Implementation of Six Sigma in Service Industry in Cyrenaica, Libya: A Case Study

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Abstract

This paper demonstrates the empirical application of Six Sigma to decrease the total number of delayed jobs (NODJ) in a service contracting company. The study is based on process information and primary data from a real project. DMAIC technique was used in this study to improve the service quality by investigating defects, defining the root causes and providing a solution to minimize the defect. The investigation shows that the mode of receiving jobs order and analyzing the jobs requirements influence the NODJ.

Keywords
Six Sigma, Service industry, DMAIC, production improvement

1. Introduction

Nowadays, customer requirements and the demand for highly reliable products have driven many companies to implement Total Quality Management (TQM) principles. The need for high-quality products at a reasonable cost to customers has been increased due to globalization and expansion of product market. Many Companies have adopted different quality management standards at their facilities such as Just in Time (JIT), ISO 9000, Lean Manufacturing, and Kaizen to respond to these demands. Six Sigma as a quality improvement approach which controls the defect rate and manages the quality as overall process function has gained popularity and acceptance in many sectors all over the world (Nonthaleerak and Hendry 2006).

In the last two decades, the service industry has played a very important role in the economies of both developed and developing countries which require the focus on the quality of the services. (Omar and Mustafa 2014). Therefore, the increase of interest in the application of six sigma not only limited to the industrial sectors but also include the service sectors since manufacturing organizations have seen significant results by implementing Six Sigma (Chakrabarty and Tan 2007). This can be seen in the successful experiences of some services companies that implemented Six Sigma approach like Citibank, Bank of America, American Express, Caterpillar and Baxter Healthcare in the US and Europe (Young 2001), (Sehwall and Yong 2003), (Schimdt and Aschkenase 2004), (Jones Jr 2004), and (Rucker, 2000).

Six Sigma as a measurement standard in product variation can be traced back to Walter Shewhart who illustrated that three standard deviations from the process mean is the point where a process needs to be corrected. Many measurement standards later came on the scene but the credit for creating the expression "Six Sigma" goes to a Motorola engineer named Bill Smith. Motorola engineers wanted to measure the defects per million opportunities therefore, they developed and created these new standards instead the traditional quality levels that didn't provide enough granularity. Thereafter, many manufacturing and non-manufacturing companies around the world have used Six Sigma as an approach to doing business (Rosing et al. 2015).

2. Literature Review

Most companies suppose that six-sigma can only be implemented in the manufacturing industry because they believe that service organizations have a huge number of human workforce and there are no measurable defects. However, this is not true, non-manufacturing also involve processes. Critical to Quality (CTQs) is one of the keys to the implementation of Six Sigma in services to identify the process parameters since it can determine what's important to the quality of a process or service to ensure what's important to the customer (Chakrabarty and Tan 2007). A recent

survey has revealed that service companies that have invested in six-sigma are all generates significant savings to the bottom line of an organization (Antony, 2004a). There are lot of articles, that deal with six sigma applications in the service industry (Antony 2006), (Antony et al. 2007), (Chakraborty and Tan 2007), (Patton 2005). Sony and Naik (2011) found that a lot of service companies have initiated Six-Sigma in their organizations and the average sigma quality level of the service was around 2.9. Chakrabarty and Tan (2007) provide some instances of none-manufacturing organizations that have implemented Six Sigma approach like (Financial Service, Healthcare, Utility, Energy, and Hospitality). Laureani and Antony (2010) mentioned that the six-sigma applications in a fast-growing call center of the service industry, assist companies to identify the areas of development for their call centers. Ferrin et al (2005), suggested that reduced costs, reduced project time, improved results and improved data integrity are some of the benefits of Six Sigma. There are considerable benefits that can be obtained from the adoption of Six Sigma. It could reinforce product development cycles and process design, shorting product lead times by minimizing the cycle time of the overall manufacturing process. Six Sigma can be used to discover and remove the root causes of the problem, so reducing the variability in the process in order to prevent defects.

The application of Six-Sigma in the service sector is relatively limited compared to manufacturing companies due to various constraints. Antony (2006) presented the possibility of implementing six-sigma in service functions. Some limitations of Six Sigma implementation in the service industry were addressed due to the nature of services by some authors in the literature: Hensley and Dobie (2005), Antony (2004b), and Sehwall and Yong (2003) mentioned that It is difficult to quantify and gather data from service processes since the service organizations have a huge number of the human workforce which required a face-to-face interview to collect data unlike automatic data collection methods used in manufacturing processes. Hensley and Dobie (2005) pointed out that the challenge is the difficulty of distinguishing between the service process and sub-processes, this leads to complicate the measure and control phase. They also indicated that measuring customer satisfaction requiring much effort since the interactions between customer and service provider are not easy to measure. Benedetto (2003) pointed out to the associated cost of implementing Six Sigma in the service industry especially the one that related to organizational resistance to change and the large commitment of organizational resources needed to have a successful implementation of the program work.

