, profit received would be very low in this cost level.

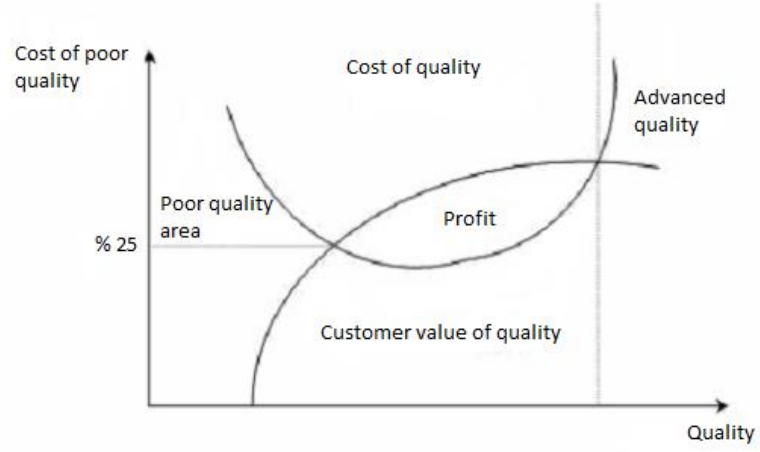


Figure 2: Quality Value and Cost

While a 3σ quality level company spends 25% of gross profit on sales for poor quality, this rate is 5% for the 6σ quality level company. The following graph shows the profit differences between two applied systems.

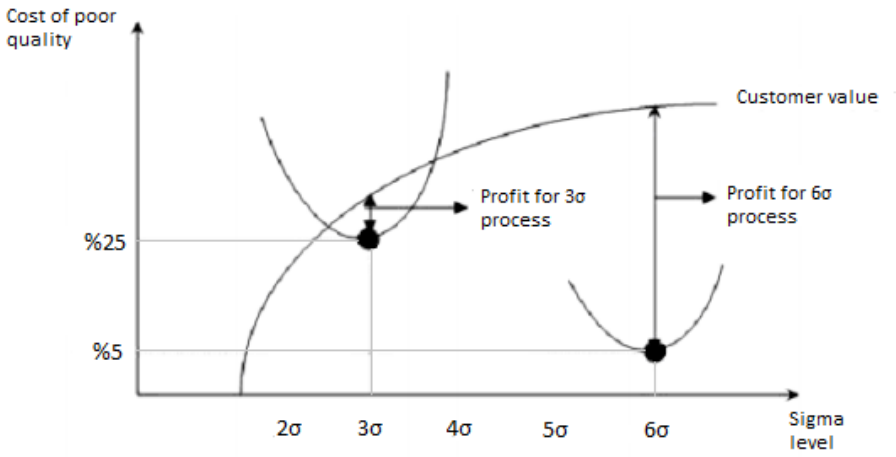


Figure 3: Profit of 3σ and 6σ

If a company which is able to manage 3σ quality level tries to reach better quality level out of existing system, this causes the cost increase. It must also develop new systems which can ensure both better quality and low cost. At this stage, 6 sigma systems are needed. 6 Sigma is not a place of destination or final point, contrary it is a journey for continuous development.

Of course, companies can't directly switch their system from 3 Sigma to 6 Sigma. Instead of it, general performance should get through from 3 Sigma to 4 Sigma, firstly, then to 5 Sigma with trainings and redesign the systems. Graph can summarize the process from start to 6 Sigma level, below.

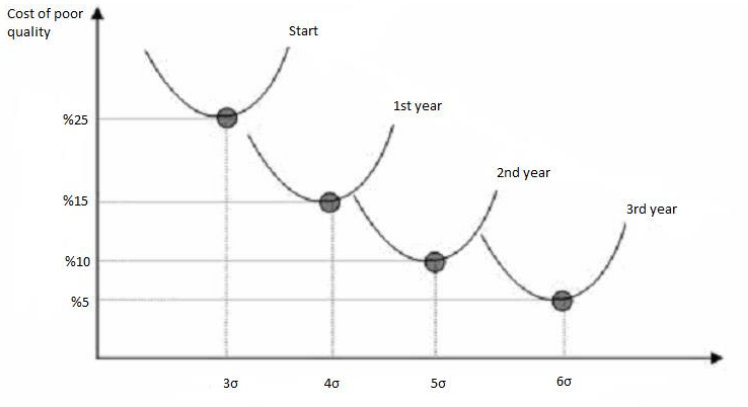


Figure 4: Development Towards to the 6 Sigma

6 Sigma aims providing better quality rates to the customers, investors and employees. From 3 Sigma to 6 Sigma, number of defects per million doesn't decrease linearly. Growth level increases incrementally like from 3 Sigma to 4 Sigma as 10 times, from 4 Sigma to 5 Sigma as 30 times, from 5 Sigma to 6 Sigma as 70 times. It proves that how important to reach the 6 sigma quality level for an organization.

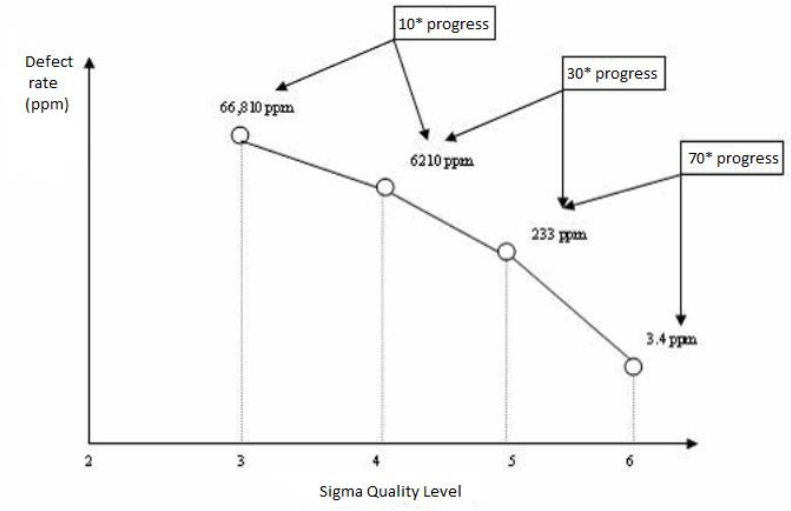


Figure 5: PPM values variation

If we want to summarize the features for those sigma levels, the chart would be seeing as below;

Comparing 6σ with 3σ

The 3σ Company	The 6σ Company
. Spends 15 ~ 25 % of sales dollars on cost of failure	. Spends 5% of sales dollars on cost of failure
. Produces 66.807 ppm opportunities	. Produces 3,4 ppm opportunities
. Relies on inspection to find defects	. Relies on capable process that don't produce defects
. Believes high quality is expensive	. Knows that the high quality producer is the low cost producer
. Does not have a disciplined approach to gather and analyze data	. Use Measure, Analyze, Improve, Control and Measure, Analyze, Design
. Benchmarks themselves against their competition	. Benchmarks themselves against the best in the world
. Believes 99% is good enough	. Believes 99% is unacceptable
. Define CTQ(Critical to Quality)'s internally	. Define CTQ's externally

Table 3: Comparison of 3σ and 6σ (Rasam, 2009)

If we take into account all of these, it wouldn't be wrong to say that value added of 6 Sigma implementations to the company is far beyond than the value of 3 Sigma does.

After all of statistical explanations, there are some samples from in real life experiments to clarify the situation. As it is seen from the chart below; when you apply 3 sigma, defect rate per million (PPM) is significantly higher than the 6 sigma. In this situation, as a customer what will you accept?

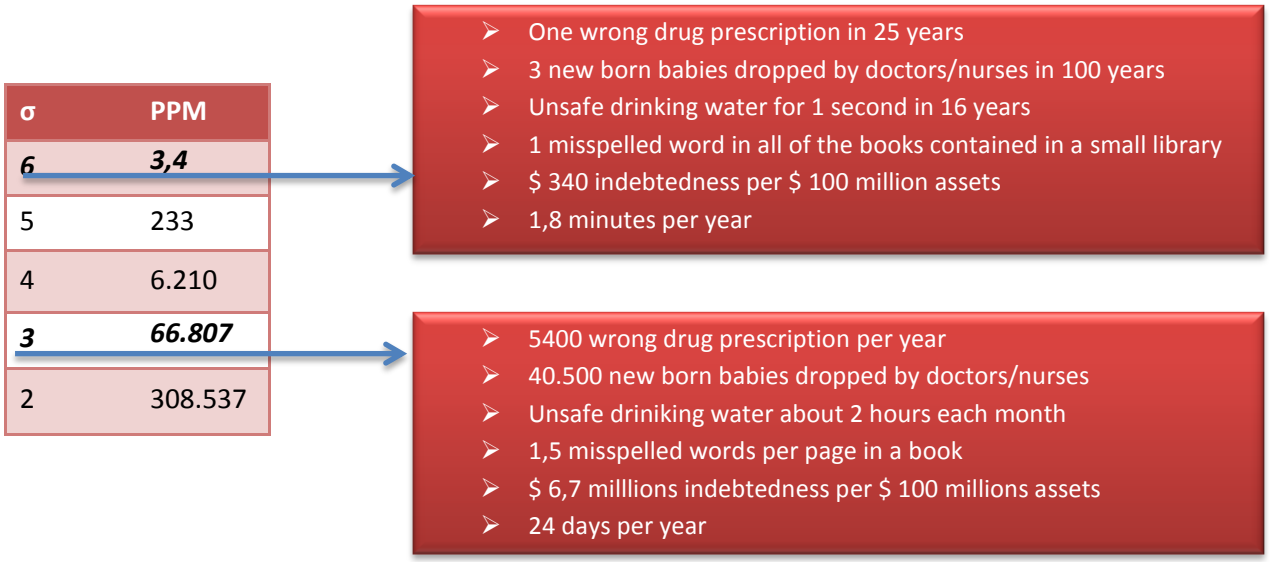


Figure 6: Examples for 3σ and 6σ (Sai, 2013)

4. 6 Sigma Organizational Infrastructures

6 Sigma successes are strongly related with organizational infrastructure. 6 Sigma is the primary strategy for enterprise-wide business process improvement; to ensure success it is necessary to institutionalize it as a way of doing business (Pyzdek and Keller, 2010). 6 Sigma is done by teams. Various roles and missions are assigned to team members. 6 Sigma organizational infrastructures include martial arts name such as black belt, green belt and master black belts (These belt names were given by Motorla). Team members are named according to education level and each team member hierarchically connected to each member (Pande et al, 2000).

Conceptual organization of 6 Sigma belt is shown in Figure 7. As observed in Figure 7, two types of structure generally applied in 6 Sigma. The difference of the organizational structure is organizational roles of the companies. In first case [A], coach of the project is Master Black Belt. In second case [B],

coach of the project is Black Belt (Pande et al, 2000). As observed in both structure top down organizational method is used in 6 Sigma. It should be noted that, 6 Sigma successes is directly related with the full participation of the companies.

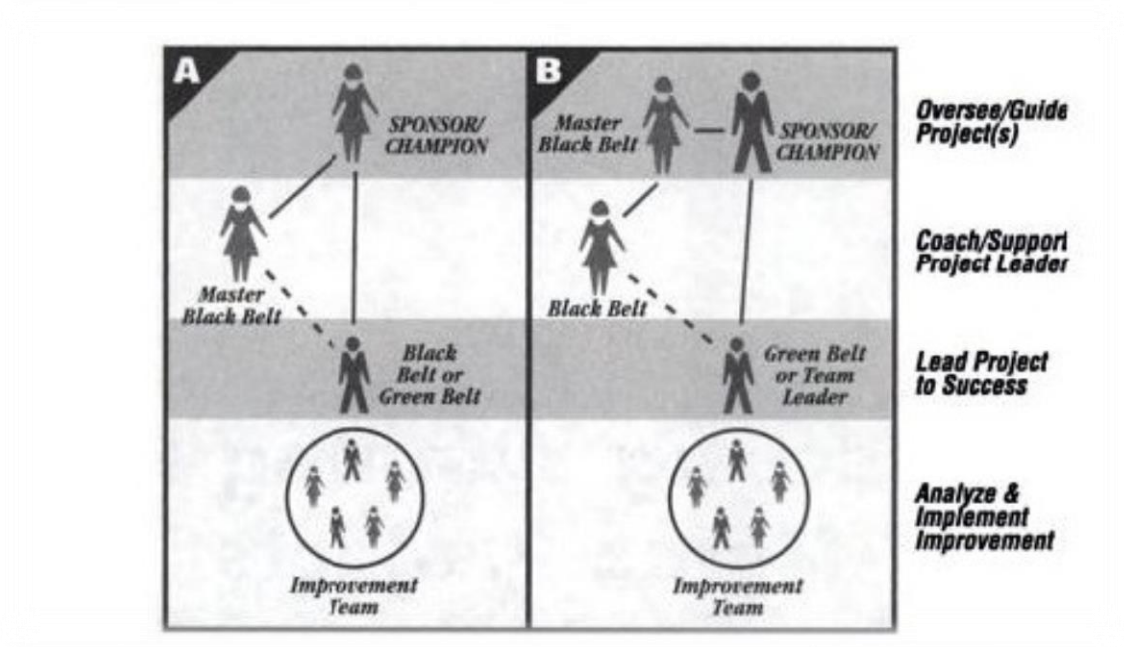


Figure 7: 6 Sigma Belt Organization (Pande et.al., 2000)

In some cases, companies may have different names for 6 Sigma infrastructures. Since, some of the companies adapt 6 Sigma organization infrastructures according to its organizational need. For instance, some companies add new belt which is called yellow belt. This belt comes after green belt. In this case, improvement team consists of green belts and yellow belts. Details of the roles are given in this chapter.

4.1 Champion

Champion is the key manager who decide to start project. Champions are really important person in the project and champions are directly responsible from the success of the project (Pyzdek and Keller, 2010). Main roles of the champion are given below;

- Provide necessary resources, time and money,
- Ensure that the project is aligned with the goal of the business and lead the team and give them clear guidelines,
- If any obstacle may occur during the project, champions help team to overcome it (Pande and Holpp, 2002).

4.2 Master Black Belts

Master Black Belt is expert in statistical methods, mathematical theory and project management. Master Black Belt, who is technical leadership of the 6 Sigma program, serves as a consultant to Black Belts. In some cases master black belts lead Black Belts to apply correct method in unexpected situations. At this point, master black belts human relations and communication with the people is important.

4.3 Black Belts

The person who has the black belt is well-informed about various statistical tools and mathematical knowledge. In addition to this, black belts have an extra knowledge about organization's information warehouse. Since, they can get necessary information for 6 Sigma activities. 6 Sigma activities are mostly integrated with information systems of the organization (Pyzdek and Keller, 2010). Black Belts is a kind of manager, coach of the 6 Sigma. Black Belts are main purpose is lead the 6 Sigma projects and work on that project full time until it finish.

4.4 Green Belts

Green Belts are the first degree of the 6 Sigma. Green Belts directly work on 6 Sigma. Therefore, green belts have enough information about statistical tools and mathematical knowledge. Green Belts are trained about 6 Sigma methodologies at least one week. However, they are not trained as Black Belts. In 6 Sigma, Green Belts work on the project part time. (Pyzdek and Keller, 2010) In addition, Green Belts work on the 6 Sigma project while doing their main jobs in the company. In 6 Sigma projects, Green Belts work on the project with the guidance and support of the Black Belts.

5. Critical Success Factors of Implementing 6 Sigma

Every output has one or more than one inputs and quality of the inputs has a direct impact on the output quality. That's because there are many ingredients in the process that affect the success of the project. There are plenty discussion about these key ingredients in the literature. Especially, the researchers such as Henderson and Evans, Coronado and Antony, Pande, Eckes tried to make the critical success factors clear and stark by examining and observing the companies which applied 6 sigma approaches successfully. CSFs are generally are gathered under the almost same titles. However, application level of the factors and effects to the project success depend on the country

and the business area. There is explanation of the each factor which generally accepted by the authorities.

Strong Leadership and Top Management Commitment: Many people, who instituted and applied 6 Sigma in their companies, agreed that support and willingness of the top management is the most important element. Top executives of the organization should conduct and embrace the 6 sigma. CEOs of Motorola, GE, Allied Signal that achieved huge success about application the approach, made it possible. Every one of them supported the 6 sigma initiative, played an active role and devoted themselves to every steps of the program.

When Lawrence Bossidy who was the CEO of Allied Signal took the lead, he made the financial targets easily accessible by using 6 Sigma. On the other hand, Jack Welch (CEO of the GE), reconstituted the company organization and it had effect on employees' attitudes and behaviors positively. Welch visited the company weekly and monthly for spot checking which means he didn't let anybody know that he was inspecting the process. By this way he could follow the process. Not only this but also he visited the field to be able to understand whether 6 Sigma was implementing properly and he actively participated the applications. Additionally, Welch shared the information about the process level of 6 Sigma with shareholders in every meeting and in annual reports.

Some of the managers can find the commitment of the 6 Sigma easy to do. Claiming responsibility for necessary activity done is important; however, top management must participate for successful application of 6 Sigma. Managers should be assigned for instituting of management system and participate in person.

6 Sigma should be part of top management's, departments' and executives' job. The real purpose and importance of the 6 Sigma would never been understood without involvement and commitment of top management.

Organizational Infrastructure: Some of the characteristics should be ready beforehand to apply 6 Sigma. For instance, good communication skills, long term strategic perspective and team work. Moreover, adequate fund and investment must be provided to be able to 6 Sigma. Successful companies invest a great amount of budget and resources for this program. Some of the elements which generate the budget are payrolls, trainings and consultancies (Coronado and Antony, 2002). Companies had better to wait to see the outcomes if they want to implement 6 Sigma. Phase transition takes more than one year from 3 sigma levels to 4 sigma levels. As the 6 sigma level being approached, progression is getting harder and slower. None the less, first progress of beginning of sigma level (to the 4.8 sigma) is much easier according to other and it can be occurred without

extensive investments. To appreciate 6 Sigma, it is important to focus on gainful occupations in the first place.

Organization should be structured as top quality council, manager representative, champion, master black belt, black belt and green belt from the top management to the very bottom.

In addition, teamwork is also another matter for 6 Sigma. Cross functional team structure would learn to employees to have ownership, better communication, benefits of teamwork and give point of view on organization.

Cultural Change: 6 Sigma is a breakthrough about management strategy. It should be integrated in value and culture of the company to be implemented properly. Besides, it is needed to change of organizational structure and infrastructure. Generally when important changes have been occurred, employees are afraid of obscurity and they don't comprehend to necessity of alterity. 'We've tried but it didn't work' or 'this is what we do all time' are examples for resistance to change. Some of the organizations are based on fear and punishment system. These kinds of organizations don't allow the error or mistakes and as a consequence employees try to hide the lack or wrong works. On the other hand, 6 Sigma develops in an environment those errors seen as opportunities.

Extensive change of organization could contravene with the habitual values. For this reason, there are four important factors of resistance to change which were identified by Eckes (2000):

- Technical: People generally get confused to understand the statistic. Training and participation are must.
- Political: Searching for a solution seems like loss and imagination. To avoid this situation, necessity and advantages of change should be explained to everyone in the organization.
- Individual: It is related with the employees who are stress-filled due to their personal problems and can't adopt the organization. Less work load could be a solution to reduce the stress level.
- Organizational: It is based on all organization having a faith in the structure. Willingness could be eradicable by explaining of benefits to change.

Successful companies who lead to change define the way of breaking the resistance to change as continuous communication, training and spreading of motivation. Besides, getting feedback from the employees, planning of change, assigning of responsibilities and encouraging people to make their own decisions is important as well (Coronado and Antony, 2002)

Training: It is highly important factor to commence and develop 6 Sigma program. People should be informed how and why 6 Sigma is going to be implemented thorough the organization. Belt system must applied starting from the top to the bottom fractionally. Belt system helps people to speak same language in the organization. Eventually, it ensures to organize 6 Sigma easily. Belt curriculum could show an alteration from organization to organization and from consultancy to consultancy. For instance, (at least) one year is the duration of being black belt in Motorola, while it is between 16-20 weeks in GE. Gaining black belt qualification is highlight for a person considering possibilities of promotion (Antony and Banuelas, 2002).

