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An application of Six Sigma DMAIC methodology in outsourcing management process improvement

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A B S T R A C T

Outsourcing is a common practice among the organizations and it is a major element in business strategy. It has recognized as an area of strategic importance. This article represents the application of the DMAIC Six Sigma approach to improve outsourcing management process with an emphasis to reduce delay of delivery time for a manufacturing company. The paper identifies each stage of the DMAIC cycle and the Six Sigma tools that were applied. The improvement project has been implemented in seven months.

1. Introduction

Outsourcing is a common practice among the organizations as well as a major element in business strategy (Kremic et al., 2006) and it has become an interesting area of strategic planning (Jennings, 1997; Cheshmberah, et al. 2011). Clearly, for outsourcing management, an efficient process is necessary and must be continuously monitored and improved in any organization. This paper describes the activities of definition, implementation and improvement of project based using Six Sigma technique. The study uses DMAIC methodology (an abbreviation for Define, Measure, Analyze, Improve and Control) to improve the process of outsourcing management in a medium-sized manufacturing organization. Six sigma is a systematic and data-driven approach and according to statistical terms, it means 3.4 defects per million opportunities (Kwak & Anbari, 2006; Ho et al., 2008). A Six Sigma defect is described as anything outside of customer specifications and a it provides an opportunity of the total quantity of chances for a defect. The objective of the Six Sigma methodology is the process improvement and variation reduction through the application of Six Sigma improvement projects. Table 1 shows details of the DMAIC methodology.

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Table 1
Key steps of DMAIC process (Kwak & Anbari, 2006)

steps	Major activities
Define	Define the requirements and expectations of the customer, the project boundaries, the process by mapping the business flow (such as SIPOC)
Measure	Measure the process to satisfy customer's needs, develop a data collection plan and collect and compare data to determine issues and shortfalls
Analyze	Analyze the causes of defects and sources of variation, determine the variations in the process and prioritize opportunities for future improvement
Improve	Improve the process to eliminate variations and develop creative alternatives and implement enhanced plan
Control	Control process variations to meet customer requirements, develop a strategy to monitor and control the improved process and implement the improvements of systems and structures

The methodology is believed to be introduced in a US firm, where first, a team at Motorola developed a process with four-phase "Definition'' ''Analysis'' ''Optimization'' and ''Control'' for improving the products quality. Based on this four-phase process, two methodologies of Six Sigma were developed: DMAIC (Define, Measure, Analysis, Improve, and Control) (Table 1), and DMADV (Define, Measure, Analysis, Design, and Verify).

The DMAIC process was developed to eliminate defects in production or service processes (Ho et al., 2008). The DMAIC cycle maintains many similarities with Deming's cycle ''Plan-Do-Check-Act'' (PDCA) and places more emphasis on integrating specific tools into each step of the method (Schroeder et al., 2008; Kumar et al., 2008).

2. Problem statement

In any organization, outsourcing management has its own processes and activities and this process may be varied in various organizations. Therefore, to improve outsourcing management process, the characteristics of each organization should be considered. In this case study, outsourcing management process was analyzed in a manufacturing company in the aerospace industry and several improvement opportunities were identified in various areas such as "product quality", "delivery time" and "products cost price". According to the importance of customer satisfaction and due to the high frequency of their complaints on delay time, reducing the delay of lead-time in the customer orders, were considered. After this decision, the improvement project team was formed and managing director of studied organization was chosen as the project administrator and the head of the project team. After the team formation, the project charter was developed and as covenant (agreement) between the project administrator and the project champion was signed.

This paper describes the methodology of the improvement project and its activities of definition and implementation. In addition to improvement of the outsourcing management process, practice in team working, enhancing creativity and the power of idea making and changing in managerial mental paradigms are other outcomes of this project implementation.

3. Definition phase

In this phase, objective(s) and scope of the project are defined and information of process and customer(s) are gathered. Activities of this phase are "titling the project", "problem statement", and "drawing CTQ tree. Moreover, the names of the champion, team members, supervisors and consultants, the project scope, the project objective, scheduling and Gantt chart, financial/non-financial benefits and outcomes, required resources, SIPOC diagram, and VOC table are other items of definition phase.