2.1. Concept of Variation

Variation has been an issue since the beginning of industrialization, introducing mass production, assembly lines and exchangeable parts required consistency and high accuracy. This matter was initially addressed by setting specification limits for important product characteristics. The concept of Variation states that no two products will be perfectly identical even if extreme care is taken to make them Identical in some aspect.

In any production process a particular amount of natural variability will always exist (Montgomery 2004). This natural variability is the cumulative effects of many small, particularly unavoidable causes. In the frame of statistical quality control, this natural variability is often called a "stable system of chance causes." (Montgomery 2005). The chance causes (common causes) are a deep-rooted part of the constant process, therefore, a process that is operating with only common causes of variation is called under control. Shewhart used the term assignable causes to describe the variation caused by a source that is not part of the constant system, meanwhile, Deming, used the term special causes of variation to describe the same phenomenon (Pyzdek 2003).

2.2. Process Capability

The process capability studies are used to compare the output of an in-control process to the specification limits by using capability indices. This comparison is made by forming the ratio of the spread between the process specifications to the spread of the process values, as measured by 6 process standard deviation units. The Process Capability analysis has been adopted as an ultimate measure of performance to examine the ability of a process to satisfy the customers in the form of specifications. To do the comparison between the output of a stable process and the process specifications, the natural variability of an in-control process with the process specification limits should be compared to each other. This can be represented by Figure 1.
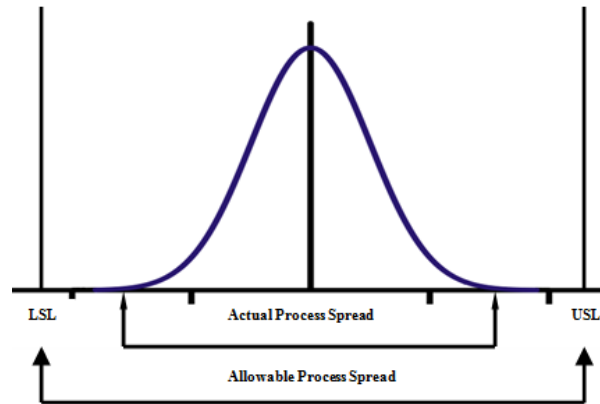
Figure 1: Process Capability (Bebr et al. 2017)

2.3. Six Sigma

Six Sigma is a data-driven leadership path utilizing specific tools and methodologies that lead to fact-based decision making. It is the set of practices that improve process by eliminating defects and focusing on continuous efforts to reduce variation in process outputs. Defect is defined as non-conformity of a product or service to its specification. It was originally developed by Motorola in 1980s and it targeted a difficult goal of 3.4 parts per million defects (Snee and Hoerl 2002). Six-sigma varies from other quality applications in its 'top-down' drive in its strict methodology that demands elaborate analysis, fact-based decisions and a control plan to ensure continuing quality control of a process (Antony and Kumar 2011).

Many of the publications suggest the use of the two most common methodologies to implement Six Sigma (Chakraborty and Tan 2007). The first one is DMAIC that stands for Define, Measure, Analyze, Improve and Control, and the second one is DFSS that stands for Design for Six Sigma. According to Edgeman and Dugan (2008) the main goals of the two methods are widely different. While DMAIC is a problem-solving method, which aims at process improvement, DFSS is defined by Watson and DeYong (2010) as "a process to define, design and deliver innovative products provide competitively attractive value to customers in a manner that achieves the critical-to-quality characteristics for all the significant functions".

Other tools that are being utilized during six sigma implementations are given as (Yousaf et al 2013):

- DCCDI (Define, Customer, Concept, Design and Implement)
- CDOC (Conceptualize, Design, Optimize and Control)
- DCDOV (Define, Concept, Design, Optimize and Verify)
- DMADOV (Define, Measure, Analyze, Design, Optimize and Verify)
- DMEDI (Define, Measure, Explore, Develop and Implement)
- IDOV (Identify, Design, Optimize and validate)
- IIDOV (Invent, Innovate, Develop, Optimize and validate)

2.4. Define, Measure, Analyze, Improve and Control (DMAIC)

Basic tools of DMAIC typically used at the Yellow-Belt level of competence include Statistical Process Control, flowcharts, check sheets, Pareto diagrams, histograms, scatter diagrams, and cause/effect diagrams (Ferrin et al. 2005). At the Black-Belt level, more advanced tools such as regression analysis (e.g. with indicator variables, curvilinear regression and logistic regression), hypothesis testing, control charts and Design of Experiments are typically used. As mentioned above, DMAIC is a problem-solving method which aims at process improvement. Basically, this methodology consists of following five key points:

1. Define the process improvement objectives that are aligned with the customer needs and demands and company's strategy.
2. Measure the existing process and create a strategy for making further improvement.
3. Analyze to verify the relationship and causality of factors. Locate what the relation is and attempts to assure that all the factors have been taken in account.
4. Improve and optimize process based on the results of analysis phase using different techniques.
5. Control to ensure that any variances are corrected before they result in defects. Figure 2 illustrates the DMAIC flow chart.
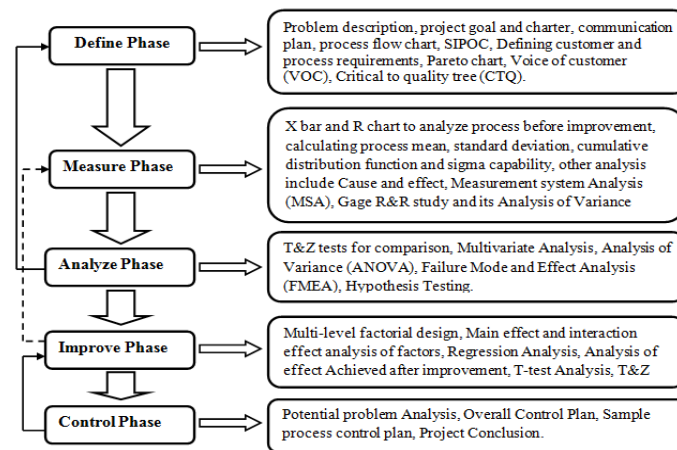

Figure 2: DMAIC Flow Chart (Yousaf et al. 2013)

3. Case Study: Using DMAIC to Reduce the Total Number of Delayed Job Orders in a Service Company

3.1. Introduction

In competitive markets, service suppliers always seek to satisfy their customers and improve their competitive advantages. In such a competitive environment, a service company is struggling to survive, and its main goal is to decrease the total number of delayed jobs (NODJ) and achieve better customer satisfaction. DMAIC (Define, Measure, Analyze, Improve and Control) as one of most common technique of six sigma was used to achieve this goal. In service sectors, defining the defect is quite challenging because it is difficult to reach an accord on it or what the service defect is? Customers repeatedly informed the delays in the service. This led to customer dissatisfaction and threaten the reputation of the company. The service defect should be defined as any process that leads to a high level of customer dissatisfaction. In this study, the defect was considered as any job that delayed more than or equal to one day from the promise date. Six-sigma methodology DMAIC is adopted to identify defect in the service process. The most immediate practical implication of this study shows that, significant decrease in NODJ and improved customer satisfaction.

- *Problem Statement*

The considered service company is established in 2004 and headquartered in Cyrenaica Libya. The business of the company is varied from catering for the oil fields and medical centers to trailer construction and mechanical. The company receives orders from different clients. The process begins by opening order by the client until the order is closed by the company. 14.3% of the orders were not accomplished on the promised due date during the period January 2017 - August 2017. This creates customer dissatisfaction and has resulted in the cancellation of orders in some cases.

3.2. Methodology (DMAIC)

- **Define Phase**

The due date to accomplish a job usually is determined by the contracting company after receiving the orders from the customer. Therefore, if any job is accomplished after this promise date, it will be considered as a delayed job. During the period of (January, 2017- August, 2017), the company received 795 order. According to the company record, 681 jobs were accomplished on the promise date and 114 jobs were not accomplished on the promised due date and considered as defects. This means that 14.3% of jobs are delayed and considered as defect in service from the company. This process, from the beginning to the end (until the order is closed) needs to be improved to obtain better quality of service and minimize NODJ. Therefore, A project team led by a project champion was created Figure 3 to conduct a Six Sigma project to improve the process of the service and reduce the percentage of delayed jobs from a current level of 14.3% to at least 5%. The team scoped down the project and create a high-level process map (SIPOC) Table 1 to identify which areas of the contracting company that they should focus on. Table 2 summarize define phase.
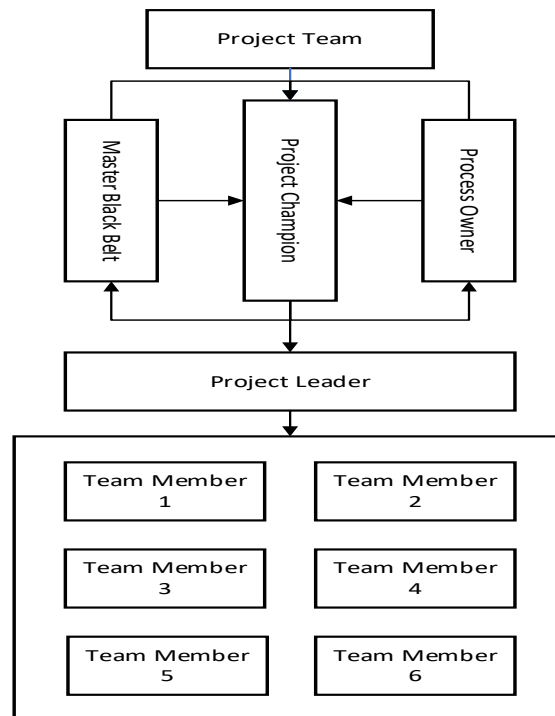