Nevertheless, having specific training doesn't mean those people are assigned only for 6 Sigma project. They are agents who have to disseminate the 6 Sigma philosophies to the entire company. Especially operators need to be met the 6 Sigma system, since they are the experts on process and quality on product/service.

In time, company needs to be open to the new and more information, methods, ideas and transmit to the learning organization from the trained organization.

Understanding the 6 Sigma Methodology, Tools, Techniques & Metrics: Understanding of underlying principles of 6 Sigma, is the first step of training of this approach. During the training, employees learn 3 main groups of tools and techniques which are process improvement, team tools and statistical tools. Generally, basics statistical tools or quality tools are enough to solve the problem with 6 Sigma. However, advanced level of tools and techniques (statistical quality control, regression analysis, analysis of variance etc.) are needed for the major developments (Antony and Banuelas, 2002).

Employees are needed to improve themselves and adopt the idea behind the 6 Sigma methodologies with obtained information. There is not a standard approach though, since it differs from organization to organization and employees should be capable of choosing the appropriate tools and techniques. It is very important and helpful that experienced ones make a contribution and follow the process. In some cases, reminder training could be necessary to help developing of employees skills' (Coronado and Antony, 2002).

Linking 6 Sigma to Customers: 6 Sigma is a customer oriented program and start with the customer requests. It is essential to satisfy the expectations to be successful in the business. If so, every step in the process should be linked with customer expectations. CRM (customer relationship management) philosophy which represents the transmission from product oriented approach to the customer oriented helps to collect data and analyze them by putting the center of design to customers. That's

because there is connection between 6 Sigma and CRM that both of them try to improve the system to get better based on customer voices.

Customers want to procure the goods / service as impeccable with lowest price as possible and in time. Meanwhile producers try to reduce the cost for the faultless product/service with lowest cycle time in order to fulfill expectations. Stronger consolidation equals better results. Eventually, perceiving of customer needs in right and dynamic way is one of the most important key to the way to success.

Project Prioritization and Selection: Since 6 Sigma is project based methodology, it is important to be given priority to projects which provides more financial yield. Poorly selected and defined projects can cause the delayed results and great deal of frustration (Pande et al., 2003). Purpose of the projects should meet quality characteristics which are required by customers. Foreground projects needs incorporate of gaining competitive advantage, reducing cycle time and increasing profit (Ingle and Roe, 2001).

Some of the measures are listed below for project selection:

- DPMO (Defect per million opportunities)
- Net cost saving
- Cost of poor quality
- Capacity
- Cycle time
- Customer satisfaction
- Inner performance (Coronado and Antony, 2002)

(Pande et al., 2003), on the other hand, determined 3 categories for selection criteria.

- ✓ Business benefits criteria
    - Impact on meeting external customer requirement
    - Impact on core competencies
    - Financial impact
    - Urgency

- ✓ Feasibility criteria
    - Resources required
    - Complexity issues
    - Expertise available and required

- Likelihood of success within a reasonable time frame

✓ Organizational impact criteria
  - Learning benefits – new knowledge gained about the business, customers, processes, etc.
  - Cross-functional benefits

When the projects are selected, it is supposed to be defined the frames, purposes, targets and make things clear about the duty and the subjects of the project. According to the stable chart, revision should be done periodically. Thanks to this way, leaders can follow their projects in compliance with 6 Sigma methodologies (Antony and Banuelas, 2002).

Linking 6 Sigma to Human Resources: 6 Sigma purposes should be assimilated through each individual level in order to actualizing behavioral changes. To achieve that, incentive actions such as reward, premium and promotion need to be putting into practice by human resources. Some researches show us that reward system applying companies are more successful to reach the expected results in 6 Sigma. In General Electric, no one can promote without accomplish all the 6 Sigma trainings and project. In addition, 40% of the managers' premium depends on the acquired success from 6 Sigma in GE (Antony and Banuelas, 2002).

IT Infrastructure: Candidates for black belts or project leaders procure the organizational support from top management or sponsors. However, this support from the point of problem solving model should be given by master black belts. Many projects couldn't reach the desired goal and mire down because of the technical deficiency, inexplicable and unnamed problem. In this case, master black belts help as being guide to black belts in order to make up this deficiency by adapting the techniques in the implementation phase. IT system is also needed to reach the data, organize and convert it to the effective decisions.

Linking 6 Sigma to Suppliers: Nowadays, all businesses is seeking the best ways to meet the customer needs while specializing in their jobs. In that direction, they need the strategic suppliers to achieve the effectiveness and quality in their service / products.

Industries, as a main player in the global market, start bringing using rational measurements, cost element, quality and productivity forefront while they are deciding to choose countries and firms in order to contact partnership relation. If a supplier has low quality and effective products, that would be a weak spot for the companies. Unfortunately, customer needs can't be met by only internal operations. Suppliers, dealers, service men and even courier could be decisive about affecting the

satisfaction level. Accordingly, strategic suppliers should be invited to the 6 Sigma journey. To achieve success at modern day's conditions of competition, advantages of 6 Sigma should be explained to the suppliers' managers and the projects should be run jointly. Following projects though would be meaning of increased mutual gain for both of company and the supplier.

6. Obstacles and Challenges of Implementing 6 Sigma

6 sigma applications are used to make the current process achieve to prodigiousness. However, results of these implementations could be clogged because of the limitations. Through the 6 Sigma journey a company can meet more than one obstacle. At that point top managers should step in and eliminate those bottlenecks. As it can be seen below, we can group them under the three main title names;

6.1 Issues in Strategy

6 Sigma strategies are not accepted by all the authorities as a new approach. It has been argued as a 'Total Quality Management on Steroid' many times. One of the main criticisms is that 6 Sigma is nothing new and simply repackages traditional principles and techniques related to quality (Catherwood, 2002). As can it be understood that this approach is not the only answer for every business issues. Companies need to assimilate the meaning and benefits of it and use it for long term sustainability matters. There are some examples are given for the limitations for this title:

- Underemphasize of the 6 sigma key results on the performance evaluation.
- Far-reaching of the projects
- Asking for the results of the project at once
- Thought of the cost of the rewarding/verifying project is being high
- Postpone the revisions
- Exclude the 6 sigma from the priorities
- Modification of project charter
- Let day-to-day business be as 6 Sigma project
- Not considering of entire process
- Misunderstood of customer expectations
- Ignored of customers while project defining
- Misidentify of errors / defects
- Thought of being successful is just related to making agreement with a good consulting firm

6.2 Issues in Organizational Culture

Quality concepts need to be embedded into the process of designing rather than just monitoring the quality at the manufacturing level (McClusky, 2000).Before the applications of 6 Sigma through the business, we need to understand the idea of this approach. Even if just one person doesn't accept the idea and the way how it is implementing, results would be questionable. The culture of the organization is supposed to be merged by the characteristics of the approach. Besides that, commitment and support of the top management is essential for being accepted the 6 Sigma among everyone in the business. There are some obstacles below about adopting the 6 Sigma:

- Thought of 'we are not ready for the 6 Sigma!'
- Not to get contribution from team members
- Thought of 6 Sigma applications being useless
- Trial purposes on 6 Sigma whether if works
- Thought of that 6 Sigma implementations wouldn't get success on service sector
- Look upon the 6 Sigma as a job of the quality department
- Generate the solutions according to the prejudice and brainstorm
- Thought of 6 sigma is the solution for everything
- Waiting the unanimity of the top management to start the 6 Sigma process

6.3 Issues in the Training (Belt Program)

Training is one of the key elements to get the successful results from the program. Organizational structure of 6Sigma needs to be started from the top management and applied to the down. It is very important that all the participants are well informed about the situation. The program should involve every area of the business from financial part to the managerial advantages. Additionally, some of other limitations are defined below:

- Part time Black Belt employees
- Additional operational work load on Black Belts while their project is still going on.
- Bludgeon somebody to be Green/Black Belt
- Disregard of Champions
- Non data based presentations
- Recommended staffs who have low work load instead of successful people at the job.
- Attempting the literal implementation of 6 Sigma
- Cut back on measuring of quality characteristics just after the completion of the project

7. 6 Sigma Methodologies

As we mentioned before, 6 Sigma is a data-driven methodology. It means 'I think' or 'I feel' phrases are out of option while we are doing the implementation. It needs to be based on fact and knowledge. If we want to put in another way, 6 Sigma is a management strategy which some easy and effective statistical tools are used for defining, measuring, analyzing, improving and controlling of the processes to achieve of faultlessness. As is also understood from the explanation, we have some technics to get into the 6 sigma implementation. Even though one of them is widely used, we can classify it into three.

- ***DMAIC (Define, Measure, Analyze, Improve, and Control):*** It is inspired by process improvement Shewhart cycle which is plan-do-check-act. DMAIC is focusing reducing variation and defects on existing process. The details about this approach will be examined in depth afterwards.
- ***DMADV (Define, Measure, Analyze, Design, and Verify):*** This method is preferred when some customer dissatisfaction occurs due to the process or company is disqualified to achieve its goals. If the company falls behind achieving the strategic targets, what to be done is creating new design. In this concept, define, measure and analyze parts are the same as DMAIC. The differences on this approach we focus on designing new processes or products in order to meet the customer needs and then verifying of this new system.
- ***DMEDI (Define, Measure, Explore, Develop, and Improve):*** This method is altered version of DMADV by PriceWaterhouseCoopers. It also is used when a new process design is needed. The situation which never existed before is defined and is taken into the consideration. In this method, company is examined in terms of fidelity to the project by collecting statistical data. If the new project suitability is detected, improvement phase is carried out. After then designed and improved the project is presented to the relevant responsible. However, as a negative thing of this approach; it requires more time and resources.

Generally, there is a equating between DMAIC and DMADV. Even though the main difference is improving the existing system / designing new system, there are also some similarities about two methods. They aims to reach 3.4 defect rate per million, they are implemented by Green, Black and Master Black Belts and above all a cross-functional team, they both are data base approaches and 6 sigma tools are used for two of them. We can see the decision making chart between them.

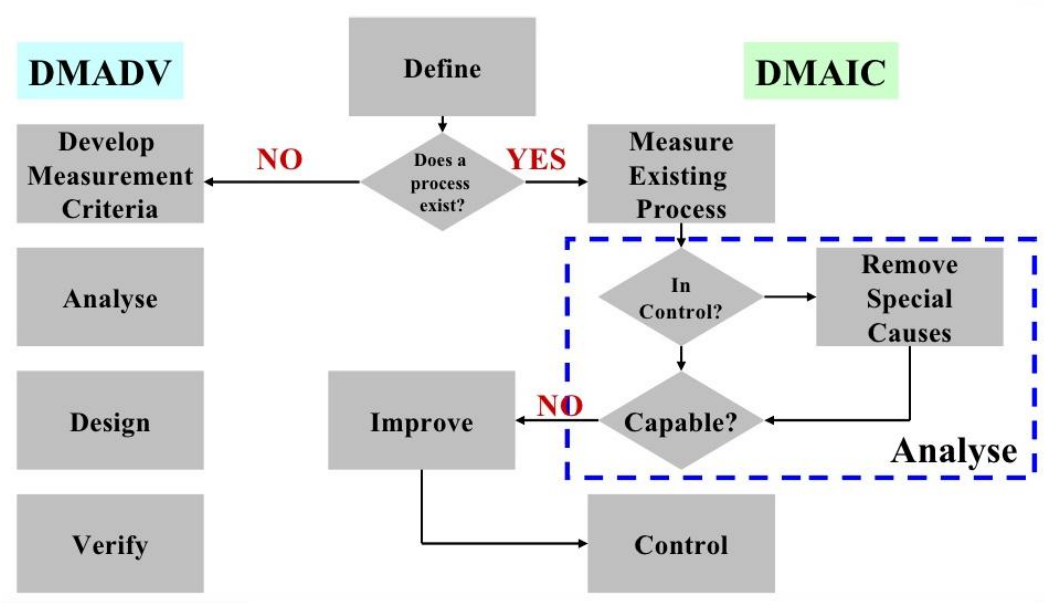


Figure 8: DMAIC vs DMAD (Subramaniam, 2009)

Considering all of these, it could be said that DMAIC is the most used and well known approach for 6 Sigma projects. In the project applied section of the study, you will see the implementation of this method as well. That's because DMAIC method would be dwelled on in details on the following pages.

7.1 DMAIC

Company has to identify its project management system to effectuate the improving by projects. A well accepted project management terminology makes the all employees to speak with same language and share all the outcomes with each other easily.

DMAIC method focuses on improving, designing and managing of the process. The most important feature which separates the 6 Sigma from the others is having DMAIC process improving management. Even though the road map has been described in this approach, outputs of every stage should be defined and actions to be taken to pass the next stage should be considered.

DMAIC could be related with any process such as product design, setting off the financial tables or order fulfillment. In the approach definition, measure and analyze are called 'process characterization'; improve and control on the other hand are called 'process optimization'. DMAIC is a cyclic action and it is desired to get the best solution out of it.

DEFINE: Define the problem	
MEASURE: Measure the parameters/ variables	**Process Characterization**
ANALYZE: Hypothesize, then test and analyze it	
IMPROVE: Improve the process	**Process Optimization**
CONTROL: Control the improved process	

Table 4: Basic steps of 6 Sigma (Gursakal and Oguzlar, 2003)

As seen from the table, we would be summarizing general perspective of the DMAIC approach. Now, we will descend each of them.

DEFINE: In this phase, 6 sigma project(s) is supposed to be defined in the first place. In this way, the connection between the critical variables for customers and job needed is entered. After then, the subjects which are project name, owner of the project, start date, deadline, project team, definition of the problem, customer, critical to quality, variables, mismatches, sigma level before improvement, targeted improving rate, improved area, targeted gain on the define sheet are defined in no uncertain terms. When all information is filled, the documentation needs to be approved by project owner, champion and top management.

While defining of performance standards, detailed present process related in working process, financial analysis and performance measures, is mapping. In addition, significant error types are prioritized by Pareto analysis, causes of the errors are defined by brain storm and the results obtained are turned into fish bone diagram. At this level there could be another problem solving technique which is FMEA (Failure Mode Effects Analysis).

To clarify the critical quality variables in a project, these variables are needed to be connecting these points below;

- Customer communication
- Market competition environment – product/price/value
- On-time and complete delivery
- Technical performance of product/service

Targets	Outputs
- Generating performance standards based on real customer evaluation which guarantees the customer satisfaction before and measures the sufficiency of process. - Constituting systems and strategies help data collecting of 'voice of customer'	- Output requirements directly related with product/service which serve to customer. - Service requirements defining how to manage customer relationship by business.

Table 5: Targets and Outputs of Define Phase (Pande, Neuman and Cavanagh, 2003)

MEASURE: In measurement phase, some tools are used to define the process and verify the measurement system. This stage clarifies the target performance and baseline of process, describes the inputs and outputs of process and verifies the measurement system. Process roadmap is used to verify the system. 'Measure' is one the most important phase among 6 Sigma. First of all, targets and sponsors are defined by filling the project state report. Later on, team which includes members from representatives of process, suppliers and customers is formed. While drawing the process flow chart, inputs and outputs are highlighted. A list which shows all the input and output of the process is prepared and connection of cause and effect is discussed by using cause-effect diagrams, cause-effect matrix and failure mode affect analyze (FMEA) tools. After it's done, an input list which has more effect on outputs is prepared according to experience of the team and measuring credential is set for the inputs-outputs.

The root causes of cause and effect diagrams are separated into controllable and uncontrollable root causes. Data is collected from controllable variables while corrective and preventive actions have been applying for the uncontrollable. At that rate, after the verification of the measurement system in that stage what is done; data collecting of process input-output and monitoring of reliability. As tools, control chars, reliability analysis and graphical techniques are used.

Targets	Outputs
- Detail evaluating the performances of each process considering the describable customer needs - Measuring the key outcomes and services	- Reference Measurements: Quantitative evaluation of current process performances - Competence Measurements: Interpretation of process sufficiency to meet the needs - Measurement Systems: Enriched resources or management for present measurement system to evaluate the customer oriented performance standard

Table 6: Targets and Outputs of Measure Phase (Pande, Neuman and Cavanagh, 2003)

ANALYZE: In this phase, variability roots and critical variables are determined to define the key process inputs. In addition potential reasons are sifted and filtered. In that purpose, we benefit from some tools like process map, brain storm, cause-effect matrix, FMEA analyze, parametric/ nonparametric hypothesis test (t test, z test, F test, ANOVA), regression and correlation analysis, statistical process control (SPC), measurement system analysis (MSA).Summarizer statistical values such as mean, standard deviation, median or ratio are used to calculate confidence intervals and perform test of significance.

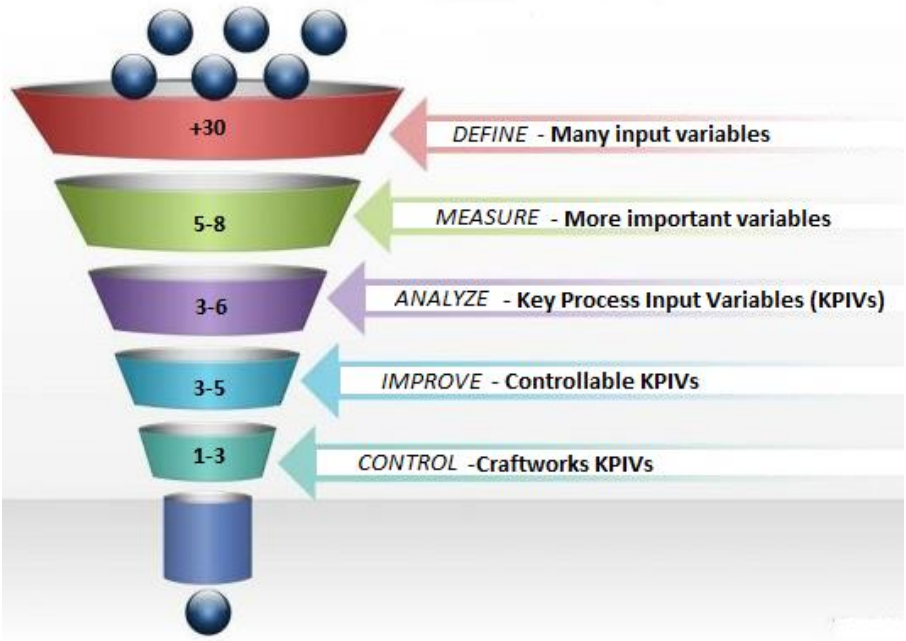


Figure 9: Filtration for Optimized Process (Haiyan Ru, Haibo Ru, HuangChao, 2005)

Targets	Outputs
- Defining the main reasons of problem and verify them	- Tested and verified hypothesis

Table 7: Targets and Outputs of Analyze Phase

IMPROVE: Improve state focus on decreasing the variability of elements which are more effective than the others come from the previous phase. Effects of improvement activities are examined again by statistical technics. Thus, a recovery plan could be defined to reduce the errors and optimize the outputs. Regression analyses, factorial experiment, ANOVA ex. tools are helping on exhibiting the connection. Thereby, the functional relation between the input and output comes to surface. In addition, circumstances of new process would be proved by statistical point of view. Optimum values

related with input variables are defined, reliability of process is calculated and cost-benefit analysis is done. In this way, project plan would be updated and actualization plan would be verified. The last thing in the stage, not only obtained results and improvements are confirmed, but also problem avoider resolutions are designed by technology and discipline, application plan is developed, improved and extended. Later on, improvements should be institutionalized by using in service training, punishment-reward system and changing organization. It could be happening by using required people in the right place and in the right time with relevant cost.

