Application of Six Sigma in Service Contracting Company

Ateekh-Ur-Rehman
Industrial Engineering Department, College of Engineering
King Saud University
Riyadh, Kingdom of Saudi Arabia
arehman@ksu.edu.sa

Abstract

In hypercompetitive market, service providers are always strives to satisfy their customers to improve their competitive advantages. To survive in such competitive environment, one of the leading service contracting company in the Saudi Arabia, struggling to reduce number of delayed job to achieve better customer satisfaction. Here in the paper, job delayed from promise due date is considered as defect in the service, and it leads to customer dissatisfaction. Six-sigma methodology is adopted to identify flaws in the service process. The most immediate practical implication of this study shows that, significant reduction in the number of delayed jobs and improved customer satisfaction.

Keywords
Six-Sigma, Service sector, DMAIC, FMEA, DOE

1. Introduction

Since its introduction by Motorola in 1980's, six-sigma is the one of successful technique that has been utilized by various organizations (Abramowich, 2005; Brady and Allen, 2006). Six-sigma is a problem-focused methodology with main objectives are decreasing defects, improving service quality, creating value and generating income (Abbas et al., 2012). Today to enhance performance and revamp work culture most of the world's leading corporations like Dow Chemicals, 3M, Bombardier, Sony and Johnson to name a few from extensive list, are adopting six-sigma.It refers to the ability of process to produce output such that, the standard deviation of the output is less than sixth of the difference between mean of the output and nearest specification limit (Jennifer, 2004). Process that operate with six-sigma quality over a short term are assumed to produce long-term defects level below 3.4 defects per million opportunities (DPMO) (Pyzdek, 2002).Scott and Sara (2012) in their study indicated that adopting it positively impacts organizational performance, more specifically enhanced employee productivity. It strives to improve the quality of process outputs, emphasizes an intelligent blending of the insight of an organization with statistical tools to get better efficiency, and effectiveness of the organization. Through improvements the ultimate goal is creation of economic strength for the customer and service provider alike. This doesn't mean that six-sigma replaces ongoing quality programs in a company. Rather, management focuses on those processes identified as critical-to-quality in the eyes of customers. Then, strong analysis and improvements should be initiated on those critical processes (Smith, 1993).

The paper deals with the reduction of number of delayed jobs in a service contracting company of Saudi Arabia. The problem was tackled using a 'DMAIC'(Define, Measure, Analyze, Improve and Control) problem-solving six-sigma approach. Unlike manufacturing operations, defining a service defect is quite challenging aspect of applying six-sigma in service delivery systems. This is because it is not easy to reach an agreement on, what is a service defect? Customers repeatedly reported the delays in the jobs ordered or even no service after placing the order. This led to immense customer dissatisfaction, and a threat to the reputation of the company. One has to define service defegct as a flaw in a process that results in lower level of customer satisfaction or a lost customer. Here, service defectsare those jobs orders, which got delayed more than one or equal to one day from the promise due date given by the service provider to the customer.

The paper is organized as follows; Section 2 reviews the use of six-sigma in service sector. Section 3 provides the detailed problem and present process at the company. Following this, a detail analysis of present process is

discussed in section 4. Our improvements and results are presented in section 5. Finally, paper is concluded in section 6 with a discussion.

2. Six-Sigma in Service Sector

Six-sigma is a business management strategy and methodology focused to enhance profitability, productivity, efficiency and customer satisfaction by escalating product or service quality (Antony and Banuelas, 2002). Six-sigma differs from other quality programs in its 'top-down' drive in its rigorous methodology that demands detailed analysis, fact-based decisions and a control plan to ensure ongoing quality control of a process (Jennifer, 2004). Though six-sigma was originally started with manufacturing processes (Kwak and Anbari, 2006), but over the years six-sigma strategy has expanded its application to a variety of fields (Thomas et al., 2006; Timony et al., 2009; Rohini and Mallikarjun, 2011; Abbas et al., 2012; Ateekh-ur-Rehman, 2012). Nowadays Six-Sigma is increasingly applied to a variety of processes ranging from manufacturing, process design, chemical processes to the service firms and variegated transactional processes (Minjin et al., 2003; Sokovic et al., 2005; Adan et al., 2009). Almost every sector is using six-sigma to increases quality, performance and profit.