Figure 3: Project Team

Table 1: SIPOC

S	I	P	O	C
Contracting department	Communication tools	Use phone, fax, radio, forms	Information flow	Head management/ Customer
Suppliers of raw materials	On time delivery of raw materials	Maintain safety stock	Avoided the risk of being out of stock to meet service levels	Warehouse
Customers	Open order	Specify Dates/ Times/ Locations	Fixed due date	Contracting company
Customers	Delivery instruction and requirements	Schedule delivery	Met the promise due date	Delivery scheduler
Warehouse	Delivery schedule, reliable trucks, well-trained drivers	Facilitate the process	Load is ready for loading	Warehouse

As can be seen in Figure 4 the process starts when the clients open a job order. The company usually receives and accepts the orders from the clients by a traditional approach such as (phone, fax or paper). After receiving the job order, planning department discusses the requirements and the available resources to solve the job order and then make decision whether the company capable to solve the problem or they need an external contractor to open and close the job order. Once the promise due date is determined, the job order is assigned to the labor and store department to work on the job order. In addition, a project charter was created to characterize the objectives of the project, delineates the boundaries, measures of success, constraints, the available resources, how it will be executed, and who the stakeholders are**.**
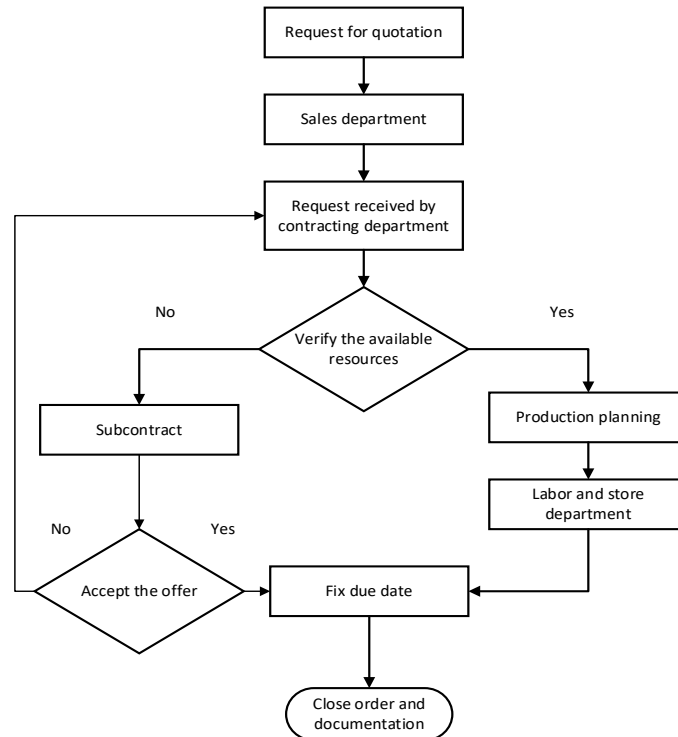

Figure 4: Process Map for the Company

Table 2: Define Phase

Term	Definition
Problem Statement	Over 795 jobs required in 8 months, 114 jobs delayed
Project Objective	Reduce the percentage of defects from 14.3% - at least 5%
Unit of Measurement	The number of delayed jobs
Defect	Any job that delayed more than or equal one day from the promise date.
Sigma Level	2.57
Capability	0.857

- **Measure Phase**

The main objective of the measure phase is to examine and understand the existing state of the process. This includes collecting data on measures of quality, cost, and throughput/cycle time. It is essential to form a list of all of the key process input variables (KPIV) and the key process output variables (KPOV). The measure phase enables establishing baseline data to later assess future influence. In this study, each delayed job has been considered as a defect. Therefore, the defects per one million opportunity (DPMO) can be expressed by the equation below. Table 3 illustrates the sigma level for the process.

$$DPMO = \frac{Number\ of\ defec}{Total\ number\ of\ units} * 1,000,000$$

Table 3: DPMO, Defects%, Yield and Sigma level for the contracting company

DPMO	143,396
Defects %	14.3
Yield %	85.7
Process Sigma	2.57

Since the current baseline for the service contracting company is 2.57 sigma and the capability of the process is 0.857 (less than 1), which is not meet the customer target at 100%, the process needs to be improved.