Targets	Outputs
- Determining the potential areas to be improved - Enhancing process based solutions by the help of verified analyses and creative thinking - Implementing the new process and solutions effectively - Acquiring sustainable and measurable earnings	- Improving Priorities - Process Improving - New or redesigned processes

Table 8: Targets and Outputs of Improve Phase

CONTROL: In the 6 Sigma approach, how to preserve the achievement is really important. Many of the projects could be failed because of the fail to keep continuity even though they achieve the targets in the first place. Therefore, documentation and control plans have to be constituted and a new system should be implemented in terms of statistical point of view to monitor the metrics. In this phase process sufficiency of the input/output variables are redetermined. In this purpose, we get benefit from the control plan, control graphs (SPC) and process proficiency analysis. Thusly, control plan relation to process, control graphs, defects per million opportunities (DPMO) and z value would be acquired. Once for all, project is completed and closed. In line with this target, financial affirmation needs to be done team meetings intended to customer is organized, monitoring the project is completed and project result opportunities are replicated. In this way, best practices and implementations are learned and experiences are gained, success of the project is announced, project report and summarize of it are reorganized and presented and consumer feedback is had. After that, project will be lost to follow up from the project leader and assignable to the responsibilities of improved process. After the assignation of project, project leader must audit periodically by adhering to the control plan.

Targets	Outputs
- Evaluating the improvement plan and the obtained results - Propounding the actions to taken to prosecution of gaining.	- Last situation of the process - Earnings and opportunities after the improvements

Table 9: Targets and Outputs of Control Phases

Beside of the information above, summarized 6 sigma tools chart can be seen from the table below;

DEFINE	MEASURE	ANALYZE	IMPROVE	CONTROL
- Project Charter - Voice of the Customer and KANO Analysis - SIPOC Map - Project Valuation / ROIC Analysis Tools - RACI and Quad Charts - Stakeholder Analysis - Communication Plan - Effective Meeting Tools - Inquiry and Advocacy Skills - Time Lines, Milestones and Gantt Charting - Pareto Analysis	- Value Stream Mapping - Process Cycle Efficiency/Little's Law - Operational Definitions - Data Collection Plan - Statistical Sampling - Measurement System Analysis (MSA) - Gage R&R - Kappa Studies - Control Charts - Spaghetti Diagrams - Histograms - Normality Test - Process Capability Analysis	- Process Constraint ID and Takt Time Analysis - Cause & Effect Analysis - FMEA - Hypothesis Tests/Conf. Intervals - Simple & Multiple Regression - ANOVA - Components of Variation - Conquering Product and Process Complexity - Queuing Theory	- Replenishment Pull/Kanban - Stocking Strategy - Process Flow Improvement - Process Balancing - Analytical Batch Sizing - Total Productive Maintenance - Design of Experiments (DOE) - Solution Selection Matrix - Piloting and Simulation - Work Control System - Setup reduction - Pugh Matrix - Pull System	- Mistake-Proofing/ Zero Defects - Standard Operating Procedures (SOP's) - Process Control Plans - Visual Process Control Tools - MGPP - Statistical Process Controls (SPC) - Solution Replication - Visual Workplace - Metrics - Project Transition Model - Team Feedback Session

Table 10: 6 Sigma Tools (International Standards for Lean 6 Sigma-ISLSS, 2014)

8. Research of 6 Sigma in Different Sectors

8.1 Sigma Implementations in Service Sector

6 Sigma has received much recognition and several companies have adopted it in order to meet their organizational targets last few years. 6 Sigma's customers include a long list of well-established manufacturers like General Motors, Ford Motor Co., GE, Honeywell and many more. However, there are still many non-manufacturing companies that have come to the conclusion that 6 Sigma will not work for them. This is because 6 Sigma was firstly developed for helping the manufacturing industry. Organizations such as health care systems, financial service providers and educational systems all doubt the usefulness of 6 Sigma.

The most obvious reason why service organizations avoid implementing 6 Sigma is that they comprehend it as a manufacturing tool. Service organizations think that their companies have a large amount of human work force because of these there are no measurable defects to be corrected. A recent survey has shown that service companies that have invested in 6 Sigma are all saving millions of dollars for every project.

Although 6 Sigma approach is especially used in the manufacturing sector, there are many 6 Sigma applications in the service sector. In these applications, service companies gain significant achievement in customer satisfaction, to save money, reduce maintenance time, etc.

Pandey (2007), examined about service sector and in research, conducted in a multinational bank located in the National Capital Region (NCR) of India. Implementation of 6 Sigma helped the human resources function to better perform this task in this study.

Kukreja, Ricks Jr., & Meyer (2009), 6 Sigma project was undertaken to analyze the performance of a university's students in the accounting section of the ETS (Educational Testing Service) major field examination in the business.

CIGNA, a national healthcare insurance company, is using 6 Sigma in several ways to drive down costs while improving medical outcomes

In terms of the differences and commonalities of services and manufacturing, scrap and rework exist in both. Expenses arise due to inconsistent and out-of specification processes, for instance the need to re-contact a customer to verify an order, provision of an incorrect or substandard service, or even over-servicing or provision of more than required. Examples of well-known success stories of service implementations include Bank of America, Citibank, GE Capital Corp, GE Medical Systems, Mount Carmel Health System and Virtua Health. Limited applications can also be found in call centers, human resources such as DuPont de Nemours (Bott et al., 2000; Wyper and Harrison, 2000), and product support services such as Caterpillar (Schmidt and Aschkenase, 2004).

6 Sigma has applied at banks for many years and proven to improve banking performance. De Koning et al. (2008) was doing research at services industries and stated that 6 Sigma is a practical solution and delivered significant result regarding cost reduction and operational improvement. According to researches and implementations 6 Sigma, which was integrated with bank activities could reduce the credit approval process time (Kumar, Wolfe, & Wolfe, 2008). Heck et al. (2010) was doing research on USA banks and found that 6 Sigma has proven to increase performance by reducing customers' complaint, credit card processing time, front liners services faults, and increasing customer for credit card approval.

6 Sigma principles and health sector are matched perfectly because of the healthcare has no tolerance for errors and has to reduce the potential medical errors. Some of the successful implementation of 6 Sigma projects is to improve the timeliness and accurate claims reimbursement, streamlining the process of healthcare delivery and reducing the list of surgical equipment and related costs.

The radiology film library at the University of Texas MD Anderson Cancer Center also adopted 6 Sigma and improved service activities greatly. Also in the same institution's outpatient CT exam lab, patient preparation times was reduced from 45 min to less than 5 min in many cases and there was a 45% increase in examinations with no additional machines or shifts (Kwak, 2006).

One of the successful implementation of 6 Sigma in service industry is that the project started in Southcoast Health System. Southcoast Health System is a three-hospital system based in New Bedford, Mass. According to New England Business Bulletin reports; Southcoast Health System has saved $20 million since it began implementing 6 Sigma in January 2009. The savings are well over the amount invested, Patrick Gannon, Vice President and Chief Quality Officer for Southcoast Hospitals Group, stated the Bulletin. The hospitals group first set a $3 million savings target for the process, but more than doubled the amount. By the end of four months, after improving management of equipment, information and supplies, they had slashed costs by $7.6 million without laying anyone off, according to Gannon.

Another brilliant implementation of 6 Sigma is the project started by Bain & Company for one large insurance company. Prior to applying 6 Sigma tools and methodologies, insurance company's cycle time for claims was 41 days. Because nearly 89 percent of past claimants deemed 14 days sufficient time for completion, customer satisfaction was at an all-time low. In less than five months, the project team not only assessed the organization's defect rate and identified the key factors involved, but it also reduced the defect rate by more than 70 percent. In addition, the company's project savings exceeded $250,000 in the first five months, and customer satisfaction increased dramatically.

Citibank is a company of Citi group which has implemented victoriously 6 Sigma principles. At the end of the 6 Sigma projects, Citibank reduced cycle time at the rate of 75 percent, the number of monthly complaint telephones reduced to 1000 from 8000. Moreover, application time of financial loan decreased 1 day from 3 days, internal return telephones reduced at the rate of 80 percent, external return telephones reduced at the rate of 80 percent.

In all sectors and countries department of finance and the credit departments to be under pressure to reduce the cycle time of cash collection and changes in collection efficiency in order to remain

competitive. Typical 6 Sigma projects in financial institutions include improving accuracy of allocation of cash to reduce bank charges, automatic payments, improving accuracy of reporting, reducing documentary credits defects, reducing check collection defects, and reducing variation in collector performance (Kwak, 2006).

Vodafone Turkey, a telecommunication provider as the use of 6 Sigma in process design, process control and process improvement, as a strategy for managing since 2007. With the help of 6 Sigma methodologies Vodafone Turkey focused on priority projects developed customer satisfaction, improved teamwork throughout the company and gain a competitive advantage in the market.

Ford Otosan, a shareholder of the Ford Motor Company in Turkey. Ford Otosan used the methodology of 6 Sigma in their service center. The company is mainly, the development of service process used in customer-centric strategies 6 Sigma, thereby reducing the cost of poor quality and product defects to minimize. This is directly reflected in the 10% -40% cheaper advantages for the company's profits.

6 Sigma methodology used as an improvement process developed in the 80’s and 90’s, Xerox explore various approaches to improve their business results. 6 Sigma and lean concepts were adopted locally Xerox manufacturing and Supply Chain Operations in the late 90's. Because of success in 2002, 6 Sigma and lean and taken to a company-wide strategy (Marx, Moscow, 2010); as a result, began intensive training belt in 2003 (Xerox 2010). Xerox has used this program to resolve a problem with a $500,000 printing press it had just introduced. Nearly 700 projects of high impact to the business carried out and brought significant financial benefits, thanks to the black belts in its organization; In addition to more than 2,000 people were as green belt and more than 11 000 employees in the yellow belt between 2003 and 2004 has been certified. Xerox also used 6 Sigma methodologies in their accounts receivables. As a result, Xerox generated more than $ 150 million in economic benefits in 2004 (Marx, M., 2010).

8.2 Sigma Implementations in Manufacturing Sector

6 Sigma is a business management system that helps trim unnecessary expenses. And also 6 Sigma Methodology is a quality improvement process that helps companies ensure that their machines are calibrated correctly, efficient and doing what they are designed to do through the help of statistic, collecting and analyzing data.

Main benefits of 6 Sigma in manufacturing sector that reducing defects and prevents rework in the production environment. More reliable products, improve product quality, customer satisfaction, reduced production costs and warranty claims are the expected results (Kwak, 2006).

There are many 6 Sigma applications in the manufacturing sector that gained significant achievement to save money, reduce maintenance time, preventing rework and scraps etc.

Boeing Commercial Airplanes has participated in numerous pilot projects using 6 Sigma principles since 1999. Boeing focusing intently on the customer, this data-driven way to manage variation in manufacturing and managing business processes also is relentlessly focused on business metrics and cultural change. Specially selected experts undergo extensive training and become certified as "green belts" or "black belts" depending on the degree of training and projects completed. Currently there are dozens of projects in work across Commercial Airplanes, with more than 300 trained as green belts and nearly 60 trained as black belts. Boeing Production System is composed of several elements that work in concert to ensure an output of the highest quality and cost effective products in the least amount of time. The Boeing Production System principles consists of 6 Sigma all elements that are critical to the company's competitiveness.

Headquartered in Morristown, New Jersey, Honeywell International is a conglomerate company that offers engineering services, commercial and consumer products and aerospace systems. Honeywell is a Fortune 100 company with about 250 factories worldwide and approximately 130.000 employees, of which the half is US-based. Honeywell International has committed to providing every employee with 40 hours of learning each year. The company has earmarked millions of dollars to give an opportunity to each of its 130,000 employees to learn and embrace 6 Sigma Plus fundamentals, which Honeywell International believes will result in concrete growth, improved productivity and increased efficiency.

In 1999, Honeywell savings related to 6 Sigma amounted to more than $600 million. Year 2000 cost savings provided by 6 Sigma Plus is expected to save at least as much.

Another success story about 6 Sigma implementations in manufacturing sector is Michigan Sugar Company. Increased throughput by 10-20% on respective processing lines, increased profitability by nearly 20%, or $50K per month, reduced changeover time by 7% Retained existing employment levels.

King Systems is a global distributor and internationally recognized designer and manufacturer of quality anesthesia and critical care products located in Noblesville, Indiana. King markets nearly 3,500 different circuit configurations, facemasks, and airway management devices with sales

exceeding $60 million annually. Working with TAP in order to better facilitate employee training, more than 100 King Systems employees attended 6 Sigma training – programs focused on workplace organization, advanced manufacturing principles, and strategic approaches to problem solving. As a result of the training and implementation of principles, King Systems met and more than doubled the fiscal year cost savings target.

Ford Otosan which is one of the major automobile companies in Turkey automobile industry started 6 Sigma implementations in 2000. In the same year in Ford firstly Black Belt Trainings completed and the next year customer- focused 6 Sigma approach adopted and Green Belt trainings completed. As well as trainings, thriving 6 Sigma projects had been offered to Top Quality Council. For each problem area optimal two projects had been chosen and one of them approved. Ford Black Belts can incorporate each other in different projects thanks to this cooperation different projects can be prepared for different problems. As a result of all 6 Sigma projects Ford had reduced process defects and company's processes had been improved in order to achieve internal and external customer needs. Especially in 2004, 133 6 Sigma Projects had been completed and $17 million profit gained.

Borusan Holding, steel pipes and flat manufacturer of steel, automotive and heavy construction equipment dealer, its 6 Sigma journey within the broader corporate strategy of transformation began to reinvent it again in order to perform in an increasingly competitive economy in 2002. The program has been credited with the creation of more than 38 million US dollars in financial benefits by completing more than 200 projects implemented 6 Sigma community of more than 1,000 employees.

Northern Indiana manufacturer Oji InterTech has supported the automotive, transportation and industrial packaging industries with its compression molding, die cutting, assembly and extrusion-coating product line for more than 25 years. Oji competes on a global front, where manufacturers that sit still are quickly passed by their competitors. To maintain that competitive edge, Oji started applying 6 Sigma principles manufacturing in. With a focus on process improvement, employees were certified in the areas of Green Belt, Black Belt and Champion. Results of the 6 Sigma project significant and immediate improvements have been observed. $400,000 reduction in inventory costs during the first two months of implementing a process known as value stream mapping. $120,000 savings after addressing variances in its poly coated chip board, the material used by its extrusion division to manufacture molding products. $40,000 in savings from improved productivity after implementing tracking and visual display monitors throughout the plant, in what's called an Overall Equipment Effectiveness (OEE) system.

Eczacıbaşı Vitra, one of the leading companies in the field of construction. 6 Sigma is used in the collection, analysis of data in order to eliminate non-value added operations in the manufacture, to

focus on customer needs and the development of internal collaboration within the company. At the end of the 6 Sigma project Eczacıbası Vitra minimized defects in the manufacturing process, and received a ranking fifth in the world building products market.

Arcelik A.S., which is one of the leading companies in Turkey home appliances industry, took the first initiative in 1998 to apply 6 Sigma in manufacturing processes and production processes, and so extended to other processes in 2002. 6 Sigma projects are designed and implemented in order to improve processes, making processes transparent and manageable, establishing a decision making mechanism based on data, achieving a constantly profit increasing platform, combining organization and process objectives, achieving customer oriented approach and encouraging innovation at Arcelik. All information about Arcelik is taken from the company website.

Bosch Bursa Diesel Plant is applied 6 Sigma methodology with success in Turkey. It is one of four plants Bursa and manufactures automotive technology. With 6 Sigma company's continuous improvement of internal processes has provided care for their customers satisfied and high quality standards. All information about Bosh Diesel Plant is taken from the company website.

In General Electric 6 Sigma implementations were started and integrated with company strategic targets by Jack Welch who was CEO of the GE in between 1981 and 2001 years. GE had spent $400 million for 6 Sigma trainings in 1997 however at the end of the 6 Sigma projects $600 million revenue had been generated. When GE started 6 Sigma implementations in 1995, the quality level of company was 3 sigma, after 22 months quality level has increased 3,5 sigma value.

8.3 Sigma Implementations in Defense Industry

6 Sigma is generally used to procure profits within the retail and manufacturing industries. Although its steps and processes are best suited to solving problems within those industries, its mainframe and tools are perfect for the overall goal of the Military. 6 Sigma principles and defense industry are matched perfectly because of one small error can mean injury or even possible death for people or soldiers in this industry so number of errors defects shall be decreased by applying 6 Sigma.

The Navy, Army, Marines and other Military parts constantly need improvement and waste elimination processes. Thanks to implementing 6 Sigma efficient and accurate systems, right tools can be used in order to create a more which, in turn, create a better and safer environment for everyone involved. There lots of defense companies that implemented 6 Sigma approaches

Lockheed Martin is the world's largest defense contractor. In 1999, Lockheed Martin developed an approach called LM21, for Lockheed Martin in the 21st century, to identify best practices for

increasing efficiency and improving financial and operating performance. The main goal is to create a system that consistently achieves excellence for customers, shareholders, and employees. Therefore the management philosophies called Lean and 6 Sigma selected and implemented.

One of the leading appliers of 6 Sigma methodology in Turkey is TEI Tusas Motor Industries which was fully adopted 6 Sigma to quality management systems in compliance with international regulatory standards. The company has its delivery strategy on time with competitive prices with the implementation of 6 Sigma through the continuous improvement of products and services, processes and quality management system.

Minitab Company's research result shows that Department of Defense saves billions with implementing 6 Sigma methodologies. U.S. Army deployed 6 Sigma in 2005, nearly 2,000 personnel have been trained, more than 1,000 projects have been completed, and more than 1,600 remain active. The Army credits these projects with achieving nearly $2 billion in savings so far. In addition to that the Department of the Navy has trained more than 5,000 sailors and Marines as 6 Sigma green or black belts since 2006. The Navy estimates savings from its projects for 2006 and 2007 to be $450 million, a 4-to-1 return on investment. Moreover U.S. Air Force has trained more than 500 6 Sigma belts, and its Air Logistics Centers received two Shingo Prizes for quality improvement in 2008. The Air Force has committed to a 40,000-manpower reduction without impairing its operational capabilities due in part to efficiencies gained from its initiatives.

The Raytheon Company is a major American defense contractor and industrial corporation with core manufacturing concentrations in weapons and military and commercial electronics. It was previously involved in corporate and special-mission aircraft until early 2007. Raytheon is established in 1922; the company reincorporated in 1928 and adopted its present name in 1959. The company has around 63,000 employee worldwide and annual revenues of approximately US$25 billion. Daniel Burnham brought 6 Sigma to Raytheon from AlliedSignal in 1998. Their enterprise-wide deployment has prospered and is known as Raytheon 6 Sigma. They follow the unique Raytheon 6 Sigma Process, six steps that guide projects to completion: visualize, commit, prioritize, characterize, improve, and achieve. They have also customized the titles they give the 6 Sigma workforces: Specialists (Green Belt), Experts (Black Belt), and Master Experts (Master Black Belts).

Currently Raytheon 6 Sigma infrastructure includes: over 1,200 Raytheon 6 Sigma Experts, 46,000 Raytheon 6 Sigma Specialists, 50 Master Experts, 9,000 senior-to mid-level trained leaders.

According to Raytheon annual reports; $3.8 billion in financial benefit, common language and culture across the business, has become the Raytheon way of doing business.

Raytheon 6 Sigma (R6s) has become part of the DNA structure of company. With tens of thousands of R6s Specialists, hundreds of Experts, and dozens of Master Experts, R6s is embedded in the company. Over the years, the application of R6s has transitioned from cash management to program performance, engineering and suppliers, and now to growth. A Raytheon 6 Sigma project, the Radar Affordability Project, resulted in a 30 percent reduction in ballistic missile defense system radar unit costs.

Boeing has been heavily involved in applying Lean Manufacturing principles since the early 90s. It wasn't until the late 90s that they began to complement their Lean initiatives with 6 Sigma. 6 Sigma at Boeing is not a corporate mandate. It began as a grassroots effort in 1999 and is now part of the Boeing Production System.

Since 1999, Boeing Commercial Airplanes has participated in numerous pilot projects using 6 Sigma principles. Focusing intently on the customer, this data-driven way to manage variation in manufacturing and managing business processes also is relentlessly focused on business metrics and cultural change. Specially selected experts undergo extensive training and become certified as "green belts" or "black belts" depending on the degree of training and projects completed. Currently there are dozens of projects in work across Commercial Airplanes, with more than 300 trained as green belts and nearly 60 trained as black belts.