3.1. Project Description

Considering that great deal of operations of the company are outsourced to outside suppliers, an important source of delay is "long time" of outsourcing process. In practice, it is possible to divide the process into two sections, (1) the company and (2) the suppliers. Therefore, it is expected that through some improvements, less delivery time is achievable.

3.2. Business case

The objective of this improvement project is to lessen the delivery delay and to increase the customers' satisfaction.

3.3. Project goal

The primary objective of the project is to address delivery delay expressed in three sub-objectives: reducing the average time of contract negotiations up to 20%, reducing suppliers' delay up to 15% and lessening the average delivery time up to 20%.

3.4. Other expected results

Higher customers' satisfaction, increased capacity, selecting proper suppliers, and providing appropriate decision-making conditions are some of other expected results of the project.

3.5. Required financial resources

Based on the estimations, costs include training courses for suppliers, project team transportation for information gathering, and implementing workshops.

3.6. Project schedule

It was estimated that the project takes 6 months, and schedule was codified based on the activities of the 5 phases of DMAIC methodology through a Gantt chart.

3.7. Project structure

Due to the importance of senior manager's commitment, he undertook the role of "champion". In addition, to facilitate project implementation, the "production manager" was chosen as the "project manager" and was commissioned to choose the team members. After the formation of the project team, "quality manager", "financial manager" and a master black belt were chosen as "quality supervisor", "financial supervisor" and "the project consultant". Fig. 1 illustrates the project structure.

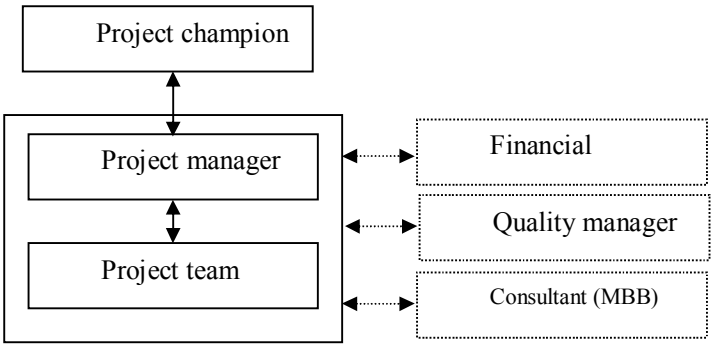

Fig. 1. Project structure

3.8. SIPOC Diagram

SIPOC is a general diagram of process and provides a general view of suppliers, inputs, processes, outputs and customers. This represents a flow diagram and is implemented to define and examine an operation from the supplier to the customer (Basu & Wright, 2003). SIPOC ensures that all project team members have a common perception of the process. Moreover, it helps the champion to see which scope that is being worked on. In fact, SIPOC is a tool for determining project scope. Table 2 illustrates the SIPOC of the outsourcing process.

Table 2
SIPOC diagram of the process

Suppliers	Inputs	Process	Outputs	Customers
		Receiving customer's order		
Customers	Orders	Contracting with the customer	Final products	Customers
		Dividing the order between the project		
Quality Dept. (QC office)	Blank forms of quality control		Supplier's qualitative performance records	Quality Dept. (quality records office)
Suppliers	Filled forms of quality control	Identifying, Evaluating and selecting the supplier(s)		
Quality Department (monitoring office)			Technical problems report	Engineering Dept.
Engineering Dept.	Technical documents (preliminary)	Signing the purchase contract		
Project managers	Suppliers' information			
				Project managers
Financial Dept.	Financial resources (cash)		Manufacturing technology	Suppliers
		Monitoring, tracking and control of supplier(s)		Engineering Dept.
Suppliers	Proposals	Delivering products to company' warehouse by the supplier(s)	Quality control reports and Alerts	Project managers
Commercial Dept.	Blank contract			
	The Rules and regulations			Senior manager
		Browsing commitments to the customers		Senior manager
Suppliers	Products (not inspected)	Receiving the products from the supplier(s), preparing & delivering to the customer(s)	Suppliers's financial performance records	Financial Dept.

3.9. Voice of the Customer analysis

Customer requirements should drive management systems development (and improvement). The purpose of specifications is to transmit the voice of the customers throughout the organization (Pyzdek, 2003). It is applied to clarify the customer's needs and understanding of the desired products or services. Table 3 shows the results of voice of the customers regarding the outsourcing process.