- **Analyze Phase**

In the analyze phase, the objective is to use the data from the measure phase to determine the cause-and-effect relationships in the process and understand the different sources of variability. In this phase, analyzing the process map, cause and effect diagram, fault tree analysis and FMEA were used to obtain a clear picture of the current situation. The details of tools used to analyze the failures in job orders are presented as follows:

1. Cause and Effect Diagram

Cause and effect diagram is a significant tool that use in analyze phase to identify the causes behind the problem. Brainstorm sessions using 5y technique was conducted to construct a cause and effect diagram Figure 5 and breakdown reasons behind job order delay. The main causes behind the defect (job order delayed) were determined by using cause and effect diagram and fault tree analysis. Those causes are the mode of responding to the client, people, the estimation of the due date and the planning and control of the resources to complete the job.
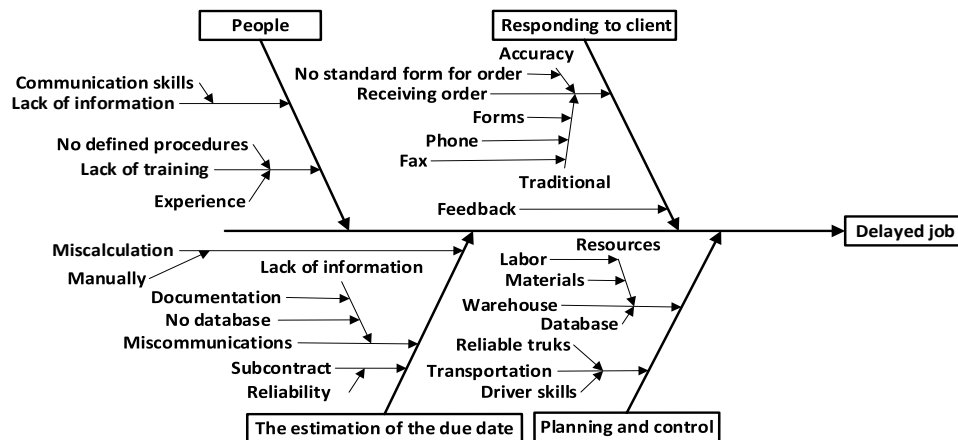

Figure 5: Cause and Effect diagram for the company

2. Pareto Chart

Pareto chart Figure 6 was used to define the most significant causes of defects (delayed job), it can be noticed that 80% of delayed job comes from the traditional method of receiving job order and the lack of database to analyze the job order.
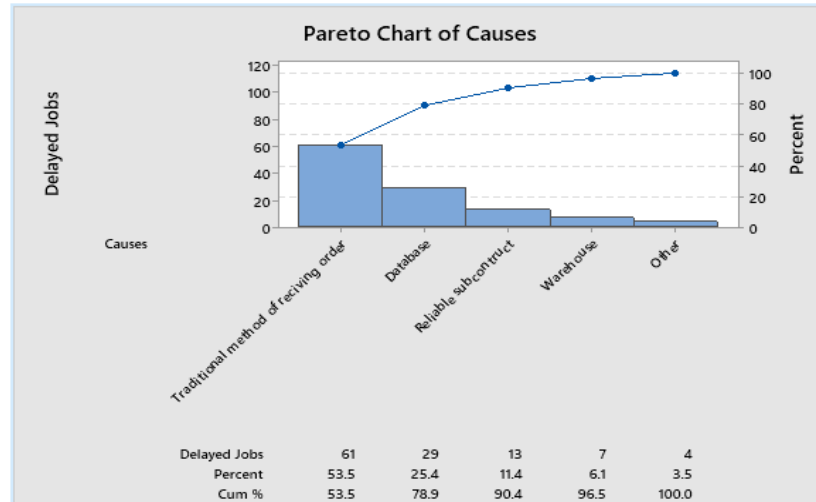
Figure 6: Pareto Chart of the causes of defect

3. Failure Mode and Effect Analysis (FMEA)

Failure mode and effects analysis (FMEA) was used to identify and understand potential failure modes and their causes and the effects on each job-order process stages and assess the risk associated with the identified failure modes, effects, and causes, and prioritize issues for corrective action. Table 4 shows FMEA of the current process for the service company and it can be seen that the factors that have the highest risk priority number are traditional method of receiving order, responding to the client and analyzing the job-order manually based on individuals experience.

Table 4: FEMA (current process)

Process function	Failure mode	Failure cause	Failure effects	SEV	OC	DET	RPN
Responding to the client	Demand characteristic	No standard form for order	Delay in receiving correct job order	9	5	5	225
Receiving job order	Receive order	No standard form for order/ Traditional method (fax, phone)/ Communication issues/No database	Delay in responding to client/Fail to meet the promise date	10	9	6	**540**
Warehouse dep	Stock level	Manual process/no database	Delay in promise due date	8	6	4	192
Warehouse dep	Transportation	Process depends on truck driver experience	Fail to meet customer expectations	6	3	3	54
Responding to the client	Communication	Traditional method (fax, form)	Delay in responding to client	10	8	6	**480**
Analyze job order	Estimate the promise date	Miscommunication with other depts/manual process/ No database	Fail to meet the promise due date	10	7	6	**420**
Assigning job order to subcontracting	Lack of information	Unreliable contractor	Delay in promise date	9	3	3	81
Assign job to L&S dept	Accomplish job	Miscommunication. issues	Delay in promise date	5	5	5	125

4. Hypothesis Testing

There are many tools that are potentially useful in the Analyze Step. Among these are statistical hypothesis testing and confidence interval estimation, which can be used to determine if different conditions of operation produce statistically significantly different results and to provide information about the accuracy with which parameters of interest have been estimated (Montgomery 2013). In this study, benchmarking is used to compare the performance of the company of interest with other company in the same field. Another company has been selected and a sample of data is collected at the same period. Hypothesis tests showed that there is a statistically significant difference in (NODJ) between the mode of receiving the job order (classical vs advanced) and the method used of analyzing the job order (based on experience vs based on database).