Although annual reports do not mention 6 Sigma by name they do call out Lean enterprise. The 2004 Annual Report states that Lean initiatives reduced costs by $210 million. 6 Sigma does get press in the monthly newsletter, *Boeing Frontiers*, which has featured 6 Sigma articles and success stories.

As a leader in the Aerospace and defense industry Northrop Grumman builds efficiencies and reduces costs using 6 Sigma. Northrop Grumman started implementing 6 Sigma in 2001, trained over 3000 Green Belts, and over 200 Black Belts. Northrop Grumman completed several hundred projects covering all functional areas, customer involvement and award fee citations; about half of the projects are improving an engineering process. The Northrop Grumman team, through a combination of aggressive engineering and management efforts, has reduced the total projected F-22 radar production costs by more than $386 million over 12 years and 339 radar systems, with all of the savings accruing to the Department of Defense.

III. 6 Sigma Implementation in Supply Chain Management

9. Supply Chain Management

Before starting of defining the project, it would be better give some information about the application of 6 Sigma in supply chain management, since our implementation held in purchasing department which is part of the SCM. The meaning of 'supply' is give a resource, provide. As for the business point of view, term of supply is the activities for searching and purchasing of auxiliary product, raw material and capital goods which are used in the manufacturing process. Supply Chain, on the other hand, is all of the activities and functions that flow from good and service supply to the production and then delivery to the customer. It's been indicated in Wikipedia as 'a system of organizations, people, activities, information, and resources involved in moving a product or service from supplier to customer'. Supply chain covers all the areas and phases from supplying materials to the customer delivery and aims maximizing the added value of products.

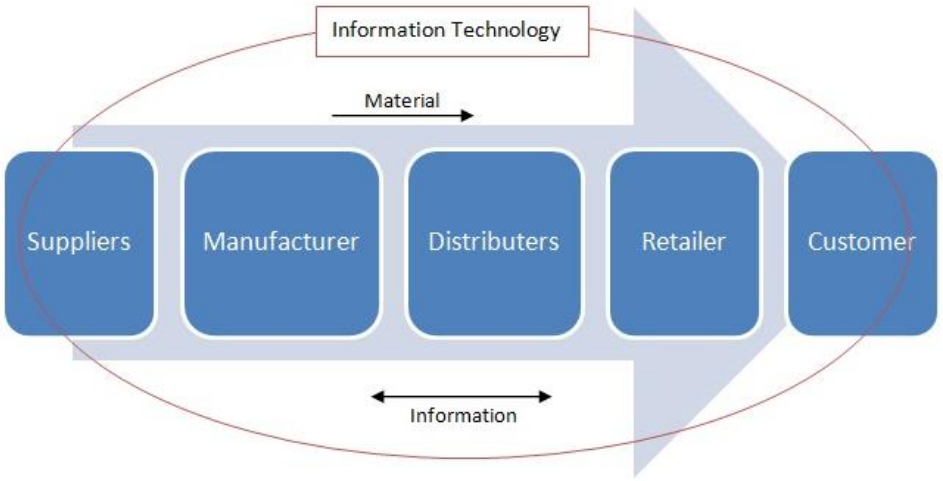


Figure 10: Supply Chain Management (Walmart SCM)

Short term target of supply chain is removing the extra stock and increasing the responsiveness to the customer. On the other side, long term target is meeting the customer expectations in the right place, on the right time and with the right product. In that case, company could improve their share in the market. The goal of the supply chain is transporting goods/service to the customer in the short run with the minimum cost.

Present conditions oblige the firms to better check their product price, cost and efficiency. It requires binding among supplier, retailer, dealer, customer and shipper. All the activities which are run within process help to develop a good environment for competitiveness. That's because, meeting the expectations of customer is not dealing with a single unit of the company but all supply chain. There are a few points to be considered in a successful customer centric supply chain;

- Receiving order should be done at will.
- Companies need to provide continuous supplying and inform the customers about it.
- Intercorporate expenses are supposed be minimum in case reducing the final cost of product.
- Decreasing of the designing time is important since it helps to cut the response time to the customer needs.

Supply chain management has been defined as the "design, planning, execution, control, and monitoring of supply chain activities with the objective of creating net value, building a competitive infrastructure, leveraging worldwide logistics, synchronizing supply with demand and measuring performance globally" (APICS Dictionary, 2013). SCM draws heavily from the areas of operations management, logistics, procurement, and information technology, and strives for an integrated approach (Bartsch, Handel retrieved 2013). Supply Chain Management is essential to be applied in the companies. Some of the benefits are mentioned below;

- Providing the continuous process while ensuring the product supply
- Increasing the lead time, thus it helps respond to variegation in the market just in time
- Improving the quality with fulfilling the customer needs ideally
- Encouraging of using technology through the innovation
- Reducing the total cost
- Helping the companies being capable of managing to control all flow of information, products and cash

On the other hand, the main goals of supply chain management could be stated as below;

- Increasing customer satisfaction
- Decreasing cycle time
- Reducing stock and cost of stock
- Minimizing product defects
- Decreasing operating cost for whole processes

9.1 Supply Chain Management and IT

Even though SCM incorporates many functionalities of the company, we shouldn't wait for it to solve all the problems. It is essential to apply this strategy correctly; this is the only way to get create a competition. Reaching the best result starts understating each including phase in supply chain management. Order management, purchasing, planning, stock management, warehouse management and shipping should be connected each other and work interdependently. In that case we can say information flow between these functions needs to be process impeccable and continuously.

By help of technology, supply chain turned to a low cost, saving money and preventing problems strategy. Centralizing operations allow the companies to find and repair the weak points in supply chain.

	Classic SCM	**SCM via Internet**
Ratio of random purchasing	High	Low
Quantity discount	Low	High
Management process	Paper based	Electronic
Employee productivity	Low	High
Order cycle process	Long	Short
Number of error	High	Low

Table 11: Differences between Classic SCM and SCM via Internet (Karaboga, 2010)

As mentioned before, supply chain management involves lot of process and every type of product, service and data used through these processes are recorded in that management. Nowadays, all processes are done by specific software, so every employee needs to know how to use and integrate it to the entire chain. This software is in all which are used from the production to the delivery processes. SCM software switches all different applications into just integrated one which provides an easy access by all departments. Software and consultancy companies are in competition about these busy business and they sell their software and applications with big amount of money. Because they also know that none of the companies can survive without getting help from technology. That computer programs/software involves continuous communication with customer, advanced planning, shipping management, production planning, warehousing and supply chain optimization skills. Because of those programs, every detail has been caught even beginning of the process which can't be realized by top level management.

Before starting production, all the raw materials and equipment should be ready to use. Not only materials but also quality of them needs to suitable due to the requester final products. In the opposite case, if the quality is not enough to meet the expectations, this poses problems such as delay cost, poor quality products, ineffectual production, delayed delivery and unsatisfied customers.

Eliminating those problems is the issue of the companies, nowadays. First rule to stay stand in the business is reducing the production cost. For this, supplied raw materials should be purchased at minimum price; it affects all the company profit though. This frame of mind forms a basis of purchasing.

9.2 Purchasing Management

Purchasing department identifies the product type, quantity of it and the time when they should get it. This department keeps the company in the competition while they are developing their sustainability. This process comes together with a few functions such as defining the needs of company, choosing right supplier, compounding about the price and shipping/delivering of the products. Those functions flows provide a relationship between materials management and external market. In that case we can talk about the activities below which are included in purchasing functions.

- Defining the needed products / services of intended quality and quantity
- Choosing the right supplier as much as possible to provide of planned materials / service
- Negotiating with the supplier about getting agreement for cost, quantity and quality
- Giving order to the agreed supplier
- Order follow-up and control
- Monitoring and evaluating of purchasing process based on supplier

There are four dimensions in procurement cycle as being technical, commercial, logistics and management. Technical dimension aims increasing the quality of purchased products, commercial part helps managing the conditions of contracts and relations with the suppliers, logistics dimension tries to optimize of processes starting with purchasing of goods until the company get them and management parts manage the order management and invoice tracking. All these dimensions help to get some targets like balancing right quantity/quality ratio, following the new trends in the market, having a good relationship with the suppliers in long term, choosing the most suitable supplier by chasing the new products and designs in the market, collaborating with all the departments in order to get more efficient.

Target of the purchasing department is providing the products with right quality and right quantity at the right time from the right supplier by right price. Those first four 'right' determines the right price. To achieve this target this department should be in communicate with other departments continuously. In that case they can fulfil their duties. Because of the increasing competition conditions, duties and responsibilities of the department are getting intense day by day. Some of the duties and responsibilities of the purchasing department are defined below;

- Data and information management
- Purchasing research and analyzing
- Conducting purchasing process

Duration of this process includes lot of activities like mentioned before. We can summarize all these functionalities in the SIPOC framework technique which is an organizational system model using for process management and technology development. This acronym is formed with initials of supplier, input, process, output and client. It helps to be seen all the steps and processes by everybody clearly. As American Society for Quality (ASQ) mentioning, there are some steps to build a SIPOC diagram.

1. Name the process
2. Indicate the start/stop, or the scope of the process. (What are the triggers that initiate and end the process?)
3. Indicate the outputs of the process (Use nouns – what is it this process does?)
4. Indicate the customers of the process (Whom does this process affect/benefit?)
5. Indicate the suppliers of the process (Which individuals/teams provide inputs into this process?)
6. Indicate the inputs of the process (Use nouns – what is needed to execute this process and deliver the outputs?)

In the light of these, there is a map of SIPOC of purchasing department framework below;

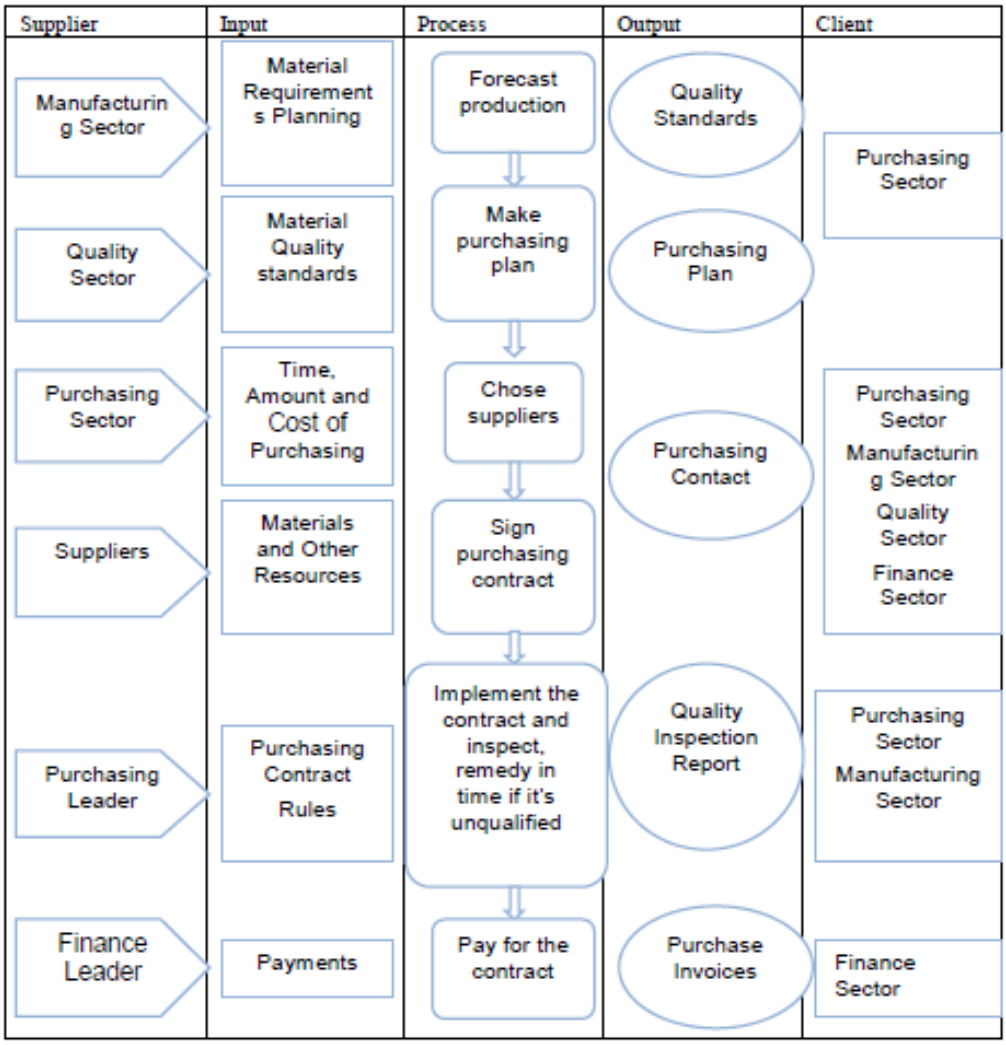


Figure 11: The Map of SIPOC of Purchasing Process (WU, WANG and ZHANG, 2010)

Even a little problem can affect all the process. This causes some delay and unhappy client which equals losing profit for the company. Preventing these problems, some points should be implementing. First of all we have to define all the steps in the processes. This helps us to observe and monitor what is going on. Second point is defining the responsibilities. Many departments should interact in those processes within the company. The other issue is merging different experience, expertise and skills. We can get benefit from anybody who has value for the process since there isn't just one person. However, no matter how we put effort on it, there could be some primary concerns such as supplier and brand properties, choosing improper supplier, insufficient experience for the contract, dwelling on the price so long, and unplanned organization management. All those problems may have occurred duration of the process and the higher time of the process mean higher risk to get one of these obstacles.

IV. 6 Sigma Project Implementation

10. Information about the Company

10.1 Company Name

ROKETSAN Missiles Industries Inc.

10.2 Company Contact Info

Location: Ankara-Samsun Road 40. Km 06780 Elmadag/ANKARA

Phone: +90 (312) 863 42 00 (PBX)

Fax: +90 (312) 863 42 08

E-mail: human.resources@roketsan.com.tr

Website: www.roketsan.com.tr

10.3 History of Company

ROKETSAN was established in 1988 upon a decision of Turkish Defense Industry Executive Committee to take lead in rocket and missile programs.

As its first production program, the company received responsibility in the Stinger European Co-production Program with 30M $ investment and fulfilled the liability of paying 25M $ taxes. In parallel to this, ROKETSAN completed construction of Elmadag facilities near Ankara and started to production here in 1991. Today, with its 1500 qualified personnel ROKETSAN is responsible for the launch and flight motors of Stinger missiles and has the second largest industrial share that is 15%, among 14 leading European companies of the Consortium.

In 1996, Extended Range Artillery Rocket TR-122 MIZRAK, Artillery Rocket Launcher T-122 SAKARYA, and Extended Range Artillery rocket TR-107 ANADOLU were produced and delivered to Turkish Armed Forces as the first weapon systems in the inventory that are completely designed, developed and manufactured by Turkish engineers in ROKETSAN's modern facilities.

Research and Development studies have been taking place at ROKETSAN since its establishment and have been awarded by Turkish Ministry of National Defense for conceptual designs.

In addition to ongoing national programs, ROKETSAN participates in the international research and development efforts within West European Armament Group-WEAG and NATO. In WEAG, ROKETSAN is working in Research and Technology Project RTP - 3.1 Aeronautical Application Technologies and RTP - 3.4 polymeric composites for short range High Mach Number Missiles under CEPA-3. In NATO, ROKETSAN is actively involved in AGARD - Propulsion and Energetic Panel (PEP) and working in Project T - 71 within this panel.

Beyond those, ROKETSAN has gained a remarkable experience in international project management by involving in integrating & producing surface-to-air precision guided munitions, anti-tank weapon & air defense systems.

10.4 Mission and Vision of the Company

The mission of the ROKETSAN is to serve in the national defense with our rocket and missile systems and contribute to the technological infrastructure of Turkey with its products.

The vision of the ROKETSAN is to become the leading establishment of Turkey with its rocket and missile systems, from the depts. Of the seas to the heights of the sky; to be placed among the first 50 companies which direct the global market with their sales volumes and missile technologies, by means of our ROKETSAN original products and advanced technologies?

ROKETSAN has some core values. These core values and its explanations are stated below;

- **National**: hundred percent national;
- **Competent**: specialized in the fields of rockets and missiles;
- **Dependable**: adhering to the rules of ethics;
- **Creative**: creating new and extraordinary ideas, approaches and solutions;
- **Partner Focused**: providing services in harmony with the expectations and requirements of our partners, customers, employees and our contractors;
- **Venturous and Pioneer**: enterprising and leader in missile technologies.

10.5 Quality Policy of the Company

ROKETSAN will, within the frame of the National Rocket and Missile Industry Policies, design, produce and timely deliver rockets, missiles and other defense industry products and services as well as civil sector products, for which its infrastructure is suitable, in accordance with the laws, regulatory

conditions, national and international standards in force, in a manner to meet the requirements and expectations of the Turkish Armed Forces and its customers in global market.

In order to improve the performance and the quality, it will act in accordance with the principles of "continuous improvement" and "right production in the first instance".

The factors which comprise the quality system of ROKETSAN are given below;

- Quality management according to AQAP 2110
- Calibration system conforming to ISO – 10012 – 1
- Purchase control
- Ambient condition tests conforming to standards MIL – STD – 810 and MIL – STD – 331
- Inspections and tests at various levels
- Improper material control
- Handling with special tools, storage in controlled conditions and shipment with documents control
- Documentation control / records
- Inspection inside / outside of the company
- Configuration management
- Personnel training

10.6 Organizational Structure of the Company

In ROKETSAN, board of directors gives the authority to the general manager, who shares it with three manager assistants and five directors. Each manager assistant of the company is responsible from different category of the products. Therefore, each general manager assistant has own engineering directorate, programs directorate and manufacturing directorate. The detail of the product categories are given below;

- **Ballistic Missile System Group;** is specialized on surface to surface guided missile system, satellite launch system and artillery rocket systems. This group is responsible from;
    - Rocket and Rocket Pot Design and Production,
    - Surface to Surface Guided Missile Systems,
    - Sensitive Inertial Navigation Systems,
    - Multiple Launcher Rocket Systems (Naval and Surface System),

- Satellite Launch Systems.

- **Tactical Missile System Group;** is specialized on intermediate stages guided missile systems and seeker system for guided missiles. This group is responsible from;
  - Laser Guided Missile Systems,
  - Air Missile System,
  - Navigation Systems,
  - Air Defense Missile Systems.
- **Operational Energetic System Group;** is specialized on propulsion systems, warhead and pyrotechnic system, ballistic protection. This group is responsible from;
  - Propulsion Systems,
  - Composite Solid Fuel Systems,
  - Passive and Reactive Armor Systems

The shareholders decides about the future of the company and manager implements the decision and tires to achieve the goals with the help of general manager assistants. Manager assistants and directors are responsible from operations; financial & administrative affairs and programs & engineering. The main organization chart is given in Figure 12.