Most companies presume that six-sigma can only benefit the manufacturing industry. Specially, service organizations believe that because their process have a vast number of human work force, there are no measurable defects. However, this is not true because a recent survey has shown that service companies that have invested in six-sigma are all generates significant savings to the bottom line of an organization (Antony, 2004). There is a rising number of articles, that deal with six sigma applications in the service industry (Biolos, 2002; Patton, 2005; Antony, 2006; Chakrabarty and Tan, 2007; Antony et al. 2007). Michael Sony and Subhash Naik (2011) found that the bulk of service companies has been initiated Six-Sigma in their organizations and the average sigma quality level of the service organizations was around 2.9. Application of Six-Sigma in the service sector is comparatively limited than in manufacturing companies due to various constraints. Antony J (2006) presented the potential of six-sigma in service functions. Through a case study, Alessandro Laureani et al. (2010) illustrates six-sigma applications to a fast-growing call centre of service industry, assisting companies in identifying areas of development for their call centres.

There are numerous companies frequently apply six-sigma to their different service processes such as safety engineering, supply chain, human resources, customer relationship management, payroll, accounting, and organization change and innovation. Fleming et al. (2005) describes how companies are making use of six-sigma for their customer relations improvement. Ateekh-Ur-Rehman (2012) report that how six-sigma is applied in safety engineering to reduce the number of accidents in a manufacturing firm. Juras et al. (2007) explained how can apply six-sigma in order to assure compliance with the Sarbanes-Oxley Act. The area of the service sector where six-sigma has been very accepted in recent years is financial services (Behnam and Joao, 2009). Six-sigma methodologies eventuate the DMAIC principle of problem solving. The DMAIC methodology provides a structure for logic progression through a problem solving activity.

3. Problem Definition

The service contracting company considered here is established in 1989. This company made many projects in Saudi Arabia in different fields like catering for military & medical centers, maintaining medical centers & city sanitation, mechanical&electricalprojects, planting gardensand organizing locations. The company has a high rating in field of catering personnel. They receive maintenance orders from different customers. The process starts from opening an order by the customer until the order is closed by the company. Probelm is defined as "how to reduce the number of delayed job from the promised due date?".

3.1. Define Phase

Usually, the service contracting company determines a date to accomplish each job after receiving the orders from the customer, is called the promise date. If any job is accomplished after the promise date, it will consider as a delayed jobs. Last year from month of April until September, total number of maintenance orders received by company were 582 orders or jobs. As per company record, during this period, there were 169 jobs delayed, and not completed on promised date. It means 29 percentage of total number of jobs are delayed and considered as defect in

service from the company. The process that starts from opening an order until it is closed, is need to be improved to achieve better quality of service and reduce the number to delayed jobs. Thus, objective of this study is to minimize the total number of delayed jobs. Table 1 summarize define phase.

Table 1 Summary of Define Phase

Term	Definitions
Problem Statement	Over 582 jobs are required in 6 months. There are 169 jobs are delayed and do not meet the customer expectation.
Project Objective	Minimize the total number of delayed jobs
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	2.037
Capability	0.68

4. Six-sigma to Map Current Service Process

In this phase, an analysis of the process map, cause and effect diagram, fault tree analysis and FMEA methods are widely used to take snapshots of the current state of the process. This phase is critical for the study, focuses on process measurement, gathering root cause and identifing the critical inputs that affects the key output of the process.

4.1. Measurephase

The measure phase allows to establish baseline data to later evaluate future impact. In order to convert defects to be defects per one million, a DPMO equation (1) is used:

$$\text{DPMO} = \frac{\text{No. of Defects}}{\text{Total No. of units}} \times 1{,}000{,}000 = \frac{169}{582} \times 1{,}000{,}000 = 290{,}378 \qquad (1)$$

Thus, using MS Excel, the current baseline for the service contracting company is 2.037 sigma. And the capability of the process is found to be 0.68. Since, the capability of the service contracting company's process is below 1, so the process needs improvemg

4.1.1. Process map

Figure 1 represents the service contracting company's process map. The company's process starts by opening a job-order by the clients/ customers. The service contracting company receives the orders from different clients. Currently very traditional approach (ontelephone, by fax or on paper) is used to accept the order. After receiving the job-order, planning department make the arrangement and requirements to solve the job-order. Usually, they analyze the job-order and decide 'is company capable to solve the problem?' Or they need an external contractor to open and close the job-order. Once job-order is assigned, a promise due date is determined and assigned for the clients.As promise due date is fixed, planning department in co-ordination with the labor and store department start to check the availability of resources, and assign the job-order. Finally, contracting company compelets the job-order for the clients and closes the order.