3.10. Drawing Critical to Quality (CTQs) tree

In Six Sigma, the customer Critical to Quality Factors (CTQ) play the key role to agree and to define critical quality factors as seen by customer. It is important that the customers' requirements are

understood when defining the CTQs (Basu & Wright, 2003). Figure 2 illustrates the CTQ tree of the outsourcing process. Considering that the senior manager has chosen CTQ of "delivery delay", it is detailed in a separate tree (Fig. 3). In addition, Table 4 shows the CTQs definitions, which are associated with defects definitions, and How to calculate the defect.

Table 3
The part of Voice of the Customer analysis

Customer	VOC	What	When	who	Where	How	Why
Customer 1	High price	Some of the orders	always	---	In all cases	In comparison to similar foreign prices and other competitors	---
	High number of non-conforming parts	Some of the orders	sometimes	---	In all cases	Nonconformity with the customer's requirements and standards (Leading to rework or scrap)	---
	Fulfilling the commitments with delay	Many of the orders	always	---	In all cases	delay in delivery after due date	---
Quality Dept.	Generally blank forms are not filled out completely	Control guidelines	always	Suppliers and observers	In almost all cases	Often are incompletely presented	They were not well justified or do have insufficient importance
Project managers	FPC and other process diagrams are partially delivered or not delivered at all	FPC and other process diagrams	always	suppliers	In almost all cases	Often are incompletely presented or not presented at all	They were not well justified or do have insufficient importance

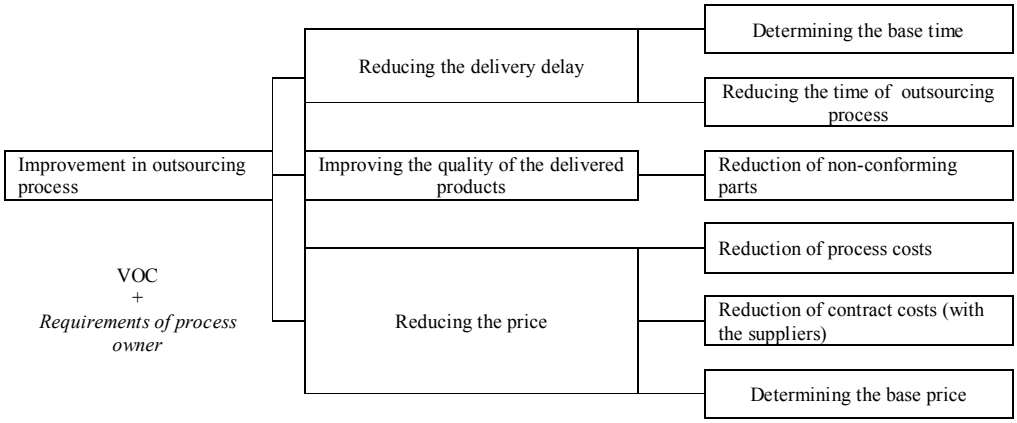

Fig. 2. CTQ tree of the process

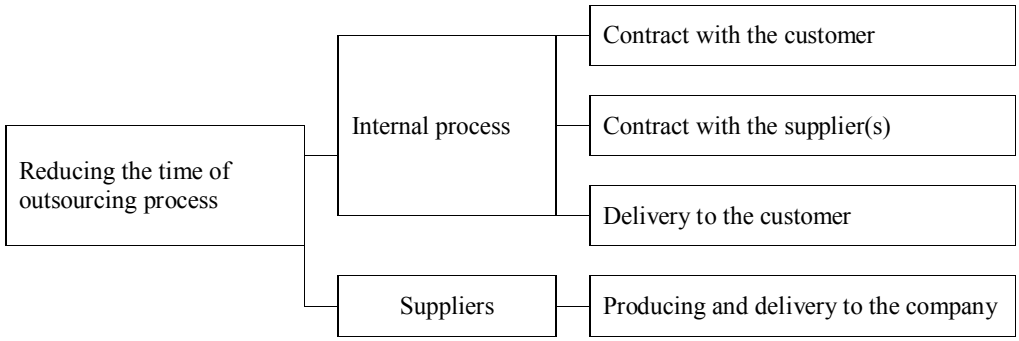

Fig. 3. Detailed CTQ of reducing the time of outsourcing process

Table 4
The CTQs definitions, related defects definitions, and How to calculate the defect

