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Analysis of Six Sigma in the Aerospace Industry

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***Abstract*—**This paper subsidizes to the discussion of Six Sigma in the Aerospace Industry. The main aim of this report is to study the literature review of Six Sigma emphasizing on the aerospace industry. The implementation of Six Sigma stages are studied and how the improvement cycle 'Define, Measure, Analyze, Improve and Control cycle' (DMAIC) and the design process is 'Define, Measure, Analyze, Design and Verify cycle' (DMADV) is used. The focus is also done by studying how the implementation of Six Sigma on an aerospace company has brought a positive effect to the company.

***Keywords*—**Six Sigma, DMAIC, DMADV, aerospace.

I. Introduction

THE organizations that are available presently in the world are constantly trying to sustain the expenditure of quality as low, reducing the amount of waste and also increase the pace of manufacturing in order to accomplish and also maintain the competition in the market. In the earlier years, there was very little competition between the commodities and services as there was minimum pressure for the continuous work at enhancing the quality. In this case, one can look at the industry of aerospace which is a multi-billion dollar industry. Reference [1] claims that the air traffic is annually increased which is approximated to be about seven per cent involving the years 1995 and 2000 whereas involving the years 2000 and 2010 the percentage will almost be 35 per cent as the world population will increase and also there will be introduction of many airlines. Reference [2] states the aviation market of the Asian sector is projected to be the highest growth sector in the commercial aviation which accounts in almost 28 per cent of the world population by the year 2010. In order to meet these percentages, the Asia Pacific region airlines are going through widespread development of fleet as well as introducing effective renewal programs.

The economic life of an aircraft is to be about 25 years and for the aircraft to be in an operative condition there should be conduction of customary checks as well as maintenance are needed to be conducted. In addition to, this refurbishment and overhauling work engages in the removal of parts as well as components from the aeroplane such as the turbine blades of the engine and the landing gear. The refurbishment actions are specified by the manufacturers such as Airbus and Boeing; also, the manufacturers specify when the refurbishment should be conducted. Reference [3] provides on every 40000 to 45000 hours of time of flight the Boeing 737 aircraft is required to conduct the aircrafts maintenance.

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Currently, the aircrafts are kept for longer time than the earlier times. As there will be requirement of more refurbishment as well as maintenance work should be conducted on the aircrafts as they are getting old there is an importance for the aerospace industry manufacturers to design aircrafts as well as provide manuals in such a way that it is easier to overhaul the components and conduct the repairing that is needed to be done without causing any damage to the other connected components of the aircraft. This has led to a competition in the aerospace industry in order to satisfy the aerospace airline companies for better repairs of aircrafts as well as providing safety to the passengers on board and this is also one of the keen aspects of business activity conducted by the aerospace industries. The aerospace airline companies looks for early delivery dates of the aircraft as well as they need services of higher standard from the aerospace manufacturing companies. The aerospace airlines prefer the aerospace companies which satisfies their needs. There is an existence in the delay on the delivery of aircrafts from aerospace manufacturing companies. This delay increases the total overall costs of the aerospace manufacturing companies. This delay happens for a reason and the aerospace manufacturing companies want their customers to be happy with the aircrafts ordered which includes by providing them with a good quality aircraft in a long-term activity and also providing safety to the passengers. The application as well as the importance of the principles of Six Sigma is considered at this stage [4].

Over the years, elevated safety principles are pursued by the aerospace industry to improve the composite products in order to develop the processes involved [5]. Furthermore, the developments of the method in order to shape up intricate products to the great safety standards are leaded by the aerospace industries. The utilization of the tools that are currently being practiced by the modern enterprises of business such as TQM and Six Sigma have currently been tested as well as espoused predominantly in the aerospace industry [6]. There are plenty of case studies that have been provided on the implementation of Six Sigma principles in the aerospace industries. Reference [7] discusses which actually provides an ultimate difficulty that ascends in ABC Aerospace in the attainment of a very high level stability levels in the process of heat treating.

II. Literature Review

A. Concept of Quality

Quality is a substantial division of amenities and production in keeping the consumers contented. There is an existence of various explanations and challenging views of quality by numerous people and the co-operative section in the

descriptions of business is that the product or service quality denotes to the degree of opinion which meets the consumer's anticipations of the product or service.

Reference [8] defines quality is that the agreement to the necessities or the qualifications as well as to also be recommended that the management of quality is done effectively and need to be quantified. Reference [9] gives an explanation that once the essential features are fulfilled by the necessities than the degree of quality has reached. In addition to, [10] suggests quality with numerous personalities having their own individual view.