4.1.2. Cause & Effect diagram

The cause and effect diagram is used to identify all the potential or real causes (or inputs) that will lead to or result in a single effect (or output). Figure 2 represents the cause and effect diagram for the service contracting company.

Fault tree analysis is also done to breakdown reasons behind job order delay. For example, underestimation of both labour and material is the cause of the job-order requirements failure. Thus, by using process map, cause & effect diagram and fault tree analysis tools, the opportunities of failure for the service company are determined. Those causes are mode of receiving the job-order, estimation of the due date and planning of resources to compelete the job order.

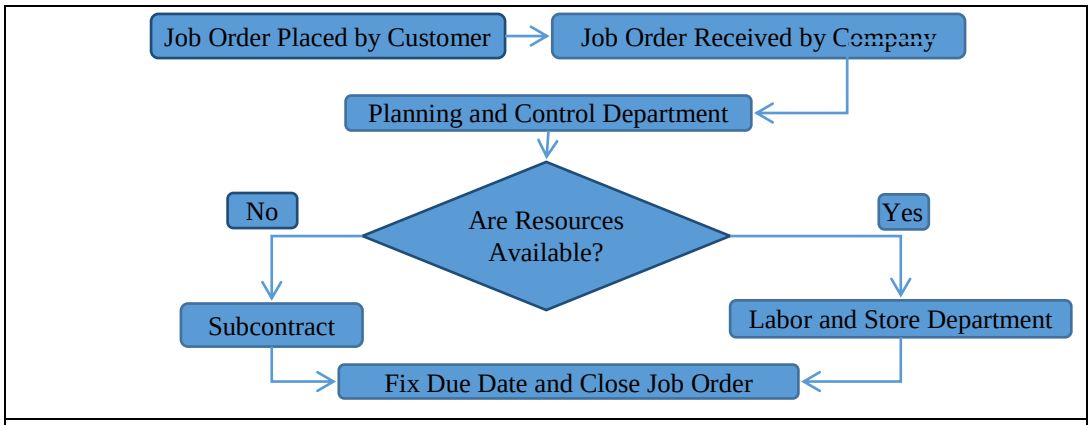

Figure 1 Process map of service contracting company

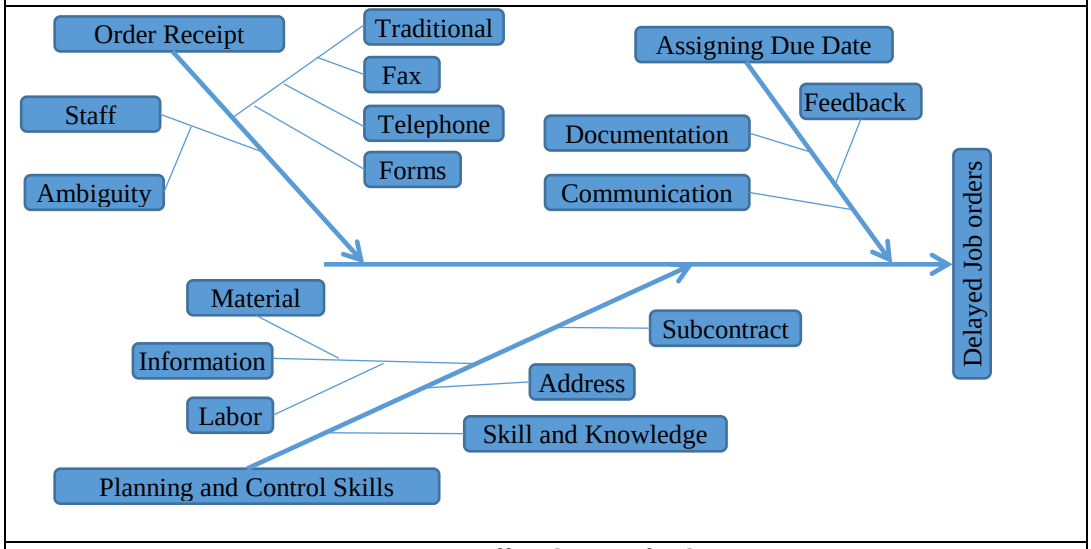

Figure 2. Cause & Effect diagram for the company

4.2. Analyze Phase

Through the use of qualitative toolsand statistical tests,the analyze phase helped us to understand what controls the process varaibility. The details of tools used to analyze the failures in job orders are presented in the following sub sections.

4.2.1. Failure Mode and Effect Analysis (FMEA)

Failure mode effects analysis (FMEA) is done for investigation of risk of each job-order process stages. The Table 2 represents the FMEA for the service contracting company. From Table 2, it is obvious that analyzing the job-order (648), mode of receiving the order (441) and assigning job-order (256) are the factors have the highest risk priority number (RPN)

4.2.2. Hypothesis testing

A benchmark with other company in the same field should be used in order to compare the performance of the service contracting company. Thus, another contracting company is selected for the purpose of benchmarking, because, both companies have the same business. A sample of data from another company is collected for the same period. Table 3 shows the data of the service contracting company and its competitor company for 2014 from April to August.

Table 2. FMEA for the service contracting company.

Process Step	Failure	Cause of failure	Effect of failure	OC	SEV	DET	RPN
Open order	Demand characteristic	No standard form for order	Delay in receiving correct job-order	2	4	1	8
Receive order	Receive order	Fax issues	Delay in responding to client	7	9	7	441
Analyse problem manually & estimate/fix due date	Estimation of promise date	Miscommunication with other supporting departments	Delay in promise date	9	9	8	648