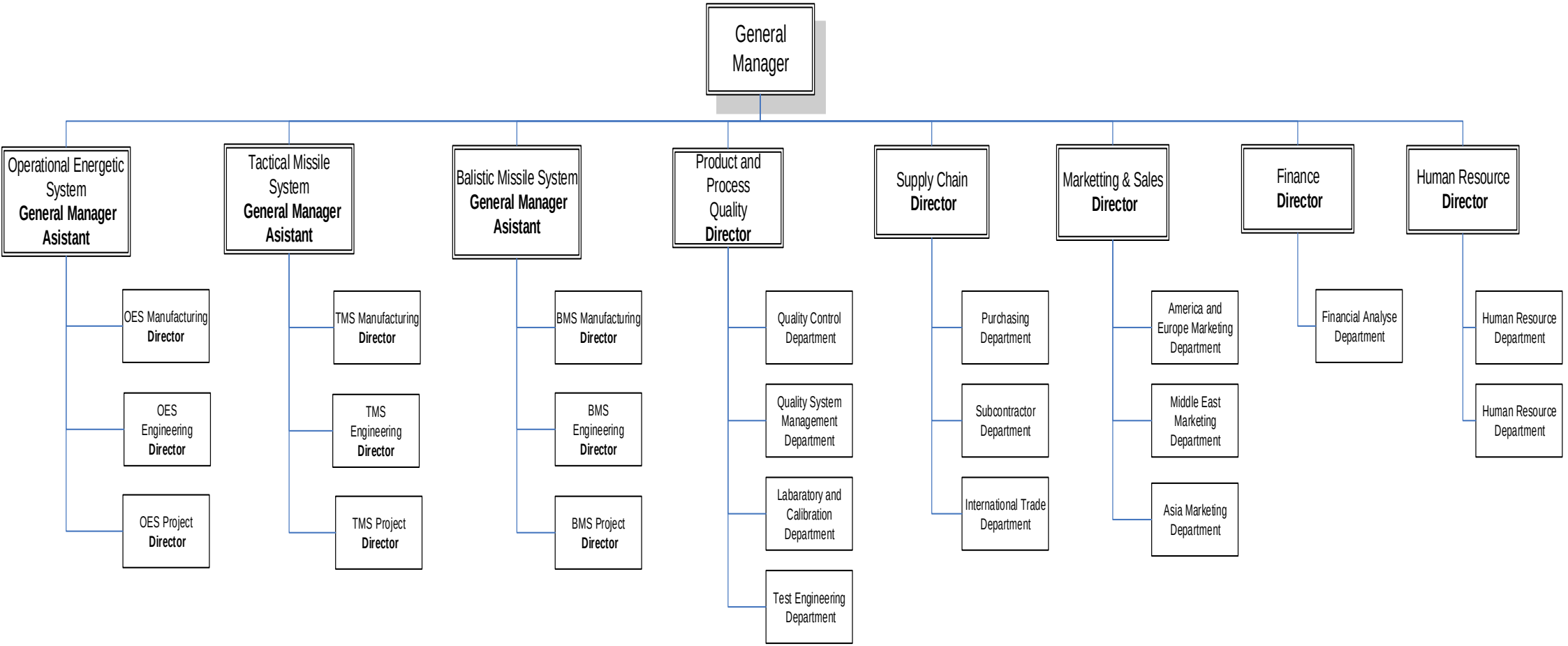


Figure 12: Organizational Structure of ROKETSAN

Some part of the shares is hold by government while a great majority is hold by private sector. The administration committee is build up by the shareholders of the company. The chart of the shareholders is given in Figure 13.

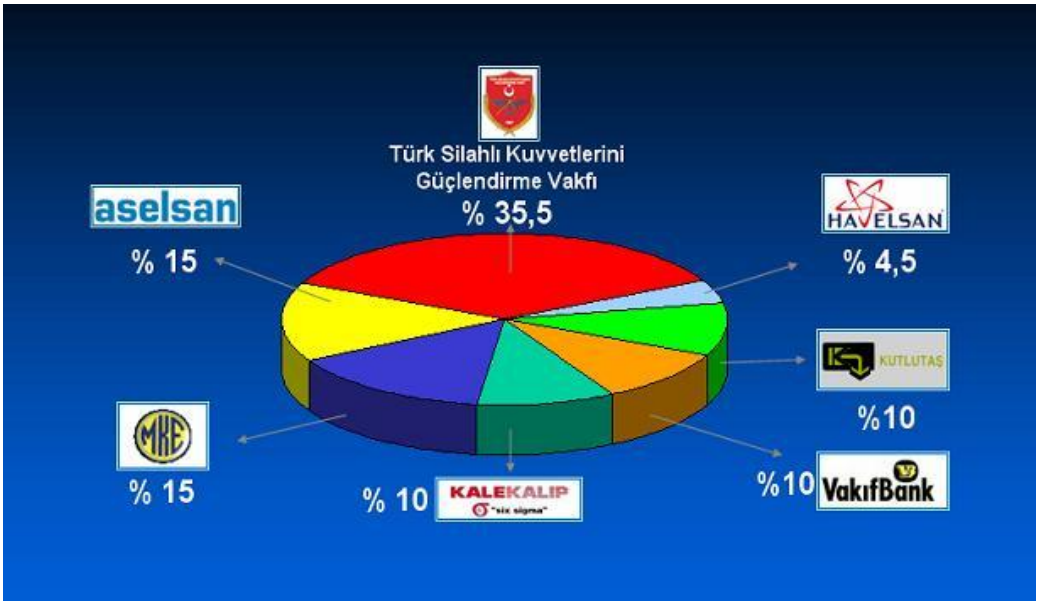


Figure 13: Corporation Structure of ROKETSAN

The committee is build up by the companies and organizations shown above. Since administration of the company is an integration of governmental and private organization the company had both advantages and disadvantages of private and governmental sectors.

The company has a developed cooperated organization compared to a private organization which is an advantage for ROKETSAN. However, it has a more hulking structure compared to private companies. This type of organization is a must for ROKETSAN. Because the company manufactures defense systems and needs support and administration of government.

10.7 Personnel Allocation

Number of engineers in the company is 45% of total employee. This is a very high ratio compared to a single company. The reason of having such a high ratio of workers is that development and manufacturing of missile systems requires high technology and problem solving capability. Since the tests of the devices of rockets are very expensive and dangerous all the calculations and simulations must be done perfectly. That is why the company employs so many engineers. The chart that shows the percentages of employees by their duties, their age average and education level is given in Figure 14.

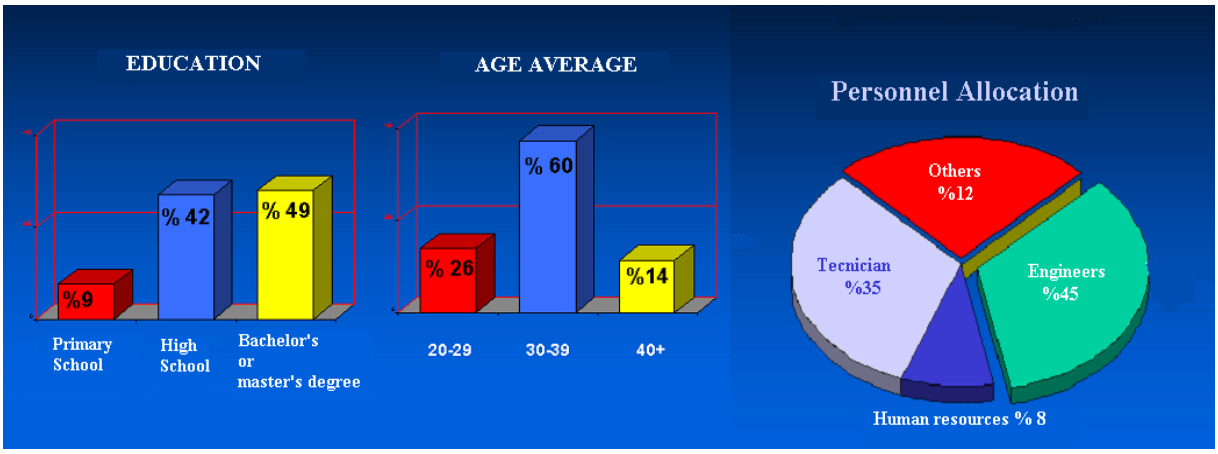
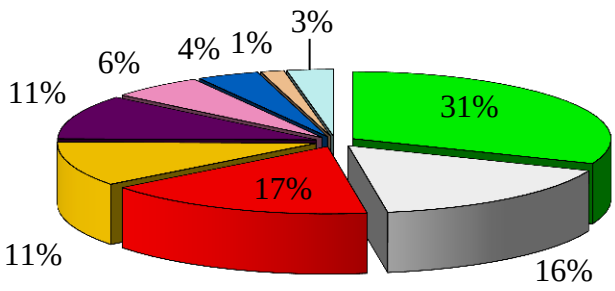


Figure 14: Statistics about the Employees Education Level

A great majority of the production and simulation systems are imported, so the engineers and specialists must be well educated and speak at least one foreign language. Engineering and Development section has a total of more than 300 engineers and this shows that research and development activities are one of the most important aspects of ROKETSAN. The technicians for the production purposes are trained and educated personnel and they are specialists at their fields of activity. The chart that shows the percentage of engineers is given in Figure 15.



- Mechanical Eng
- Chemical Eng.
- Aeronautical Eng.
- Metallurgical Eng.
- Electrical and Electronics Eng.
- Physical Eng
- Industrial Eng.
- Civil Eng.
- Other

Figure 15: Percentage of Engineers Working in the Company

In Production Management, most important role belongs to mechanical engineers and aerospace engineers. Also rocket fuel technologies need a great number of chemical and metallurgical engineers. These engineers rule all the processes of production and quality control. On the other hand, the company is investing more money to engineering and development. Additionally, the modernization projects of existing missile systems require, electrical and computer integrated mechanical systems which is the responsibility of electronics engineers.

10.8 Programs & Product

Establishment of ROKETSAN has aimed produce and develops rocket and missiles. Its main business is to provide rocket and missile requirements of Turkish Army. There are several programs and production at ROKETSAN, some of which are; Air Defense Programs, Antitank "Missiles, Precision Guided Munitions, CSC Program and Airbag Program. Additionally, 122mm and 107mm Artillery Rocket Systems are two examples of the company's products.

Details of the projects cannot be declared because of the security rules at ROKETSAN. Some of the project visual is given in Figure 16.

CİRİT

Figure 16: Some of the Projects at ROKETSAN

11. 6 Sigma Project Implementation in Purchasing Department

11.1 Project Definition Phase

As mentioned in previous part ROKETSAN produce a missile and rocket system. Especially, ROKETSAN has some problem in its purchasing process since; most of the materials are not delivered on time. This problem causes diversion from company production plan. This problem generally observed in direct production materials. Most of the direct production materials have not been delivered on defined delivery date.

In ROKETSAN, direct production materials must be present in the inventory. Since, actual production must comply with the production plan. It is very important to receive direct production materials on time. Since, any delay on the delivery causes deviation on production plan and final products are not delivered to customer on time.

Aim of this project is increase the ratio of the direct production materials which is delivered on time. In Figure 17, aim of the 6 Sigma project is represented.

Figure 17: Aim of the 6 Sigma Project

Direct production materials have been defined on each project Below Material List (BOM). Each project BOM is defined in company ERP system. According to ERP system of the company 2013 purchasing data were collected and these collected data are categorized for counting the purchase order which is delivered on time. In this project firstly direct material purchase order data which was considered between February 2013 and June 2014. These purchasing order data were categorized according to delivered time of the material item.

According to categorization about delivered time of the direct production materials, total purchase orders were listed. In **Error! Reference source not found.**, direct material purchase order categorization is given.

Delivered On Time	Number of Purchasing Order	Rate
YES	1119	40,8%
NO	1626	59,2%

Table 12: Purchase Order Delivery on Time List

Figure 18 represents the Pareto diagram of the purchase order which is delivered on time.

Figure 18: Purchase Order Delivery on Time Pareto Diagram

As observed in Figure 18 and Table 13, %59.2 direct production materials was not delivered on time. This causes really important production problems. Especially, overtime cost of labor for catching the production plan was increase total production cost of the product.

Considering this problem, average delay time for direct production materials were considered and average delay time of direct production materials was calculated. According to company ERP system data, average delay time was found 22.7 days.

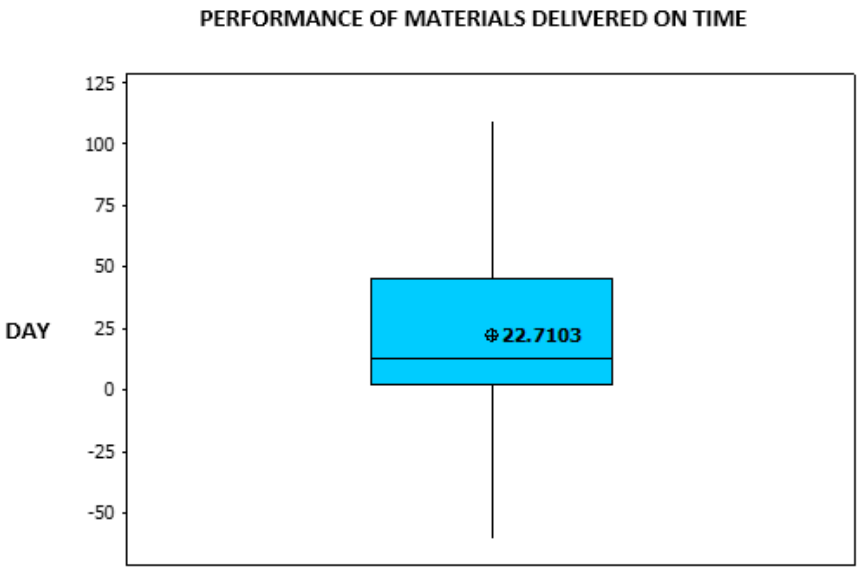


Figure 19: Performance of Direct production Materials Items Delivered on Time

As mentioned above, Figure 19 data are taken from the given purchase orders between February 2013 and June 2014. According to Figure 19, average delay of the purchase order is calculated 22.7 day. Its means direct production materials was delivered average 22.7 day delay. As observed in Figure 19, 22.7 day delay on direct production material causes more production cost for the company. For analyzing the problem, delivered material level was calculated. In Figure 20 represents the percentage of the material items which is delivered on time.

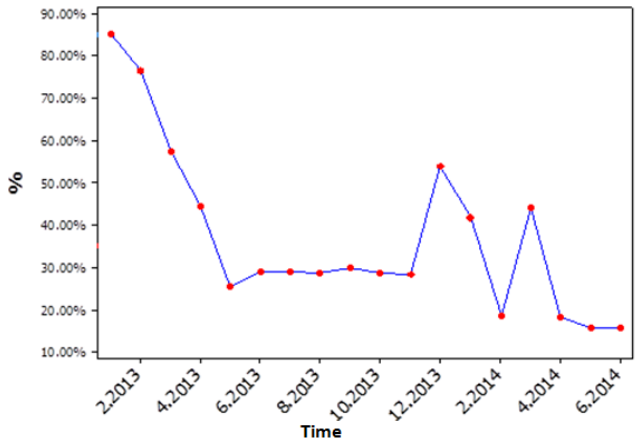


Figure 20: Percentage of the Material Item Delivered on Time

As observed in Figure 20, 2th and 3th mouth, over 50% of the direct production material was not delivered on planned time. With this 6 Sigma project, this delivered on time materials rate will be increased above %70. As mentioned above, this decrease has big effect on the total production cost of the final product. For this project, project charter which was prepared by the 6 Sigma project team is given in Figure 21.

Figure 21: Project Charter

As a consequently, our main aim in this project is decreasing this delay time with analyzing purchasing department process. While analyzing company purchasing process, 6 Sigma project group will find the company bottleneck points of the process and try to solve it.

11.2 Project Measurement Phase

In this phase of the project direct material purchasing process was defined. In Figure 22, detail of the direct material purchasing flow is given.

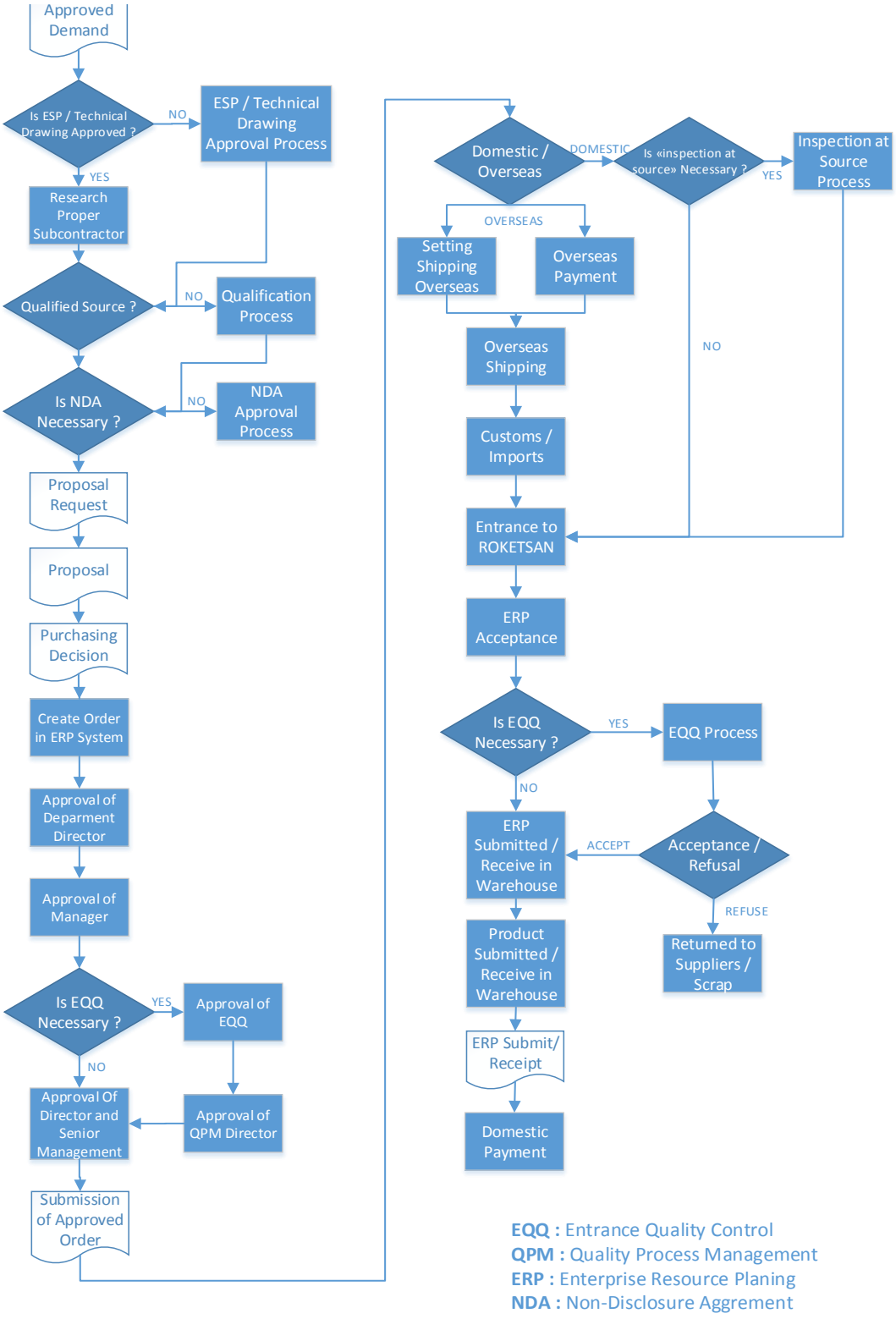


Figure 22: Direct Material Purchasing Process Flow

According to this flow, direct material purchasing order is directly coming from the ERP system of the company. In ROKETSAN, direct material order is given by Production Planning Department. Orders are given from the ERP system of the company. Firstly, order is created by production planning personnel in ERP system than this order is approved by department manager. This approved order is automatically delivered to purchasing department in ERP system and then, approved order is assigned to related Purchasing Department personnel. As observed in Figure 22, Direct Material Purchasing process start with this approved order.

In ROKETSAN, purchasing order is made with engineering specification procedure or technical drawing of the material item. When production planning personnel make purchasing order, they have to add necessary procedure or drawing to system. Beside, this specification and procedure has to be approved. Therefore, when purchasing department personnel gets the purchasing order, they control the necessary documents and its approval situation. If these documents are not approved, then ESP or technical drawing process is going to begin. If necessary document for purchasing order is approved, then they start to research proper subcontractor for requested material. According to their research, purchasing department personnel find proper firm/firms for buying requested direct production material item.

After purchasing department personnel find proper subcontractor, they control the subcontractor which is qualified or not. If subcontractor is not qualified, subcontractor qualification process is going to begin. After purchasing personnel control the qualification situation, they make Non-Disclosure Agreement (NDA) with subcontractor. If NDA was made, they do not need to make NDA agreement again.

After Qualification and NDA situation of the subcontractor is controlled, purchasing department personnel send proposal request to subcontractor. Number of the subcontractor may be differing from each item. According to proposal request, subcontractor makes an evaluation and send proposal. According to proposal which is sent by subcontractors purchasing department personnel makes an evaluation and they choose the subcontractor which gives the most proper proposal. According to this decision of purchasing department personnel, they create an order in ROKETSAN ERP system. After order is created on ERP system, Order is automatically send to manager of purchasing department.