WORKSHEET 1
Two-Sample T-Test and CI: NODJ (Trad/indiv experience), NODJ (online/database)

Method

μ_1: mean of NODJ (Trad/indiv experience)
μ_2: mean of NODJ (online/database)
Difference: $\mu_1 - \mu_2$

Equal variances are assumed for this analysis.

Descriptive Statistics

Sample	N	Mean	StDev	SE Mean
NODJ (Trad/indiv experience)	8	11.50	2.88	1.0
NODJ (online/database)	8	7.38	1.69	0.60

Estimation for Difference

Difference	StDev	Pooled 95% Lower Bound for Difference
4.13	2.36	2.05

Test

Null hypothesis H_0: $\mu_1 - \mu_2 = 0$
Alternative hypothesis H_1: $\mu_1 - \mu_2 > 0$

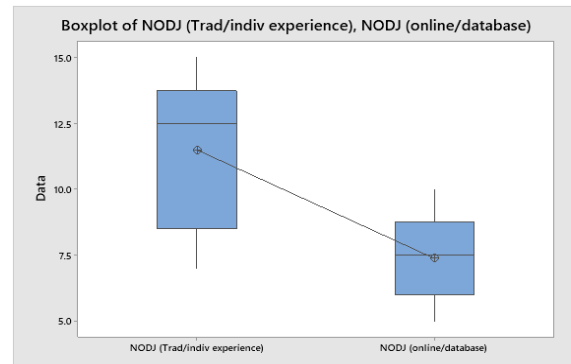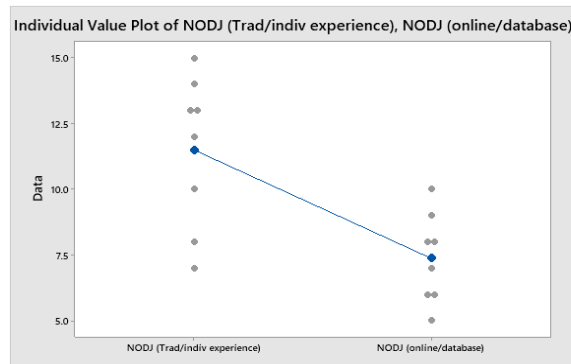| T-Value	DF	P-Value
3.50	14	0.002

Figure 7: Minitab output of Two-sample T-test & CI (service company vs competitor company)

From the Minitab output Figure 7 it can be noticed that the mode of receiving the job order (classical) and the method used of analyzing the job order (based on individual experience) have a significant effect on NODJ comparing to the competitor company.

- **Improve Phase**

In the improve phase, the focus turn to the specific changes that can be made in the process and other issues that can be done to have the desirable impact on process performance. Designed experiments are probably the most important statistical tool in the improve phase. It can be applied either to an actual physical process or to a computer simulation model of the process, and can be used to determine which factors influence the outcome of a process and obtain the optimal combination of factor settings (Montgomery 2013).

1. Design of Experiments (DOE)

In this study, DOE was conducted using Minitab to create general full factorial design. two factors were considered, the mode of receiving order (A) and the mode analysis of job order requirements (B), the response is the number of delayed jobs NODJ. The factors and its levels are shown in Table 5.

Table 5: Factors and levels of DOE

Factor	Name of Factor	Level
A	Mode of receiving Order	A1: Classical A2: Online
B	Mode of analyzing Job Requirements	B1: Individual experience B2: Database

Figure 8 represents the main effects and the interaction plot for NODJ, it can be seen that the overall mean of NODJ is 9.5. Moreover, using online approach of receiving order reduces NODJ on average by 45% and using shared database technique to analyze the job requirements decreases NODJ on average by 38%. Looking at the interaction plot, it can be noticed that there is no interaction between the two factors.
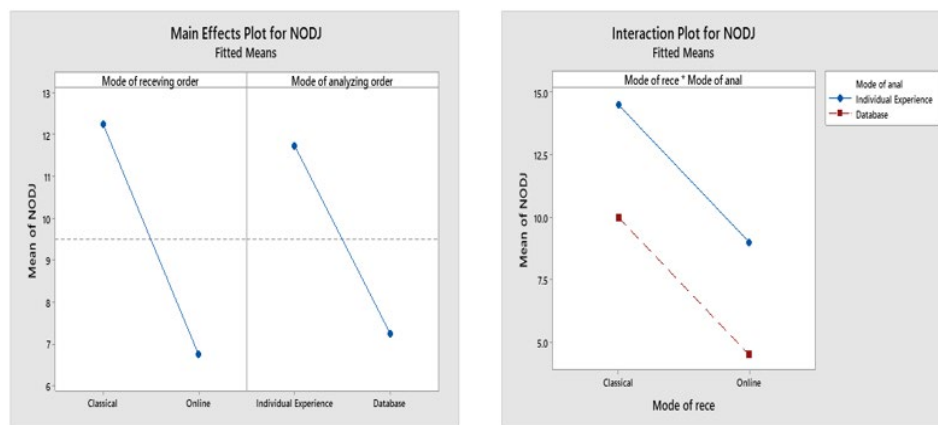