Making subcontracting	Estimation of promise date	Unreliable contractor	Delay in promise date	3	2	4	24
Assign problem to L&S dept.	Accomplish problem	Miscommunication with analysing problem dept.	Delay in promise date	8	8	4	256
Fix & close the order	Accomplish job	Transportation issues	Delay in promise date	4	3	1	12

OC: Occurrence SEV: Severity DET: Failure detected RPN: Risk priority number

Table 3. Number of delayed jobs data of the both companies from last year April to August

	The service contracting company			Competitor contracting company	
Month	Delayed job observed	Delay caused by receiving order traditional approach	Delay caused by analysingjob-order requirement based on individual experience	Delay caused by receiving order advance online approach	Delay caused by analysing job-order requirement based onshared database
April	51	19	29	3	4
May	19	10	7	6	7
June	15	4	11	3	6
July	51	20	28	3	7
August	19	10	7	8	9
September	14	3	11	5	8

Is there a difference between receiving order approach of the service contracting company and its competitor company?

H_0: $\mu_{traditional} = \mu_{advance}$ H_1: $\mu_{traditional} > \mu_{advance}$

Confidence interval = 95%Estimate for difference: 6.33.95% lower bound for difference: 0.16.

T-Test of difference = 0 (vs>): T-Value = 2.07 P-Value = 0.047 DF = 5.

P-value: =0.047<0.05 so we will reject the null hypothesis (H_0).

Is there a difference between analyzing the job order requirements based on individual experience or systemically using central database?

H_0: $\mu_{manually} = \mu_{database}$ H_1: $\mu_{manually} > \mu_{database}$

Confidence interval = 95%Estimate for difference: 8.67.95% lower bound for difference: 0.13.

T-Test of difference = 0 (vs>): T-Value = 2.05 P-Value = 0.048 DF = 5.

P-Value =0.048<0.05 so we will reject the null hypothesis (H_0).

From hypothesis testing, it is obvious that receiving order by traditional approachhas a significant affect on number of delayed jobs compare to receiving order by advance technology. Similar obesrvation is made with respect to planning and control based on individual experience has significant affect on delayed jobs compare to planning and control job ordersusing a shared databaseProcess map, cause and effect diagram, FMEA and hypotesis testing opens window to modify the present delivery process of service contracing company. The subsequent section described how the present process is modified to minimized number of delays in job orders.