From the above explanations, the quality can be considered in the consideration of features of the product or amenity capability for the satisfaction of a particular need that avoids any sorts of error. It is also said in the previous lines that there are valid requirements which are defined as conditions so that there is a confirmation that they meet the needs of the customers, the products are measurable as well as achievable to a high quality. Reference [11] considers quality as a 'magic bullet' which actually provides the cost to be lower, customer service to be higher, manufacture of enhanced products as well as attaining higher margins; the 'quality is in the eyes of the beholder' this expression by him meant that to follow what the customer needs. By reference [12] quality is explained on the basis of the employee's enablement. He also adds that the key purpose of a firm is to enable itself to the workforces as well as customers as attractive while the profits are made for the investors.

B. Six Sigma

In the mid-1980s, the methodology of Six Sigma was adopted first by Motorola [13]. As Motorola confronted strong competition from Japanese electronics industry, this led Motorola to create a strong development in the quality levels. A Six Sigma is focused in the manufacturing process, quality of the product and also forms a cultural change in the organization by the conduction of certain enhancement [14]. Motorola dedicated the program of Six Sigma in all the actions within a procedure which led them to have huge benefits.

Reference [15] discusses that Six Sigma methodology was later followed by Samsung, IBM, American Express, Sony, Ford, Allied Signal, Honda and General Electric in the year 1995 which led to the enhancement of net revenues and also the margin of operation. Moreover, the Six Sigma has actually become the supreme noticeable trend in the management of quality.

Six Sigma can be implemented and is clearly discussed in the sections below:

1. Steps to Improve

There is presence of many models of enhancement for the improvement in process; moreover, these steps are based on the 'Plan, Do, Study and Act cycle' [16]. Reference [15] discusses that there is an enhancement cycle for process and design process of five-phase that is widely held in the organizations of Six Sigma. The improvement cycle is 'Define, Measure, Analyze, Improve and Control cycle' (DMAIC) and the design process is 'Define, Measure, Analyze, Design and Verify cycle' (DMADV).

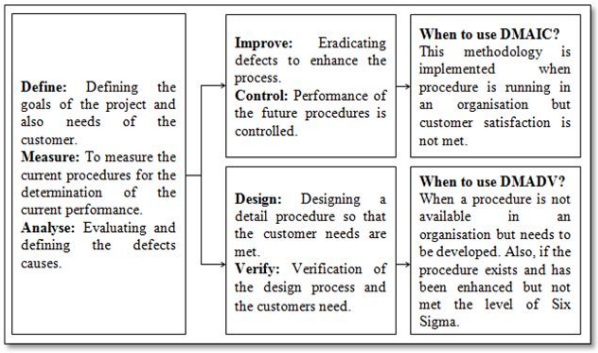

Fig. 1 Differences between DMAIC and DMADV [17]

2. Roles of Staff

For the Six Sigma to be an effective action there is a need of precise important roles that is needed to be applied by the organizations staff members. By the help of maintenance, resources and also tough leadership the high-ranking management is eventually accountable for the project to be successful. The development of vision, tactic and also the alterations that are needed in an organization is the key role played by the chief executive officer (CEO) and the other staff members of the organization have specific roles. Reference [18] provides details on specific roles in an organization which are discussed below.

a) Champions: The term 'champions' is given to the senior managers, they are actually the project supporters and they are also accountable for the success efforts of Six Sigma. These senior managers encourage and lead the organization of Six Sigma projects as they are completely qualified leaders of business.
b) Master Black Belts (MBBs): This term is used for the trainers as well as consultants as they are the ones accountable in the organization for the Six Sigma strategy to be applied, training to be conducted, mentoring and also obtaining the results.
c) Black Belts (BBs): This term is used to the ones that have the main effective part in the organization as full time Six Sigma players. The 'BBs' are specialists in Six Sigma as they are completely trained and also lead the teams of the organization for enhancement.
d) Green Belts (GBs): The 'GBs' are controlled by 'BBs' in an organization to work on the projects of Six Sigma.

3. Training Investment

Reference [15] discusses that training is the main element in order to attain victory in Six Sigma. Reference [19] provides with the complete training program of General Electric which they have designed for the roles of the staff. This training program developed by General Electric stretches towards all the staff members of the organization as the program includes skills of leadership, measurement, enhancement and

systematic tools, planning and implementation skills. The details are shown below for the training programs that are applied by General Electric.

a) Champions: The staff members involved here has a week training associated to Six Sigma improvement, leadership and also the plan for implementation.
b) Master Black Belts (MBBs): The staff members here are accountable for the training of all 'BBs' and 'GBs'.
c) Black Belts (BBs): The staff members here spend around four to five weeks in order to obtain highly quantitative and intensive training corresponding to the DMAIC or DMADV cycles.
d) Green Belts (GBs): The staff members here are given training for about six to ten days focusing on software's relating to statistics, new and enhancement tools and also on the project management skills.