Process requirements (CTQ)	definition of the defect	How to calculate the defect
Reduction of the average time of contracting	Up to 30 days	30 minus real time of contracting
Reduction of supplier delay	Difference between "in the contract" and "happened" delivery time	"in the contract" delivery time minus "happened" delivery time
Reduction of the average time of delivery to the customer	Up to 30 days	30 minus real time of delivery to the customer

4. Measure Phase

The primary objective of this phase is to specify the place and source of the problem by providing a realistic understanding of the problem and the process. Such insight helps us to limit the range of potential causes. The key elements of this phase include establishing a plan for data collection, analyzing variations and determining the level of Sigma performance (Basu & Wright, 2003) (Pyzdek, 2003). Different steps of measure phase are as follows:

Table 5
FMEA table for the process

requirements of the process	Modes of potential failure	Potential impacts of failure	Strength (S)	Causes of potential failure	Occurrence (O)	Current controls of process	Diagnosis (D)	RPN
On-time delivery	Delay in delivery time	Increased price	5	Weak assessment of staffs' capacity	10	Assignment sheets, project control forms	6	420
		Customer dissatisfaction	7	Failing to assess suppliers' capacity	10	Project manager's point of view, evaluating suppliers	6	420
				Technical weakness of the suppliers	10	Project manager's point of view, evaluating suppliers	6	420
		Reduction of capacity	6	Insufficient identified suppliers	8	Suppliers' database	7	392
				Lack of technical feasibility study by suppliers	10	Request for quotation (RFQ)	7	490
		Disruption in the company planning	6	Lack of capacity feasibility study by suppliers	10	Project manager's point of view	9	630
				Long geographical distance to the suppliers	9	Project control, Project manager's point of view	2	126
		Delay penalty (by customers)	3	Not having suitable environment for accurate measurement	2	Project manager's point of view	10	140
				Difficulty in providing accurate measurement and special control tools	8	Quality Dept.	9	504
		Reduction in sales	6	Lake of a base time	9	Project manager's point of view	10	630

Step 1- Conducting FMEA for the CTQ under study (outsourcing process time, which is divided into 3 independent CTQs): To calculate risk priority number for potential defect causes in order to facilitate the analysis phase and to have more concentration on potential causes with maximum RPN. In fact, using FMEA, data gathering activities focus on more critical input and process variables. For example, table 5 lists part of FMEA table about delay time.

Step 2- Defining sample for the study domain and calculating sigma level: considering that sale contracts generally include several "order rows"; Each "order row" contains specific lot size and order delivery time (for example, a sale contract contains over 300 "order row"). there are only a limited number of main contracts of sale over a period of 3 years. Therefore, a sale contract was chosen by champion and the project team. This contract was constituted of 177 separate "order row" (Table 6).

Step 3- calculating sigma level of the process: this index was calculated as follows in table 6. Each "order row" has chosen as "failure unit".

Table 6
Calculation of sigma levels of three sub-processes

Calculation of sigma level of "contracting sub-process"	CTQ1	The number of potential failure opportunities	177 × 100 = 17700
		Total number of actual failure opportunities	17700
		Calculation of DPO	1
		Calculation of DPMO	1,000,000
		Calculation of sigma level (by standard tables)	0.0
Calculation of sigma level of "supply sub-process"	CTQ2	The number of potential failure opportunities	59 × 100 = 5900
		Total number of actual failure opportunities	2630
		Calculation of DPO	0.438333
		Calculation of DPMO	438333
		Calculation of sigma level (by standard tables)	1.6552
Calculation of sigma level of "delivery sub-process"	CTQ3	The number of potential failure opportunities	17 × 100 = 1700
		Total number of actual failure opportunities	1112
		Calculation of DPO	0.654117
		Calculation of DPMO	654117
		Calculation of sigma level (by standard tables)	1.12

Step 4- Detailed drawing of the process based on breaking up to the three sub-processes: in order to have better chance of analyzing and according to the determined Sigma level for each sub-process, we need to plot the process in more details.