5. MODIFIED PROCESS

By applying all presented method in measure phase, two critical factors are selected to improve the process. A new, modified process need to be developed and should be tested for the number of delayed jobs.

5.1. *Improve Phase*

Improve phase is the fourth phase in methodology of six sigma. Design of Experiments (DOE) can be a very effective tool in understanding and optimizing process control, and is used in the improve phase of many six sigma projects. Through the use of experiments and qualitative tools, the improve phase helps us to understand what the the vital few factors those are controlling the process average & variation.

5.1.1. *Design of Experiments*

Considering the problem onhand i.e minimizing delay in promise due date. Two factors are of interest- the first mode of receiving order (Factor 'A') and the second is the analysis of job order requirments and determine due dateto compelete the received order (Factor 'B').The levels of interest for Factor A (mode of receiving order) are 'by traditional approach' and 'by advance online approach', those for Factor 'B' are 'analysis based on individual experience(manual)' and 'analysis using shared database system (database)'. Levels for each factor are shown in Table 4.

Table 4.Factors and Levels for design of experiments

Factor	Name of Factor	Levels
A	Mode of receiving order	A1: Traditional approach A2 :Advance online approach
B	Analysis of job order requirements	B1: Manual B2:Database

The response of interest is the volume of delayed jobs. Minitab16 is used to creat general factorial design with number of factors, factor names, number of levels and level values. Subsequently, design work sheet is created. The obtained design worksheet is as speceified in Table 5. There are two factors, each factor with two levels. The number of combinations in our experiment would be four. This is expressed by 2^2 factorial DOE.The mean delayed jobs for each level together with over all mean delayed jobs is presented in Table 6.

Table 5. Full factorial design with 2 replicates design

Std. Order	Run Order	Mode of receiving order	Planning and control of job order requirements	Total number of delayed jobs
3	1	Traditional	Manual	64
2	2	Advance online	Database	55
6	3	Traditional	Database	62
4	4	Advance online	Database	34
8	5	Advance online	Database	45
5	6	Traditional	Manual	85
7	7	Advance online	Manual	67
1	8	Traditional	Manual	84

Table 6. Mean delayed jobs for each level of factors

		Factor 'B': Analysing customer job order and determine due date/time to complete received order		
		Analyzing manually individual experienced based (B1)	Analyzing with shared database system (B2)	Mean
Factor 'A': Mode of receiving order	Traditional (A1)	84.5	60	72.25
	Advance online (A2)	65.5	39.5	52.5
	Mean	75	49.75	62.375

Using Minitab, main effects plot for Factors 'A and B' are ploted as shown in Figure 6. In main effects plot, horizantal line indicates the overall mean delayed jobs i.e. 62.375. The mean delayed jobs for each of the two levels of Factor 'A' are plotted in first panel and the mean delayed jobs for each of the two levels of Factor 'B' are plotted in the second panel. Two insights are obtained. The first is that, on average, switching the mode of receiving order 'by traditional approach' to 'by advance online approach' recduces volume of delayed jobs by 19. The second is that, on average, mean volume of delayed jobs decreases as one switch 'analyzing customer job order and determine due date/time to compelete job orders' from 'analyzing manually individual experienced based' to 'analyzing with shared database system'.

Subsequently interaction plots are created, the interaction plot is as shown in Figure 7. In this plot levels of Factor 'B' are indicated on the horizontal axis. The levels of Factor 'A' (refer legend in the top right hand corner of Figure 7) are indicated through connection of line segments. The pairs of line segments lying vertically above each other are parallel. This shows that, when using one perticualr level in Factor 'B', similar decrease in mean delayed jobs are experienced on changing level from 'A1' to 'A2' of Factor 'A'. This means that there is no interaction between Factors.