If Entrance Quality Control (EQQ) is necessary for order, order is automatically send to Quality Process Manager. After approval of QPM director, order is sent to senior managers for affirmation. After finishing approval process, order is submitted to subcontractor. In this point, purchasing department personnel control the location of the subcontractor. According to location of the

subcontractor different process are applied. In first case, if subcontractor state in the domestic, purchasing department personnel make a decision about the direct product material which is inspection at source is necessary. According to decision of purchasing personnel, they may choose to make inspection at subcontractor. In this situation, they applied “inspection at source” process and then direct product materials accepted to ROKETSAN. If purchasing personnel do not think to make inspection at subcontractor, direct product material is directly accepted to ROKETSAN.

In second case, if subcontractor located in overseas, purchasing department personnel make necessary setting about shipment and payment method for subcontractor. After making necessary setting about shipment, direct material products are sent to Turkey. In this point, purchasing department personnel make necessary documentation about import procedures. After finishing custom process, direct production materials accepted to ROKETSAN.

Both domestic and overseas subcontractor materials are firstly entered to ROKETSAN, and then these materials are accepted in ERP system. In this point, purchasing personnel may decide to apply entrance quality control. If they decide to apply entrance quality control for all materials or sample materials, quality personnel control the materials which are proper with given requirement. If they find improper materials, they refuse the materials which are bought from subcontractor. Then, improper materials are sent to subcontractor. If quality personnel do not find any improper material, they accept the direct production material which is sent by subcontractor. After they accepted materials, material accepted situation entered to the ERP system.

After finishing all material acceptances, materials are transferred to warehouse of the company. In this point, employee who works in the warehouse controls the situation of the materials. In the end, purchasing personnel prepare order receipt in ERP system then make payment to subcontractor.

According to mentioned purchasing process, 6 Sigma project groups decided to divide all activities of the purchasing process under three main topics. Each of these topics represents the sub-process of the main purchasing process. This sub-process is created according to potential improvement area of the purchasing process. According the evaluation of the 6 Sigma group this sub-process is named as “Order Turnover Process”, “Order Approval Process” and “Order Procurement Process”. In Figure 23**,** sub-process and these processes details are represented.

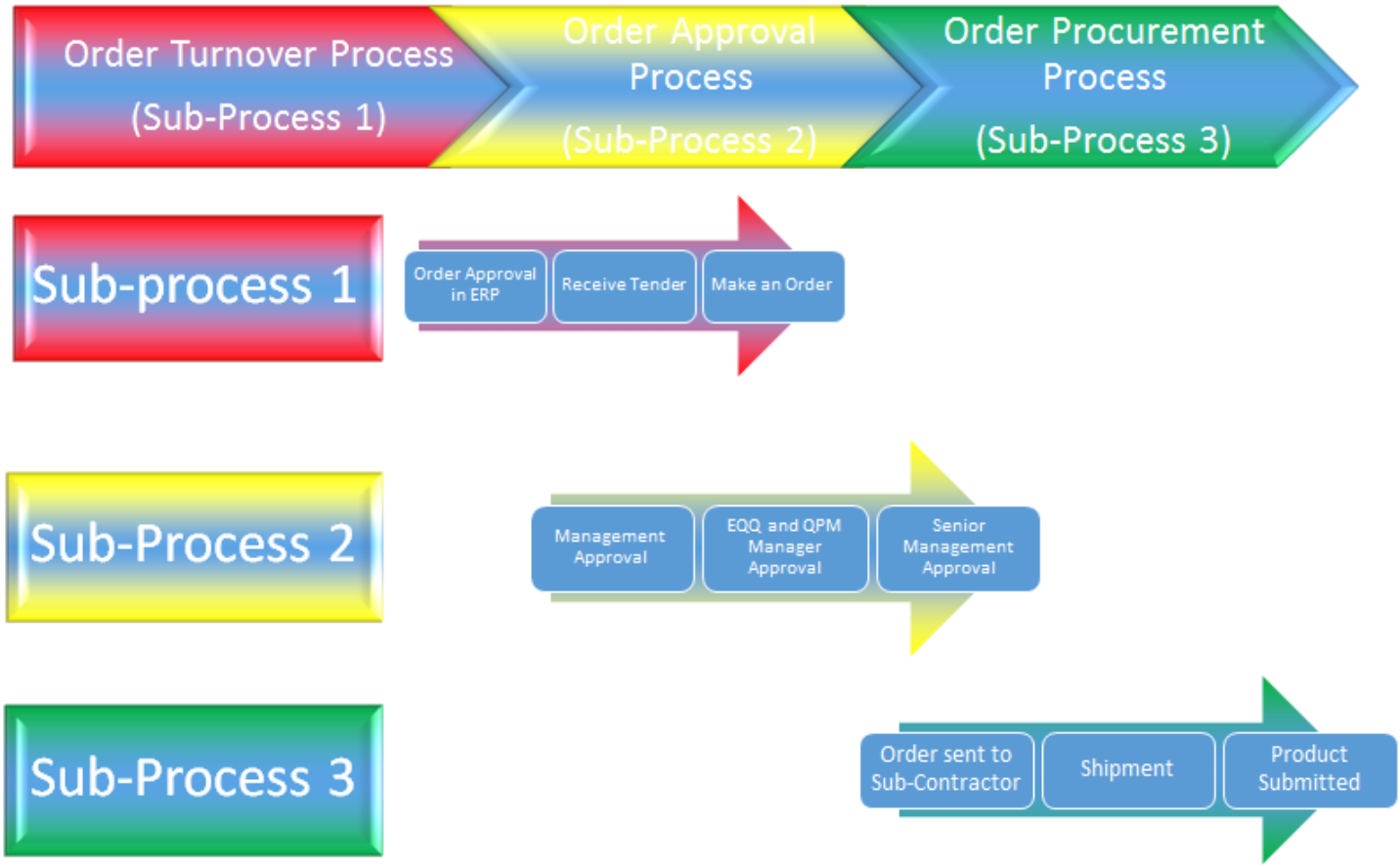


Figure 23: Sub-Process of the Purchasing Process of the ROKETSAN

As observed in Figure 23, each of sub-process main activities is listed. Each of sub-process explanation and duration time were analyzed. Detail results of the analysis are given in related sub-process chapter.

11.2.1 Order Turnover Process

This process area starts with the approved order, as mentioned in previous part approved order forwarded to purchasing personnel in ERP system and this process area finish with first approval of the management. In Figure 24, main steps of the order turnover process is given.

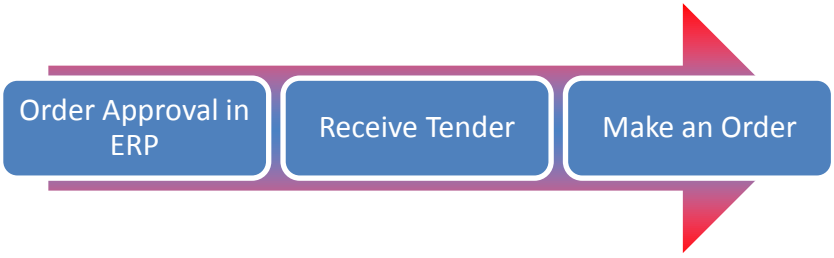


Figure 24: Main Steps of the Order Turnover Process

6 Sigma project group analyze all main step of the order turnover process. According to their research, they analyze the order approval delay time and delay time reasons in this process. Total process time is given in Figure 25.

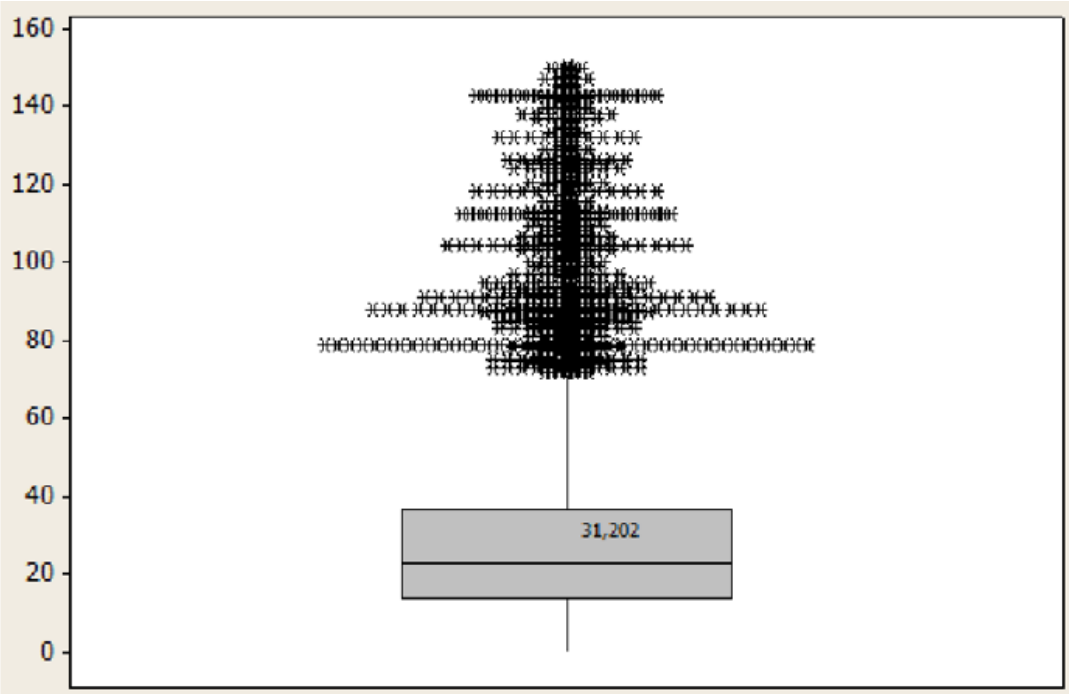


Figure 25: Average Order Turnover Process Time

As observed in Figure 25, average process time of the order turnover process is found 31.2 days, these data is taken from ERP system of the company.

11.2.2 Order Approval Process

This process area starts with first management order approval and finish with submission of approval order. This process mainly includes average approval time of the orders.

Figure 26: Main Steps of the Order Approval Process

As observed in Figure 26, order approval process includes respectively approval list of the manager. As mentioned in Figure 22 order is firstly approved by purchasing department manager then, order is sent automatically to EQQ or QPM manager for approval. Finally, order is approved by senior

management. After all approval list completed, approved order is submitted to subcontractor. In Figure 27, average time of the approval process is given.

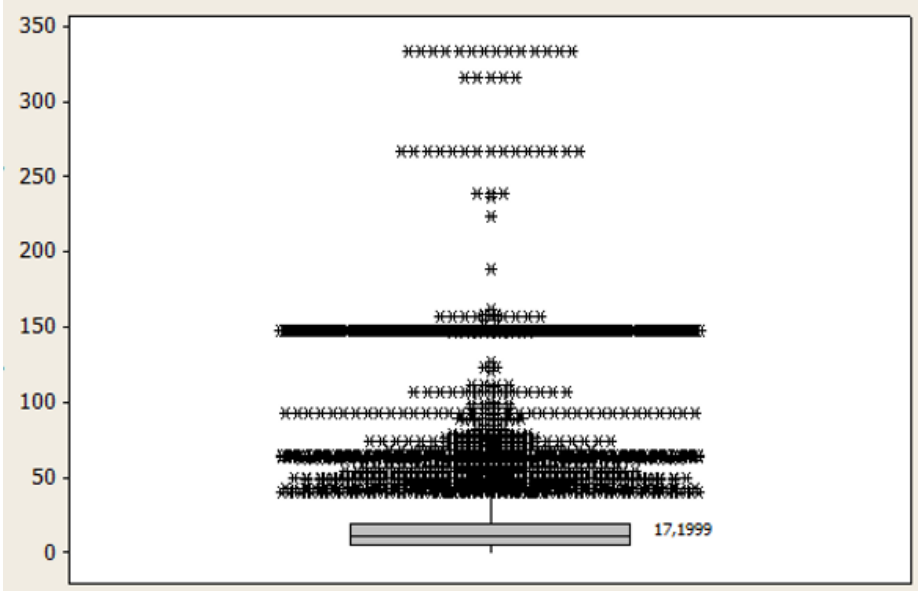


Figure 27: Average Order Approval Process Time

As observed in Figure 27, average time for approval process is found 17.19 days; these data are taken from the ERP system of the company.

11.2.3 Order Procurement Process

This process area starts with approved order which is submitted to subcontractor and finish with the submission of the materials. Main step of the procurement process is given in Figure 28.

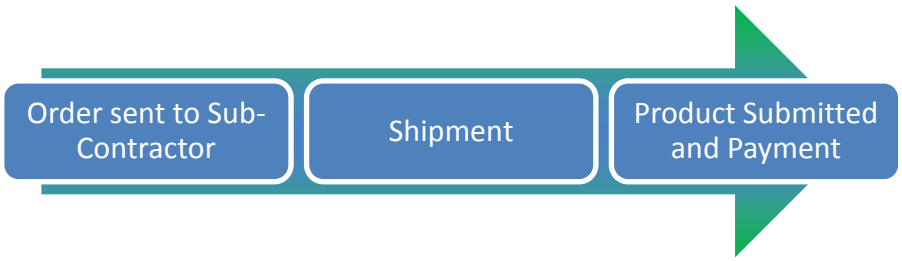


Figure 28: Main Step of the Order Procurement Process

As observed in Figure 28, order procurement process starts with the order sent to sub-contractor. According to this order, sub-contractor starts to produce requested materials. Total production time of the materials is agreed with the sub-contractor. Therefore, requested materials shall be finished in defined time period. After all production activities are finished, materials are shipped to ROKETSAN.

Then, materials are accepted from ROKETSAN. As mentioned in Figure 22, all accepted materials are entered to ERP system. Finally, payment of the materials is made to sub-contractor. In Figure 29, average time of the order procurement process is given.

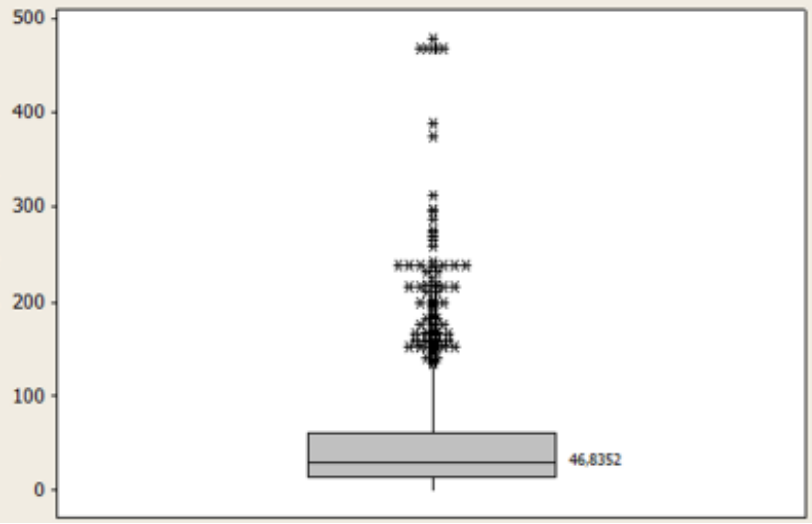


Figure 29: Average Order Procurement Process Time

As observed in Figure 29, average time for order procurement process is found 46.8 days; these data are taken from the ERP system of the company.

11.3 Project Analyze Phase

In Measurement Phase of the project, main purchasing processes are explained. According to main process, sub-process is defined by 6 Sigma project team for finding reason for delay. Each sub-process steps are explained and average time of the sub-process are calculated in measurement phase. In analyze phase, main reasons which are effected total process time will be investigated. The reason which is effected total time of the sub-process is explained. In addition to, weight of the reasons are investigated and explained in the following parts.

11.3.1 Order Turnover Process

6 Sigma project group is analyzed order turnover process average time and some of the reasons which are listed for delay. All of these reasons are listed below;

- **Define Order Item:** In ROKETSAN, different kinds of product are made. Especially, some of the product material has some specific requirements. Therefore, this order items requirement should be defined as well as possible. However, in some cases order item ESP or

technical drawing is not including enough information. In this situation, purchasing personnel has to communicate with the production planning department and designer. Then, clarify all requirement of the order.

- **Untimely Order:** In ROKETSAN, some dates are not proper to time to give order. Since, in this dates company works on inventory count and financial account closure. In these dates, orders are not considered and orders are waited. Especially, end of the year most of the order are not approved and these orders are waited for closing the year. Therefore, all order must be given 11'Th month of the year.
- **Define Subcontractor:** ROKETSAN has many different products such as rocket, missile etc. Therefore, there are many different type of materials are used in production line such as electronic component, chemical material, etc. As mentioned in the main purchasing process, each of materials is supplied from different subcontractor. Each of material subcontractors are found according to research of the purchasing personnel. Therefore, finding proper subcontractor is really important job for purchasing personnel. This subcontractor research job is generally called Define Subcontractor.
- **Define Company to Approved Sub-contractor List:** Each of the subcontractors of the ROKETSAN is controlled by the purchasing personnel. As mentioned in the process, when purchasing personnel research proper subcontractor, they control the qualification status and NDA status. In addition, purchasing personnel control that is there any agreement was made. If purchasing personnel find an agreement with subcontractor, they do not need to define subcontractor to ROKETSAN's ERP system. However, if they do not find any agreement with subcontractor, they have to make necessary agreement and necessary controls then, they define subcontractor to ERP system. In the end, company status is called Approved Subcontractor.

According to these reasons, 6 Sigma project group analyzed the weight of these reasons. Therefore, all of this reasons and its percentage for the delay is given Figure 29**.** All of these reasons weights are analyzed with help of the company ERP system.

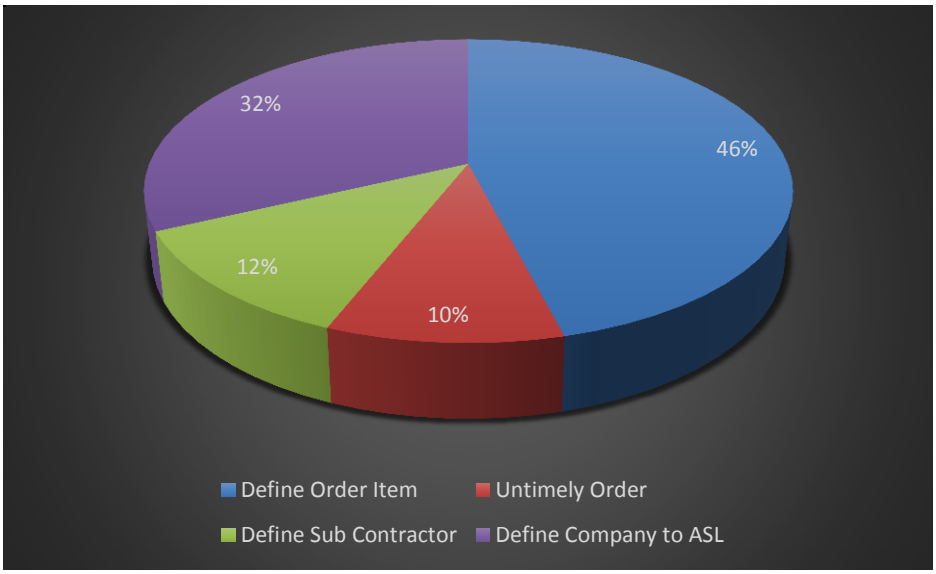


Figure 30: Order Turnover Process Reasons Weight

As observed in Figure 30**,** defining an order item is a really important delay reason for order turnover process. %46 of the delay is caused for defining and order item. This reason is directly related with the communication of the purchasing personnel and production planning department. If this communication way will be improved, order turnover process will be increased. Another important delay reason is defining company as Approved Sub-Contractor List. As mentioned above, some controls must be made for sub-contractors. These controls take some time and cause some delay so; order approval process must be improved. In improvement phase, improvement opportunities for this process area will be given.