Figure 1: Minitab output of DOE

Therefore, a combination of using online approach for receiving job order and shared database system for analyzing the job order should be selected for improvement. Table 6 shows the improvement action plan for improve phase; however, in this study the focus was only on the methods of receiving and analyzing job order since they have the most significant effects on the process.

Table 6: Improvement action plan

Cause	Improvement action	Responsibility
Demand characteristic issues	Standardize	Company senior management
Impropriate methods of receiving job order	Advanced method (website, email)/ Standardize/ Computerize, Database	Company senior management
Inaccurate estimation of stock level	Control inventory through automation	Warehouse management
Technical transportation issues	Install GPS system/radio	Warehouse management
Impropriate methods of communication with the client	Advanced method (website, email)/ Standardize	Company senior management
Impropriate procedures of Estimation the promise date	Training programs/ using computer software	Company senior management
Assigning job order to subcontractor	Improve contracting dep	Contracting department
Accomplish job	Training program	Company senior management

2. Updated process map

After applying the improvement action plan, the service contracting company process map should be updated to be compatible with new changes. Figure 9, shows the modified process map after the improvement process. Table 7 shows the failure mode and effect analysis FEMA for service contracting company after the improvements and Figure 10 illustrates the significant drop of the risk priority number after the improvement process. In addition, a hypothesis test was preformed to know if there is any different of the mean of the NODJ between before and after the implementation the improve phase. It is clear that using online-shared database procedures decrease the overall mean of NODJ. Since $P < 0.05$,the null hypothesis can be rejected and it can be concluded that there is a significant decrease in the overall mean of NODJ after the improvement process, see Figure 11.
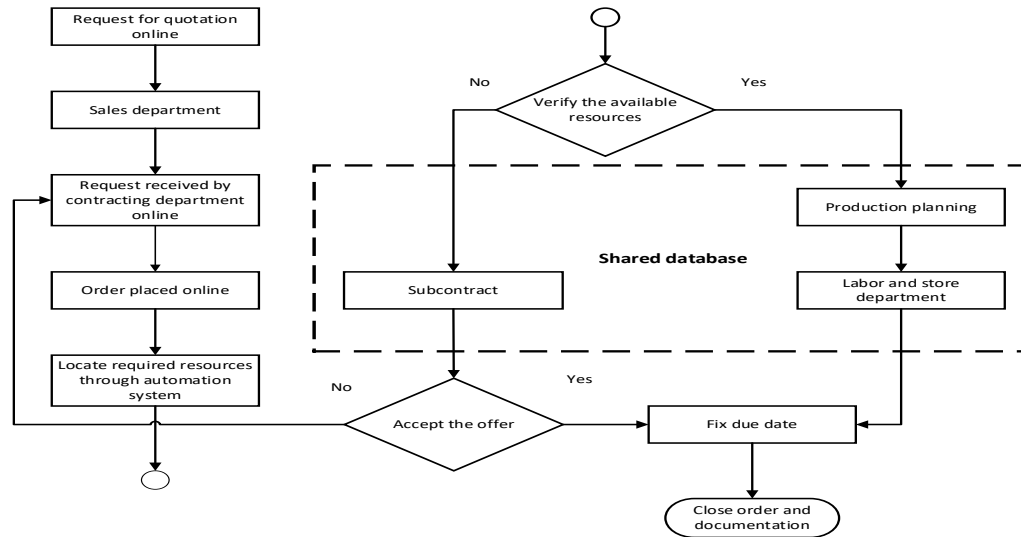