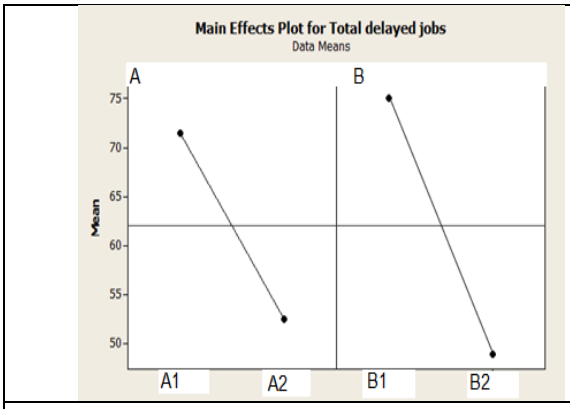

Figure 6 Main effects plot for total delayed jobs

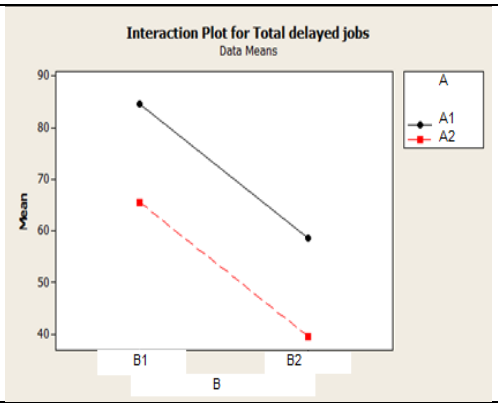

Figure 7 Interaction plot for total delayed jobs

After observing residual plots, it is decided to proceed to interpret, interaction between factors by two way ANOVA analysis. ANOVA results with interaction are shown in Figure 8. The ANOVA with interactions provides no evidence of interaction between Factor 'A' and Factor 'B'. This means that there is no evidence from the experiment that the effect on volume of delayed jobs of changing mode of Factor 'B' (Analyzing customer order and determine promise date/time to compelete received order) used depends on the type of Factor 'A' (Mode of receiving order) being used. In such case it is advice to do ANOVA with fit additive model . ANOVA results with fit additive model are shown in Figure 9.

Two-way ANOVA: Total delayed

Source	DF	SS	MS	F	P
A	1	722	722.0	32.09	0.005
B	1	1352	1352.0	60.09	0.001
Interaction	1	0	0.0	0.00	1.000
Error	4	90	22.5		
Total	7	2164			

S = 4.743 R-Sq = 95.84% R-Sq(adj) = 92.72%

Two-way ANOVA: Total delayed

Source	DF	SS	MS	F	P
A	1	722	722	40.11	0.001
B	1	1352	1352	75.11	0.000
Error	5	90	18		
Total	7	2164			

S = 4.243 R-Sq = 95.84% R-Sq(adj) = 94.18%

Figure 9 ANOVA results with interaction**Figure 10** ANOVA results with fit additive model

DOE and ANOVA provides strong evidence that the factors of interest – "Analyzing customer order and determine due date/time to compelete received order (factor B)" and "Mode of receiving order (factor A)" influence the response of interest, i.e volume of delayed jobs. If aim is to minimize response (i.e number of delayed jobs), combination of fixed set of levels for Factors A and B should be considerd. As improve phase the levels 'receive the customer using online advane approach (A2)' and 'analyz customer order and determine due date/time to compelete received order with shared database system (B2)' should be selected for improvement. This combination will lead to minimization of delayed job orders.

5.1.2. *Verification and documention of the improved process*

After applying improvements the process map is modified to be compatible with new changes.