11.3.2 Order Approval Process

6 Sigma project group is analyzed order turnover process average time and some of the reasons which are listed for delay. All of these reasons are listed below;

- **Forget:** Some of the manager may not see the order which is automatically assigned for approval. Therefore, some order is waiting for manager approval. This problem is especially observed when managers are out of company.
- **System Defect:** Sometimes some of the problem may occur in company ERP system. In this case some of the orders are not automatically forward to related managers. Therefore, average approval time of the order increases.
- **Company Audit:** In ROKETSAN, most of the audit is made from quality department. Therefore, most of the orders are not approved during these audits. Since, most of the

manager work related to audits. Sometimes, these audits are made with the order of the board of directors. In this case, every purchasing department managers works on the claimed audit.

According to these reasons, 6 Sigma project group analyzed the weight of these reasons. Therefore, all of this reasons and its percentage for the delay is given Figure 31.

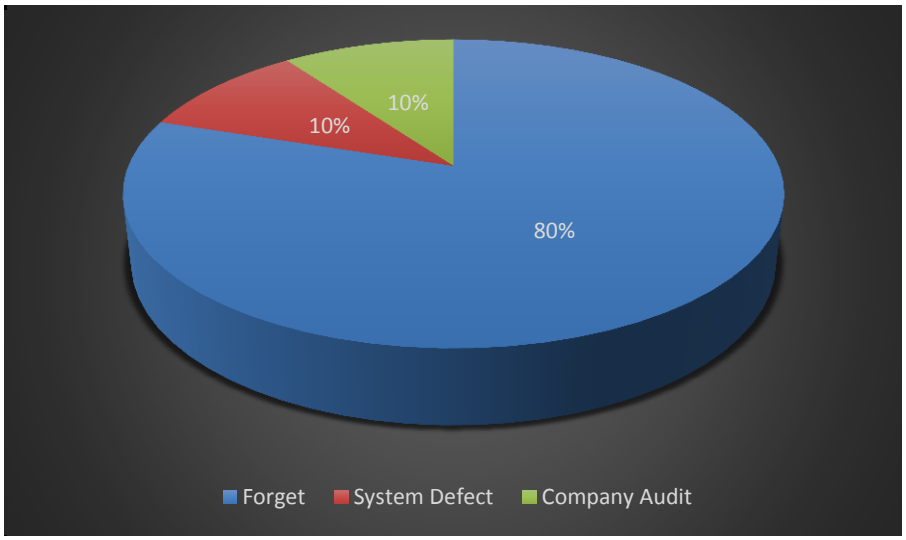


Figure 31: Order Approval Process Reasons Weight

As observed in Figure 31, forgetting an approval is a really important delay reason for order approval process. % 80 of the delay is caused for forgetting to approve an order. Company Audit and System Defect is just covering %20 of the delay. For improving this process area, order approval system must be developed.

As mentioned in the order approval process, different managers are approved for each of the order. Forget to approve each of the order has a big effect on the purchasing process because, this time directly added to total delay of the purchasing process. Therefore, new analyze was made for understanding that who forget to approve order. Result of this analyze is given in Figure 32.

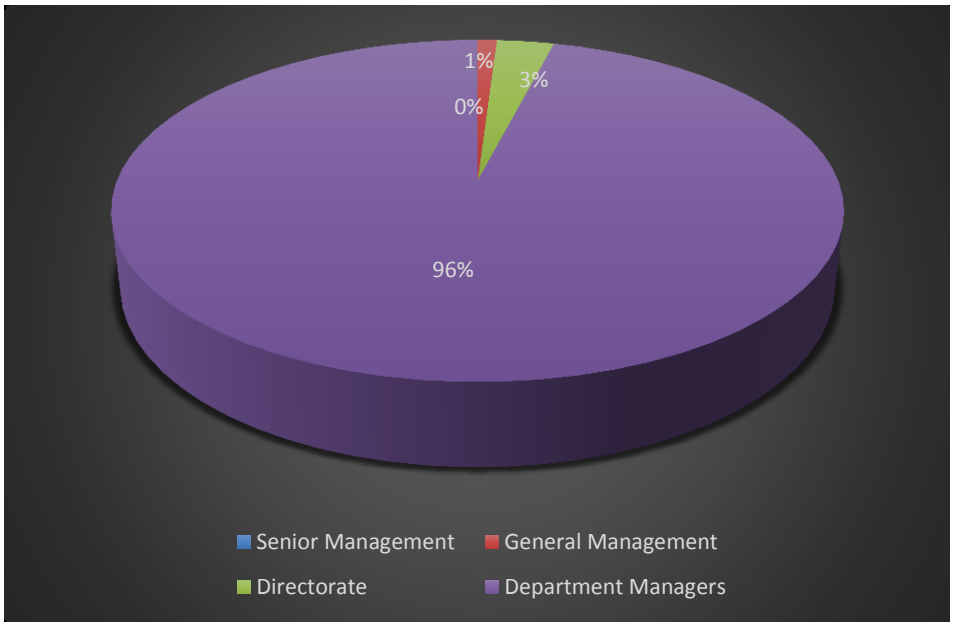


Figure 32: Order Approval Process "Forget to approve order Manager List"

As observed in the Figure 32, %96 of the approval forgets was made by department managers. Therefore, a new system must be applied for improving approval process of the purchasing process. This analyze was made with the data which was taken from company ERP system. ERP system hold the time interval of the order which starts after related purchasing order is directed to relevant managers until order is approved by same managers.

11.3.3 Order Procurement Process

6 Sigma project group is analyzed order procurement process average time and some of the reasons which are listed for delay. All of these reasons are listed below;

- **Payment:** After all materials are submitted in ROKETSAN, materials are entered to ERP system. ERP system gives the receipt of the related material. According to this receipt, payment is made from finance department and purchasing department of the company. However, for some internal reason this payment may delay. Therefore, this delay causes to increase total time of the process.
- **Lack of Quality Document:** As mentioned in the all process, materials are accepted according to necessary quality control. In addition, these controls are made according to necessary quality documents. If any problem may observe in quality documents, materials are not accepted and these materials are not accepted until all quality documentation is completed. In some cases, this quality documents may related with the sub-contractor company quality

process such as ISO, CMMI etc. To sum up, if necessary quality documents are missing, materials will not be accepted. Therefore, total process time is increased.

- **Customs:** As mentioned in the process, some direct production material is purchased from outside of the Turkey. Therefore, customs procedure must be applied for these products. Especially, customs procedures may take longer time than expected, so total delivery time of the material is increased.
- **Delay from Sub-contractor:** In some case, direct production material delivered time may be longer than expected. Therefore, delivery time of the product is increased. The reason for this delay may be production time etc. All of this delay responsibilities are belongs to subcontractor.
- **Gathering Document:** As mentioned in the process, some documents such as customs documents, quality documents are necessary for order procurement process. If anything is missing from these documents direct production material acceptance time will be increased.
- **Licensed Materials:** As mentioned in the process, some of the materials are purchased from outside of the Turkey. In some cases, some of the special permission is necessary for buying materials which is purchased from outside. In this case, ROKETSAN need to take specific license for these products. If this license was taken, it is not necessary to take this license again. For taking this license some of the procedure must be applied. Therefore, purchasing this kind of materials take longer time than expected increase total time of the order procurement process.

According to these reasons, 6 Sigma project group analyzed the weight of these reasons. Therefore, all of this reasons and its percentage for the delay is given Figure 33.

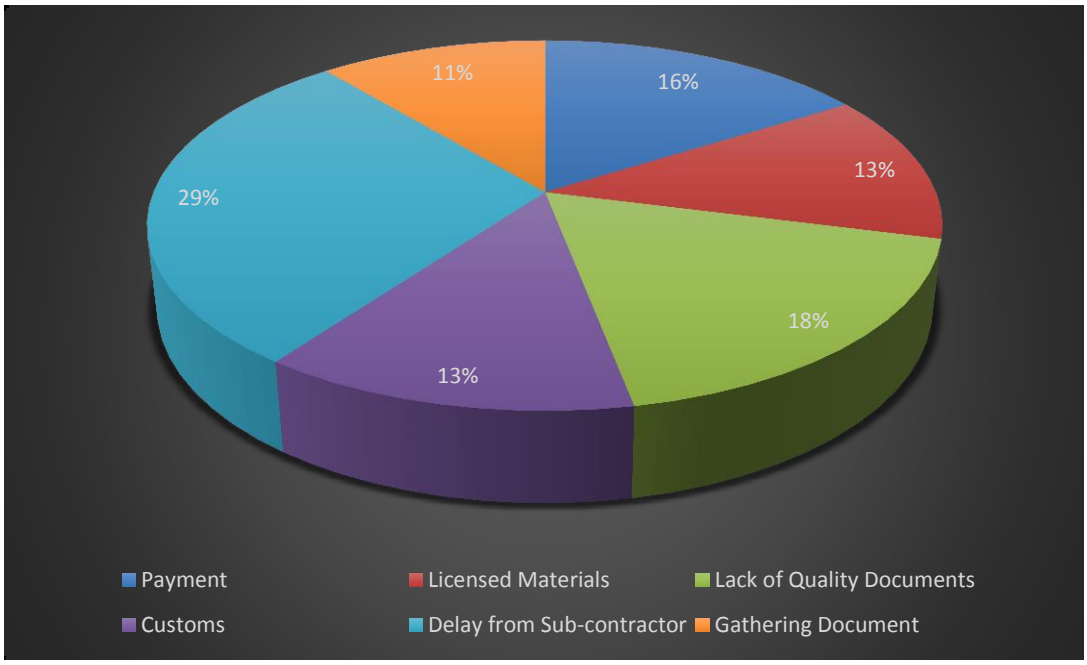
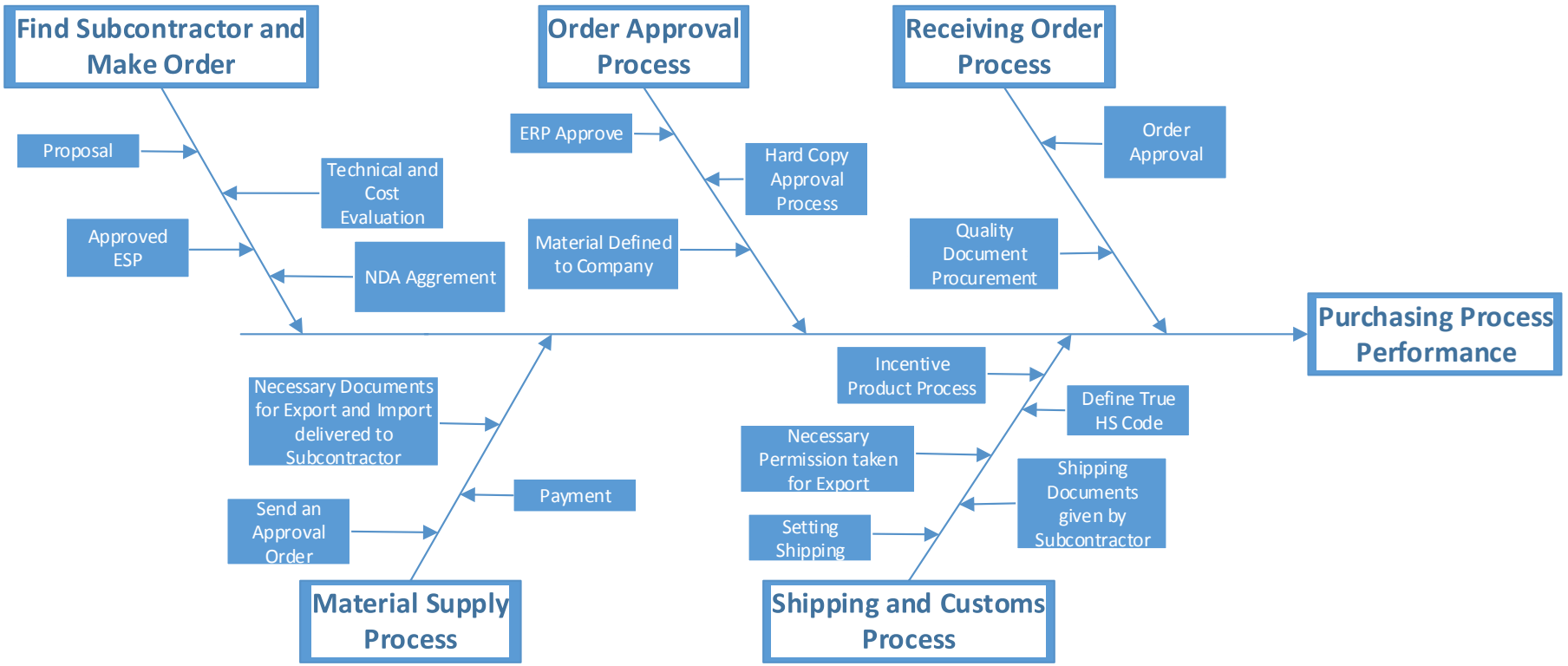


Figure 33: Order Procurement Process Reasons Weight

As observed in Figure 33**,** delay from sub-contractor is a really important delay reason for order procurement process. %29 of the delay is caused for sub-contractor delay. Beside, another reasons effect on the order procurement process can be observed in Figure 33. This analyze was made with the data which was found with survey about the purchasing personnel. This survey is including some secret information about ROKETSAN and its projects so, only results are shared.

11.3.4 General Purchasing Process Evaluation

All sub-processes are detailed and delay reasons are explained. Considering all reasons and purchasing process performance cause and effect diagram is prepared.



NDA : Non Disclosure Aggrement
ERP : Enterprise Resource Planning Software
HS Code : Harmonized Commodity Description and Coding System

Figure 34: Cause and Effect Diagram for Purchasing Process Performance

As observed in Figure 34, all reasons which are affecting performance of the purchasing performance are written in the cause and effect diagram.

After evaluating all reasons some of the important point is observed from 6 Sigma project group. Firstly, some of the given reason which is given below is directly related with the performance of the purchasing personnel;

- Define Order Item,
- Define Subcontractor,
- Define Company to Approved Sub-contractor List,
- Payment,
- Gathering Documents.

Secondly, 6 Sigma project group observed that some of the direct production materials are purchased shorter time than other. Therefore, 6 Sigma project group decided to research main working area of the purchasing personnel. According to their research, they listed all working area of the purchasing personnel. List of the purchasing personnel working area is given below;

- Communicate with the Production planning Department
- Open an Order in ERP System
- Correspondence (General)
- Prepare Cost Analysis for Purchased Material
- Prepare a Report which is necessary for Supply Chain Directorate
- Prepare Supply Chain Evaluation Report
- Make a research about alternative sub-contractor
- Invoice Matching
- Talking on Cell Phone
- Send an Final Order
- Send an Budgetary Proposal
- Photocopying (Necessary for making Job)
- Attend a Meeting Between Different Department
- Prepare an order document for sign
- Attend a meeting between sub-contractor companies
- Communicate With Entrance Quality Control Department
- Controlling ESP and Technical Drawing
- Payment Mapping
- Communicate With the Financial Department

- Prepare an ESP.

Above list was prepared with the help of the purchasing personnel. Especially, each detail is represented. According to this list 6 Sigma project group analyzed each work item. Especially survey was made to purchasing personnel and average working time for each working item is analyzed. In Figure 35, result of the analysis is given.

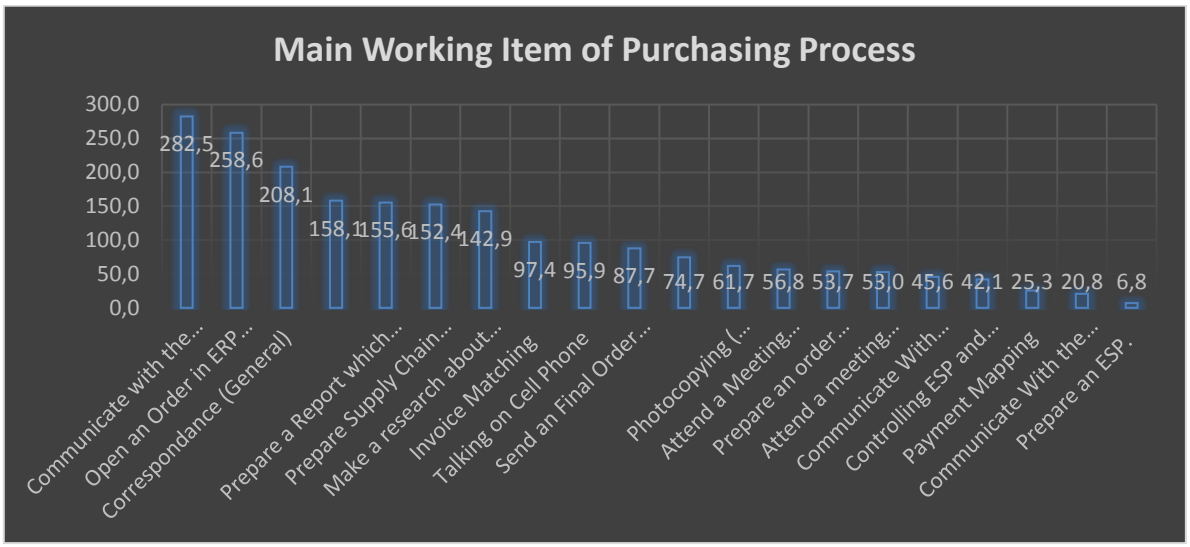


Figure 35: Purchasing Personnel Working Items

In this analyze, one man total working hours for one year is evaluated. This mean, one man total working hour is calculated as 2080 hour in year. This value is calculated from 52 weeks of the year and each weeks has 40 working hour. According to this 52x40, gives 2080 working hour of the year. Time distribution of the working item is given in Figure 35.

In addition to, 6 Sigma groups analyzed total purchased item number. Especially, they research general distribution of the purchasing item. Then, they find the table which is given in Table 13.

Overseas Purchasing Order (2014)	Domestic Purchasing Order (2014)	Total Order Number (2014)
3759	9255	13014

Table 13: Total Purchasing Item Number in 2014

Considering total purchasing order number for 2014, they analyzed general work distribution between purchasing personnel. Then really interesting result are observed. These results are given in Figure 36.

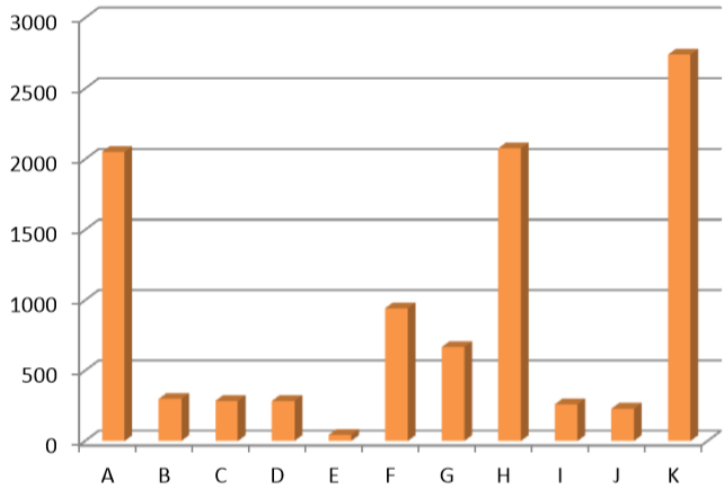


Figure 36: Job Distribution in Purchasing Department Personnel

As observed in Figure 36**,** job distribution is not made equally to purchasing personnel. Some of them are responsible from over 1000 purchasing item but someone is responsible from less than 500 purchasing item. This cause some of the assigned purchasing materials can be purchased less time than others since, the work is not shared equally. This is another important problem for performance of the purchasing process.

11.4 Project Improve Phase

All reasons which are affecting the performance of the purchasing personnel are explained in analyze phase of the project. In improve phase, considering all factors which is affecting the performance of the purchasing process is analyzed and proper solution for improving the performance is found. All suggestion and improvement areas of the purchasing process are given in this part.

- **Decrease Payment Approval Process:** As mentioned in the Order Approval Process, some of the managers may be forget to approve the assigned tasks. In addition to, related managers may be out of the company. In this case, assigned tasks must be waited to approval of the manager. For improving the approval process two solutions are suggested.
    - If related manager is out of the company, system will automatically sent assigned tasks to another related manager. Before any manager goes out of the company, they have to notify this situation on the ERP system.
    - Secondly, a unique person will be responsible for the sign of the payment documents. This person might be assistant etc. However, this person is directly responsible for remind approval documents to managers and senior managers.