Step 5- Determining bottlenecks: it is essential in this section to define time bottlenecks discuss more in analysis phase. Considering the three separate CTQs (contracting sub-process, supply sub-process, and delivery sub process), it was decided to conduct separate sampling for each CTQ after gathering information about the sample wholesaler contract.

Moreover, according to the consultant (master black belt) and the team's decision 20 samples adopted for each CTQ. This was because there is no limitation to get more than 20 samples for CTQ1 (contracting) and CTQ2 (supply), while only 20 articles of delivery CTQ had been fulfilled. In other words, 20 random samples for CTQ1 and CTQ2 and all fulfilled delivery cases were chosen and time bottlenecks were determined based on the average period of samples.

5. Analysis Phase

The problem is investigated more thoroughly in this phase especially by studying time bottlenecks by utilizing proper tools, root causes of the problem are identified. In fact, having root causes identified, the conditions for presenting the appropriate solutions and preventing causes of the problem in the next phase (Improvement phase) are provided. Followings are different steps of the analysis phase:

Step 1- Holding brain storm meetings and utilizing cause and effect analysis tools (fish bone) and Pareto analysis for CTQ1 (contracting), and CTQ3 (delivery); because these two sub-processes are completely in the functional area of the company.

Step 2- Depicting flow-chart and value analyzing of each of the three sub-processes to have better distinction between "value added" and "non-value added" operations.

Step 3- Interviewing suppliers: four suppliers were chosen; of which two suppliers had the highest delivery delay and two ones had the lowest. This tool was particularly used for supply sub-process. Finally, conducting the mentioned steps, lead to determining the root causes of delay in all 3 sub-processes of contracting, supply and delivery. Table 7 lists the identified causes.

Table 7
List of the identified root causes

No.	Title	No.	Title
1	Weak assessment of staffs' capacity	18	Inadequate training of the project managers and QC inspectors
2	Failing to assess suppliers' capacity	19	Failing to conduct proper heat treatment on the part of suppliers
3	Technical weakness of the contractors	20	improper working environment for QC inspectors and project managers and improper measurement environment
4	Insufficient identified contractors	21	Ineffective supplier evaluation system
5	Lack of technical feasibility study on the part of contractors	22	Incomplete quality control instructions
6	Lack of capacity feasibility study on the part of contractors	23	Lack of QC inspectors evaluation system
7	Geographical distance to the contractors	24	Lake of project managers evaluation system
8	Not having suitable environment for accurate measurement	25	Inaccurate calibration system
9	Difficulty in providing special control tools	26	Not taking quality standards into consideration (requirements of contracts) by the project managers and producers
10	Lake of a base time	27	Lake of statistical quality control system
11	Administrative bureaucracy (complexity of the process)	28	Improper packaging and transportation
12	Poor contractor selection	29	Failing to define the exact specifications of product, design and preparation of technical documents
13	Lack of documented process procedure	30	Low quality raw materials used by the suppliers
14	Inadequate staff expertise	31	Poor performance of QC inspectors
15	Failing to provide technical maps and documents for the contractors in time	32	Unmotivated QC inspectors
16	Quality control system inefficiency (units' interaction)		
17	Evaluating staffs performance based on volume of the production rather that quality of products	33	Not considering waiting time for quality control in production planning by project managers

6. Improvement Phase

In this phase, appropriate and effective solutions for the identified root causes in the previous phase are proposed, and then evaluated, selected and finally implemented. Overall, improvement phase can be divided to three main parts of identifying solutions, prioritizing solutions and executing them. Actually, Budget and time constraints and problem-solving capacity of the organization need to be taken into consideration. Thus, necessarily first the more important causes must be taken into account which are the Pareto analysis. By holding brain storm meetings and investigating possible solutions for each root, a list of solutions were obtained (table 8); it got clear that the main part of the solutions were common . Therefore, along with listing the mentioned solutions, they were prioritized in table 10. Following steps were taken in improvement phase:

1. Listing all possible solutions for the main identified roots
2. Refining and prioritizing the list of solutions based on determined criteria
3. Initial planning and appointing implementation teams
4. Activities and resources planning
5. Time scheduling (Gantt Chart preparation)
6. Assigning tasks to the teams and defining action plan
7. Training the teams
8. Implementing solutions (activities) by the teams
9. Results evaluation
10. Troubleshooting and supplementary measures

Table 8
The list of solutions

No.	Solution
1	Revising suppliers' identifying, evaluating and choosing system
2	Preparing instructions for inquiring basic price and basic delivery time
3	Improving contracting process
4	Establishing suppliers information database
5	Improving QC procedures
6	Improving evaluation system
7	Developing the comprehensive project management system
8	Designing operational information database for all activities
9	Improving employees' motivation system
10	Quality policy review
11	Upgrading the existing suppliers
12	Ranking quality experts
13	Needs assessment and providing calibration system for inspection equipment
14	providing jobs standards
15	Codifying and executing training programs for the existing procedures
16	Strategy reconsideration
17	Standardization (localization) production technology
18	Establishing participatory management system

Table 9
Criteria for prioritizing the solutions

No.	Title
A	The manager's priority
B	Feasibility of project at the present time
C	Feasibility based on authorities and capabilities of project team
D	Coordination with Six Sigma project
E	Possibility of developing methods in other modules
F	Profitability
G	Effectiveness

Each criteria is scored between 0 and 5

Table 10
High priority improvements

No.	Title
1	Improving outsourcing process
2	Revising suppliers' identifying, evaluating and choosing system
3	Improving contracting format and process
4	improving suppliers information database
5	Improving QC procedures
6	Revising data flow and designing operational information database
7	Upgrading the existing suppliers
8	Developing the comprehensive project management system

7. Control Phase

In this phase, improvement project team makes sure that the problem has been solved (removal or neutralization of the main roots), solutions have been executed and the new proposed procedures have been completely established. In other words, control phase is the monitoring and maintaining phase. The followings measures were taken in this phase:

Step 1: Supervise execution of the solutions and making feedbacks,

Step 2: Document the whole procedure of defining and implementing of the improvement project,

Step 3: Document the experiences and the findings,

Step 4: Document conducted solution as standard procedures,

Step 5: Re-caluclate the Sigma level (sigma level of the contracting sub-process 0.7; supply sub-process 1.9; delivery sub-process 1.4),

Step 6: Investigat and discussion for defining the next improvement project and targeted Sigma level.

8. Conclusion

In conclusion, the improvement project brought the firm, the employer, the executer, and the executive team valuable lessons, including:

- At the beginning and before initiating the project, there were many doubts on whether it is a correct approach to conduct the project using Six Sigma and DMAIC methodology, or by using simpler methods like the seven-step problem solving traditional approach, desired results would be achieved in a better, easier and faster way.
- Deeper investigations made it clear to the team that DMAIC methodology is a structured problem solving methodology with a meaningful and coherent classification, leading to the achievement to desired results and effective problem solving. On the other hand, using Six-Sigma tools and techniques, should be highly selective and proportional to the conditions of the problem.
- Commitment of senior managers to definition and implementation of an improvement project, taking the position of employer and delegation of authority to a competent and influential person as the project manager, are of necessities and prerequisites to meet the objectives of an improvement project.

- It is necessary to make sure of the correct definition of any improvement project before execution.
- However, the logic of DMAIC methodology demands that project team reconsider definition phase upon any ambiguity in definition, even in measurement or analysis phases.
- Before applying different methods of problem solving, it is needed to apply various methods of problem finding to determine improvement opportunities correctly. Techniques such as SPC, periodical/annual evaluation, organizational troubleshooting such as BSC, EFQM are some proper techniques of problem finding.
- The project team definitely needs to take advantage of opinions and experiences of at least a well-experienced master black belt level consultant.
- To have better results in improvement projects, we can proceed to develop a motivation system (regulations) at the organizational level.

This project only considered the CTQ of delivery delay. First, it is possible to set goals for higher Sigma level for this CTQ, other improvement projects can be defined. Second, other important issues like quality, necessity of reducing non-conforming lots and reducing the prices can be taken into consideration to continue the outsourcing process improvement and to define the future improvement projects.

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