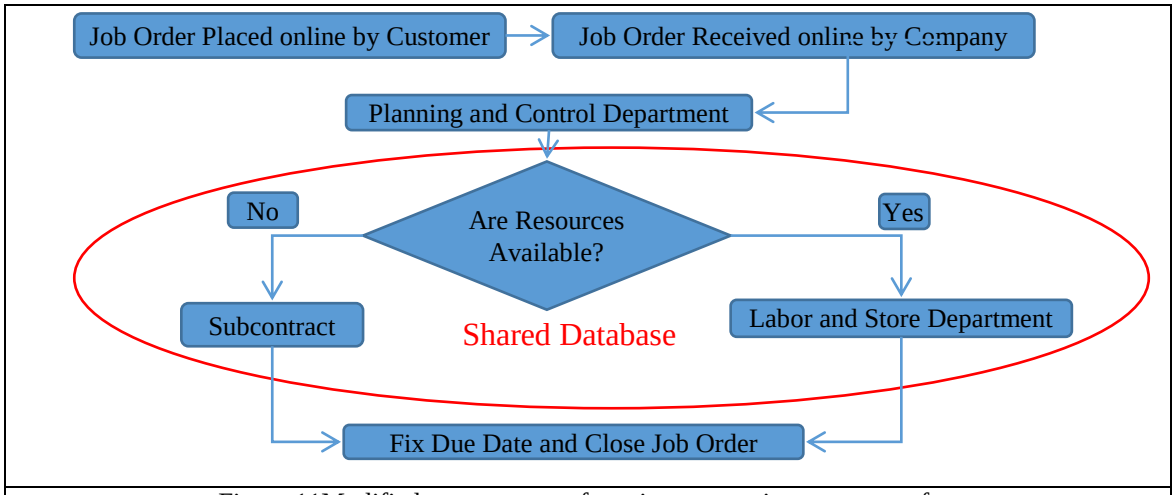

Figure 11Modified process map of service contracting company after

It is verified that sigma level before the improvements was 2.037. After applying the above improvements it is observed that there is drop in number of delayed jobs, and which leads to increase in sigma level for the service contracting company. The effects of applying the improvements are presented in Table 7.

Table 7 Situation before and after improvements

Description	Situation Before Improvements	Situation After Improvements
No. of Total Jobs	582	582
No. of Delayed Jobs	169	39
DPMO	290,378	67,869

At the end of improve phase, it is observed that the critical X's are: receiving order in traditional way and analyzing the requirements manually based on individual experience, and their effects are -19 and -26, respectively. The best combination is to have an an advance online job order reciept and a shared database between departments within the company. This combination will lead to 39 delayed jobs of the total number of jobs and increase the sigma level from 2.037 to 3.0 sigma. The increase in sigma level is almost 1 sigma.

5.2. Control Phase

The six sigma project is brought to closure through the control phase. While the project is coming to an end, this does not close the door on continuous improvement. This phase sets the tools in place to continually monitor the process. By monitoring the process data can be used to evaluate the performance and areas for improvement. The strategy of Poka Yoke is adopted for preventing errors in the processes. The purpose of Poka-Yoke is tomake it impossible for defects to pass unnoticed, corrects problems as soon as they are detected. The service contracting company to keep the job order process under stability and control, they should have a plan for corrective actions. The service company should share data (related to order profile and resource availability) online and keep improving. Train employees to use new technology to communicte and updates eachone who is envlved in the process of job order directly or indirectly.

6. CONCLUSION

For any service contracting company, customer satisfaction is highest goal. Due to very high number of job orders, a small error in process of estimating the jobs requirments result in high number of delayed job orders. These delayed job orders which plays a very important role in the customer satisfaction, even single unsatisfied customer leads to the big loss to company. What one can do is, identify the causes of delay and try to minimize number of job delayed.

Minimizing total number of delayed jobs, for the presented service contracting company, is achieved by implementing six sigma methodology. The main root causes for the delayed number of job orders are: use of traditional approaches for receiving orders and analyzing the requirements manually individual based witout co-ordination. The suggested improvements to be considered in order to increase the service quality for the company ar, use advance online approach to receiv orders and use a shared database between departments to avoid shortages in both labor and material and increase the accuracy of the promise due date.

Here in the paper as presented, six sigma methodology is applied for the service contracting company to increase the service quality level. The total number of delayed jobs decreased from 169 to 39 for a six month period. The sigma level increased from 2.037 up to 3.0 sigma for the total number of delayed jobs.Poka-Yoke strategy is adopted by the service contracting company with two main strategies: use features that inform the internal and external customer about his/her order status, and update the availability of labor & materials continuously through the shared database. These strategies will assure the service contracting company to keep process and performance stable and accurate.

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Biography

Ateekh-Ur-Rehman is a faculty member of the Industrial Engineering Department, College of Engineering affiliated with the King Saud University Riyadh. He earned B.E in Production Engineering from Marathwada University and M.Tech in Advance Production Systems from Barkatullah University Bhopal. He holds PhD in Industrial Engineering and Operation Research from Indian Institute of Technology Bombay, India. His areas of interest are reconfigurable manufacturing system, multi criteria decision analysis, decision support systems for production management, quality engineering and operations management, and supply chain management. He has published number of papers in major international journals.