- **Lead Time of Purchased Material Entered to ERP System:** In ERP system, lead time of the sub-contractor company is not entered to system. Therefore, forecasts about the ROKETSAN production plan may be deflect from the sub-contractor production plan. With using lead time, ROKETSAN production plan will be more realistic and delay time of the purchasing process will be decreased.
- **Modules of Request for Quotation (RFQ) implement to ERP System:** RFQ modules is currently used in ROKETSAN. However, this system is not connected to ERP system. Therefore, necessary documents such as financial report, supply chain general report etc. is prepared by purchasing personnel for each purchased materials. If these modules will integrate with the ERP system, previous year data will be stated in the ERP system. Therefore, purchased materials document which was purchased in previous years is not need to be prepared. With using this module, number of the documents which must be prepared for the purchasing personnel is not need to be prepared.
- **Establish Barcode System:** In ROKETSAN, after accepting the purchased material, materials are placed in the warehouse. In some cases, purchased materials documents get lost. In addition to, purchasing personnel do not know that the material was entered the ROKETSAN so, some of the materials are re-purchased. If barcode system will be established to ROKETSAN, purchased materials documents and materials location can be followed from the system.
- **Meeting with the Sub-contractor:** Most of the ROKETSAN sub-contractor does not know the purchasing process of ROKETSAN. Therefore, some of the problems may occur while purchasing the materials. For instance, most of the companies do not prepare necessary quality documents or acceptance documents. Beside, some of the sub-contractors do not have Non-Disclosure Agreement with ROKETSAN. All of this reasons cause to increase total time of the purchasing process.
- **Improve Order Following System:** As mentioned in the purchasing process, ERP system is used for opening order and following it. As observed in Figure 35, purchasing personnel spend %13.5 of their time for communicating with the production planning department. For decreasing this time, order following system will be improved and necessary information is entered to system while making an order. Therefore, purchasing personnel less communicate with the production planning department
- **Prepare a Financial Procedure which includes all detail of the Sub-contractor Payment:** As mentioned in the process, purchasing personnel and financial department personnel make a payment to subcontractor. However, in some cases financial personnel and purchasing

personnel do not think same idea about payment. In this situation, senior management gives the final decision about payment. All this process increase the delay time of purchasing process.

- **Define Company to Approved Sub-contractor List:** As mentioned in the order turnover process; sub-contractor status must be in approved sub-contractor list. If sub-contractor status is not an approved subcontractor, necessary controls must be made with sub-contractor. This controls generally include quality and qualification status controls. All this controls take some time so, ordered material are accepted longer time than expected. If this affirmation process time is decreased, total purchasing process time will decrease.
- **Increase Custom Process Performance:** Some of the purchased materials are come from outside of the Turkey. Therefore, some of the documents which is necessary for the custom affairs. In some cases, custom affairs documents are sent missing so, material are stated in the customs area until all customs documents are completed. For prevent this kind of situation, all customs documents are prepared completely without any missing. Therefore, all purchased direct production materials are accepted according to production plan.

As mentioned in the measurement phase, work distribution and general works of the purchasing personnel is a really important problem. This problem is not only observed for direct production materials purchased departments. Each purchasing units have that kind of work distribution problem. For solving this general problem, new unit is established. This unit is named “Supply Chain Planning Coordination and Price Analyze Unit”. Figure 37 represents the new organization of the supply chain directorate.

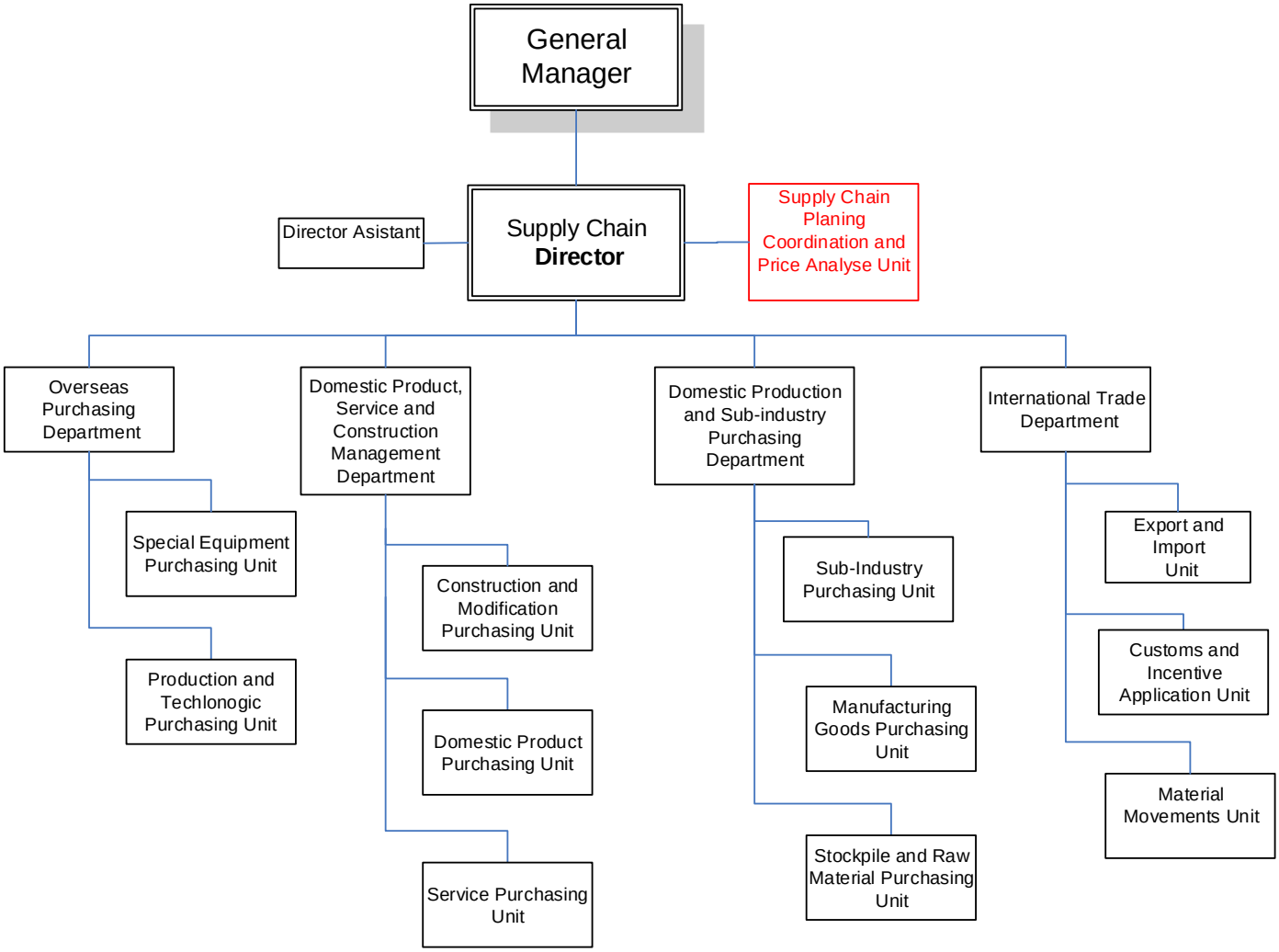


Figure 37: Supply Chain Director New Organization Chart

New established unit position in the organization chart is indicated as a red mark in Figure 37**.** This unit is directly connected to supply chain director. This unit job definition include, planning and coordination of the supply chain directorate. In addition to, this unit decides payment methods to the sub-contractor. With the help of this unit, purchasing personnel work distribution is going to be fairly and moral and performance of the purchasing personnel will increase. In addition to, purchasing personnel is not deal with sub-contractors for defining payment method. All of this works are made by this unit.

11.5 Project Control Phase

In Improvement phase, all improvement areas are listed by 6 Sigma project group. As mentioned in the project plan, improvement phase was finished in 01.02.2015. After that day, decided improvements are applied to company purchasing process. However, some of the improvement takes more time than expected. Therefore, some of the improvements areas were not measured by 6 Sigma project team but, others improvements level were measured by 6 Sigma project group. In control phase, all applied improvement situation are given.

- With the applied improvement on the approval process, all payment orders are approved within 3 days. This situation is observed within February and March 2015. As mentioned in the measurement phase, mean time of the order approval is 17 days. However, this time is decreased to 3 days. This is really important improvement for direct production material purchasing process.
- Implement request for quotation (RFQ) modules has a big effect on the purchasing process. As observed in the general working item of the purchasing personnel, preparing a cost analyze for purchasing materials take average 158.1 working hours for one year. Considering the production plan for the 2015, %18 of the materials was purchased in 2014. Therefore, with the help of these modules, cost analysis is not necessary for that purchased materials. To sum up, %13 percent of improvement is calculated for 2015.
- Order following system has big importance for purchasing process. Since, production planning department and purchasing personnel communication takes so times. Especially for defining an order item, communication with production planning department causes delay in total process time. For decreasing this time, new internal web portal was developed. With the help of this web portal, purchasing personnel can easily communicate with the production planning personnel. Consequently, in each phase of the purchasing process, purchasing personnel can easily achieve production planning department personnel and clear all points. The web portal was firstly used 20th of the March. Considering first 10 day after web portal started to use, %20 of the improvement is calculated in total purchasing process.
- Barcode system was established in the company warehouse. With this barcode system, purchasing personnel can easily follow the direct production materials situation. As mentioned in the process, purchasing personnel do not know that materials acceptance situation. With the barcode system, automatically message is sent to purchasing personnel

when materials entered to company. In addition to, materials location can be followed from the system.

- Lead time is really important information for production planning. In company production plan, lead time of the sub-contractor was not considered. Therefore, most of the purchased materials were not delivered on time to company. As mentioned in purchasing process, order is opened from company ERP system. With the improvements in the ERP system, lead time of the sub-contractor is entered from the purchasing personnel. In addition to, lead time information is taken from each material supplier. With the new improvement, production plan will be prepared more exact than past. Company production plan has already been prepared. Therefore, this improvement system is going to started to use beginning of the June. Therefore, improvement level of this application is going to be measured after June 2015.
- As observed in Figure 37, organization scheme of the supply chain directorate was organized. According to new organization, Supply Chain Planning Coordination and Price Analyze Unit were established. As mentioned in the analyze phase, purchasing personnel do not works effectively and work distribution in the purchasing department is not made equally. Main mission of this unit is distribute all purchased item equally to purchasing personnel and understand the need of the supply chain directorate. In addition to, financial problems and payment procedure is going to be organized from this unit. Therefore, purchasing personnel is not deal with sub-contractors about payment method. In addition to, Invoice Matching and Payment Mapping is not going to be made by purchasing personnel. This mean 122.7 working hour is saved from purchasing personnel total working time for one year. In addition to, purchasing personnel total work load is going to be decreased. Therefore, purchasing personnel will be handling more purchasing materials.

In the beginning of the project, main aim is increase the rate of the delivered on time material over %70. According to given project schedule in the project definition phase, improvement areas have been controlled in March 2015. Considering the given orders in March, %70.8 direct production material was delivered on time. Thereupon, company was saved respectively 10.000$ from overtime cost. Consequently, with the help of this project, ROKETSAN saves respectively 120.000$ for a year.

V. Conclusion

In globalizing economy, supply chain management is essential for the companies to increase the product/service quality that affect the customer service level. Either production or selling a product via import, on time procurement with a decent price a high quality always brings absolute customer satisfaction with itself. Hence, in that situation purchasing processes come into prominence to decrease the cycle time of buying procedures and gear up of supply chain while increasing the quality level. In competitive environment which both products and services have low price, quality is the key issue of the companies to bring themselves to the fore. Consequently, a good quality output needs a high quality job process.

At that point, supply chain management comes to the forefront. SCM which supports to teamwork, aims exceeding of customer expectation, reviews and improves of all the processes, helps not only to increase of market share, customer satisfaction, profit share, competitiveness, but also decrease the costs.

However, application of supply chain management has some missing points to its own. Generally, a team is assigned to solve a problem and end of the project they reassigned. It causes not to focus on quality as integrally. In addition SCM targets impeccability just focusing on outputs, so there is possibility to miss the errors which come from the sub processes. At very this moment, 6 Sigma approach becomes a part of the activity.

As mentioned before, 6 Sigma focuses on process quality rather than field of activity. That's because it can be applied from manufacturing to the service industry. This method improves the profit and efficiency of the companies while keeping the customer satisfaction as elementarily. On the contrary to the other management approaches, 6 Sigma uses the statistical and mathematical tools and gives quantitative measurements to the company to see everything clear and comprehensible. Another benefit is that all the employees in the company should get actively involved in this improvement, so it raises the intercorporate communication.

In this study, after the examining of the 6 Sigma applications of different sectors, a real case project implementation in a military company is defined. Since the efficiency of the procurement process is directly related with the quality level, 6 Sigma approach is applied in that department to get some improvement. In this way the most common method which is DMAIC is used through the project. In the first place, the situation is showed by using Pareto chart that data is taken from the ERP system of the company. Then, the root reasons which cause the delays on purchasing of the products are

defined with helping brain storming and fish bone diagram. After detecting the root reasons, improvement areas of the process are defined by project team. Then, each of these improvement areas is analyzed and action items are defined. In the end of the project, improvements are observed and improvement levels are calculated by six sigma team. In our project, company purchasing process is improved.

To sum up, company gains some important benefits which are listed below;

- Purchasing process is improved and company saves from overtime cost of the employee,
- Purchasing process cycle time is decreased,
- Six sigma project team skills are developed.

Especially, ROKETSAN employee perspective is changed positively for six sigma projects. Therefore, number of six sigma project might be increase in the near future.

Bibliography

Adi, R. Z. & Chand, N. (2010).*The Effectiveness of Six Sigma in Services Sectors: Health Care Sector Approache.*, Nottingham University Business School

American Society for Quality, (2008). *Glossary – Entry: Quality.* [www.asq.org/learn-about-quality/cost-of-quality/overview/overview.html]

Antony, J. & Bhaiji, M., *Key Ingredients for a Successful Six Sigma Program*. Warwick Manufacturing Group, School of Engineering, University of Warwick, UK

Bartsch, F. (2002) *Supply Chain Management (SCM),* retrieved on 2013/06/19 at [www.apics.org/sites/apics-supply-chain-council]

Basu, S.(2005). Six Sigma and OR at Boeing. *INFORMS Roundtable Meeting at Cambridge*, 56

Behnke, L. & Breyfogle, F. (2005). *Focusing the Power of Six Sigma in the Healthcare Insurance Industry: Lowering Medical Costs while Improving Patient Service and Outcomes*, 3

Brief, B. (2008). *Lean Six Sigma for the Service Industry*, 20-24

Brun, A. (2011). Critical Success Factors of Six Sigma Implementations in Italian Companies. *Int. J. Production Economics 131*, 158-164

Chakravorty, S. S. (2009). Six Sigma Programs: An Implementation Model. *Int. J. Production Economics 119*, 1-16

Chan, M. (2003). Roadmap for Success —Raytheon Missile Systems (RMS) Company, Tucson, AZ. *Progress in lean and Six Sigma Systems*, 58-59

Coskun, A. (2009). Toplam Kalite Yönetimi ve Altı Sigma. *Bilim ve Teknik,* 70-75

Crosby, P. (1979). *Quality is Free*. New York: McGraw-Hill

Edwards, D. W. (1986). *Out of the Crisis*. Cambridge, Mass.: Massachusetts Institute of Technology. Center for Advanced Engineering Study

Erhan, M.(2008). *Six Sigma and Its Execution in Service Sector*, 30-40

Green, R.(2010). *Dedicated Teams Successfully Merge Two Divergent Quality Systems*, 7

Gursakal, N. & Oguzlar, A. (2003). *Altı Sigma*. Vipaş A.S. Bursa: Uludag Universitesi Guclendirme Vakfı Istiraki

Haiyan R., Haibo R. and Huang C. (2005). *Seeking Innovation in a Six-sigma Project by Applying TRIZ Theory*

Hambleton, L. (2007). *Treasure Chest of Six Sigma Growth Methods, Tools, and Best Practices: A Desk Reference Book for Innovation and Growth.* Prentice Hall, 13-27

International Standards for Lean Six Sigma-ISLSS, (2014) [www.islss.com]

Joyce, M. & Schechter, B.(2004). The Lean Enterprise: A Management Philosophy at Lockheed Martin. *Defense Acquisition Review Journal*, 173-180

Juran, M. J. & Godfrey, A. B.(1999). *Juran's Quality Handbook* (5th ed.). McGraw-Hill

Keller, P.A.(2001). *Six Sigma Deployment – A Guide for Implementing Six Sigma in Your Organization*. QA Publishing

Kuik, S.S., Nagalingam, V.S., Amer, Y. and Saw, P.Y.(2010). Implementation of Six Sigma Methodology to Improve Supply Chain Network in the Context of Malaysian Manufacturing Industries. Supply Chain Managmenet and Information Systems (SCMIS), *8th International Conference*

Kwak,Y.H. & Anbari T.F. (2006). Benefits, Obstacles and Future of Six Sigma Approach. *Technovation 26*, 708-715

Maleyeff, J.(2007). *Improving Service Delivery in Government with Lean Six Sigma*, 12-17

Marks, M.(2004). Raytheon New Challenges, New Solutions and Documented Results. *Defense Acquisition Review Journal*, 35

Martin, L.(2004). *Lean Manufacturing and Environment – Case Studies & Best Practices* [www.epa.gov/lean/environment/studies/lockheed.htm#chemical]

Mast, J. & Lokkerbol, J.(2012). An Analysis of the Six Sigma DMAIC Method from the Perspective of Problem Solving, *Int. J. Production Economics 139*, 604-614

Metovic, J.(2015).*Lean Six Sigma Industry News, Resources, Success Stories, Using Lean Six Sigma*

Minitab Company Web Page News (2008).*Department of Defense Saves Billions with Lean Six Sigma*

Motorola Annual Report, (1988)

Okur, Y.(2009). *Six Sigma and Its Implementations Different Sectors*, 38-42

Pande, P. & Holpp, L.(2002). *What is 6 Sigma*? McGraw-Hill

Pande, P., Neuman, R. and Cavanagg, R.(2000).*The Six Sigma Way: How GE, Motorola and the Other Top Companies Are Honing Their Performance.* McGraw-Hill, New York

Parris, A.(2012). *Case Study-Impact and Value of Lean Six Sigma in Transactional Processes*. Atlas Program Black Belt Certified

Pyzdek, T.(2001). *The Six Sigma Handbook*. McGraw-Hill: London

Pyzdek, T.(2003). *The Six Sigma Handbook: A complete Guide for Green Belts, Black Belts and Managers at All Levels*. McGraw-Hill: London

Quality Management Systems, (2008). *Fundamentals and Vocabulary - International Organization for Standardization(ISO 9000:2005)*

Ramias, A. (2005). *The Mists of Six Sigma*, BPTrends.

Sasthriyar, S.(2006). The Critical Success Factors for Six Sigma Implementation, 21-23

Singh, J. & Malhotra, M.(2014). Incorporation of Six Sigma in Organizations and Its Role and Impact Upon Operational Performance: A Review of Existing Literature. *1st National Conference on Global Advancements and Futuristic Trends in Management*

Supply Chain Management (SCM), (2013). *APICS Dictionary*

TAP Success Stories (2010). *Perdue University* [www.sixsigma.purdue.edu/success_stories/oji.pdf]

Walmart, Supply Chain Management (2014) [www.cmuscm.blogspot.it/2014/09/technology-in-supply-chain-examples.html]

Wojciech, J.F., Stanley, E.P., Robert, L.S. and Bernhard, B., (2009). *Postharvest Handling* (2nd ed.), 161

Wu, J., Wang, M., Zhang, L. (2010). Improve the Quality Level of Purchasing Based on Six Sigma. *Proceedings of the 3rd International Conference on Logistics and Supply Chain Management,* 58-63