Figure 9: Updated process map after the improvement phase

Table 7: FEMA after improve phase

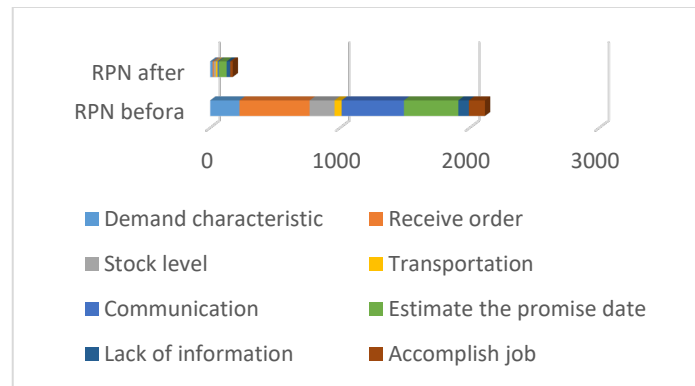| Process function	Failure mode	Failure cause	Failure effects	Action results				
				Action taken	SEV	OC	DET	RPN
Responding to the client	Demand characteristic	No standard form for order	Delay in receiving correct job order	Standardize	9	1	2	18
Receiving job order	Receive order	No standard form for order/ Traditional method (fax, phone)/ Communication issues/No database	Delay in responding to client/Fail to meet the promise date	online/ Standardize/ Computerize, Database	10	1	1	10
Warehouse dep	Stock level	Manual process/no database	Delay in promise due date	Control inventory system	8	2	1	16
Warehouse dep	Transportation	Process depends on truck driver experience	Fail to meet customer expectations	Install GPS system/radio	6	2	1	12
Responding to the client	Communication	Traditional method (fax, form)	Delay in responding to client	Online approach/ Standardize	10	1	1	10
Analyze job order	Estimate the promise date	Miscommunication with other depts/manual process/ No database	Fail to meet the promise due date	Training programs/ using computer software	10	2	3	60
Assigning job order to subcontracting	Lack of information	Unreliable contractor	Delay in promise date	Improve contracting dep	9	3	1	27
Assign job to L&S dept	Accomplish job	Miscommunication. issues	Delay in promise date	Training programs	5	2	2	20

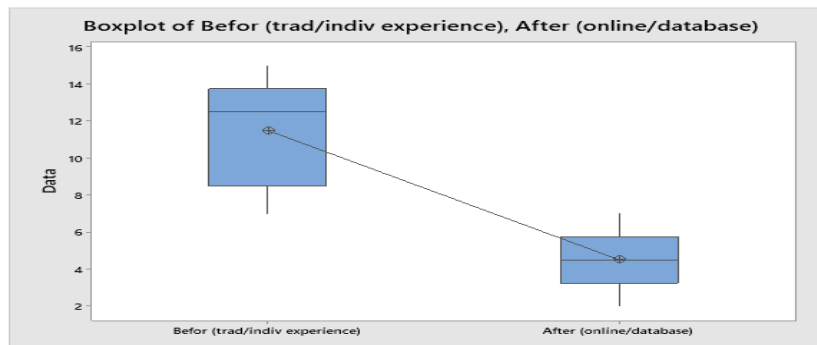Figure 10: A comparison of RPN before and after improvement

Figure 11: Hypothesis testing before-after improvement process

It can be observed that the critical areas named receiving order in traditional way and analyzing the requirements manually based on individual experience have the most negative effects on the performance of the company. Having an advance online job order receipt and a shared database between departments within the company is the best combination. This combination increased sigma level by about 0.55 sigma to reach 3.12 sigma.

- **Control Phase**

The objectives of the control step are to complete all remaining work on the project and to hand off the improved process to the process owner along with a process control plan and other necessary procedures to ensure

that the gains from the project will be institutionalized. That is, the goal is to ensure that the gains are of help in the process and, if possible, the improvements will be implemented in other similar processes in the business (Montgomery 2013). As part of the control phase, having a plan for corrective actions, sharing data related to order characteristics and resource availability, online upgrading, developing the inventory systems, installing a reliable GPS system as well as conducting training programs for its employees to keep up with new technology and encourage them to communicate with each other are very important to keep the job order process under stability and control. Documentation of the improvement actions plays a vital role in the control phase to ensure the sustainability of the process going forward. Table 8 summarizes the results gained from implementing the application of six sigma.

Table 8: Project results

Description	Before improvement (Jan 2017- Aug 2017)	After improvement (Mar 2018 - Oct 2018)
Number of total jobs	795	683
Number of delayed jobs	114	36
DPMO	143396	52708
Defect %	14.3	5.3
Yield %	85.7	94.7
Sigma level	2.57	3.12

4. Conclusion

In this paper, we tried to demonstrate the power of the applications of Six Sigma as an improvement tool and show the potential domains where it could be utilized in the non-manufacturing industry. This paper presented a successful case study of minimizing the number of delayed jobs which was considered as defects in a service contracting company by conducting a Six Sigma project and the DMAIC problem-solving methodology. After the analyses carried out in the project phases, it was found that the mode of receiving jobs order and analyzing the job requirements had a statistically significant impact on the NODJ. Taking this into consideration, an optimum combination of using an online approach and database system were determined to receive and analyze the jobs order and its requirements.

Although the improvement has not reached to the sigma level of six, the implementation of Six Sigma methodology has achieved its purpose and considerable improvement has been obtained in the service quality. The percentage of NODJ decreases from 14.3% to 5.3% and the sigma level increased from 2.57up to 3.12. Therefore, this study can be considered as a pilot project that demonstrates that the applications of Six Sigma are effective approaches capable of improving the service quality in non-manufacturing sectors as long as the organization continues embracing Six Sigma within its continuous improvement culture.

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