Fig. 2 The stages of Six Sigma [18]

C. Critical Success Factors of Six Sigma

Reference [20] discuss in their paper that there is in need of resilient practical support with the resources required that is delivered by the management of the top level. There is also in need of approval as well as enactment of the basic disciplines of Six Sigma's by the staff members. Also, there should be a relation between the innovative and substructure accomplishments. Reference [19] says that there should be complete obligation as well as support from the management, there should be training given to the staff members so that they perform the Six Sigma procedures without any flaws that is familiarizing all the tools and techniques of Six Sigma, the communication must be well enough so that Six Sigma can succeed, moreover, the firm must focus on the results that are obtained and also on the customer's needs. These are the critical success factors for Six Sigma that should be considered by the firm.

D. Six Sigma in the Aerospace Industry

Six Sigma is used widely in the aerospace companies for the enhancement of design, business, supply chain procedures and also manufacturing [21]. Reference [22] says that the aerospace company Lockheed Martin established a methodology called LM-21 which represents Lockheed Martin in the 21st Century. The main aim of this methodology is to deliver the finest system for the attainment of superiority to the customers, staff members as well as shareholders. For the achievement of this aim, Six Sigma was espoused as an organizational philosophy.

Reference [23] discusses in his paper, the program of Boeing 777 had a fault as the re-circulating air fans were precluded during its testing on the assembly line. The data gathered from this program concluded that there is in need of replacement, therefore this increases the overall cost and also needs further testing. The professionals from the various departments of the company were integrated to a team for investigation and the core cause was found to be foreign object debris. The parts that were designed and intended to avert debris became debris themselves such as the caps of the ductwork and the plastic sheeting. The process was altered by the professionals by the help of Six Sigma and the problem was deciphered.

III. Case Study of Six Sigma

Reference [24] gives detail about a machining company possessed by a small family which grants machining services to the aerospace industry actually wanted to reduce the cost of manufacturing by the reduction of cycle time of machining of a particular product. The company exposed themselves to Six Sigma and shifts in theory in the procedures are required to take place. The main Project Engineer decided to make use of DMAIC enhancement procedure in order to reduce the time of cycle. Each of the DMAIC phases are considered separately and emphasis was done on each of them.

a) Define: Currently the cycle time was surplus in 1200 seconds having a standard deviation of 31 seconds. It was decided by the engineer to set a target of 50 per cent to reduce the cycle time without the negative affect that will cause any sorts of variation; also, a sigma level of minimum three is set. There were several risks that were taken in consideration like reduction in overtime, reduced time for assessment and also a quicker pace for business; a process map was also developed.
b) Measure: Input, process and output are the three metrics that were classified, from the three metrics there were nine key metrics that were acknowledged. The operational descriptions were clearly noted and a fresh collection of data technique was put in a certain position. An analysis of Gauge Reproducibility and Repeatability was conducted on the new system of measurement which resulted in less than five per cent in the discrepancy of study. The data gathered was investigated for stability and also illustrated no presence of special cause variation. Moreover, the sigma value was clearly calculated for the procedure and the result was a large negative value.
c) Analyze: The data gathered in the measure phase, the proficiency of the team member and also the statistical investigation, four considerable 'x' factors were authenticated as basis causes for a longer phase time. Furthermore, the data resulted in a prospective of over forty per cent improvement.
d) Improve: There were prospective elucidations that were produced by the solution generation practices and also models of Lean. The elucidations were later positioned

and presented to the organization and then later piloted. The methods of statistical validation were utilized to demonstrate efficacy of the particular solutions. In addition to, the control charts represented the stability of the new procedure while descriptive statistics illustrated a sigma value in excess of five. Also, a reduction of twenty per cent was resulted in the number of steps of the procedure.

e) Control: The old documents were updated and a new document was developed along with a new procedure map. As part of the solution implementation, training plans were developed as well as implemented. The potential difficulties were identified into three categories that are techniques, environment and human factors. The control plans were put in place in order to supervise the hazards. Later, the lessons obtained were outlined and the outcomes were calculated.

TABLE I
ORIGINAL TIME AGAINST IMPROVEMENT TIME [24]

Description	Original	New
Average Cycle Time (seconds)	1245	670
Standard Deviation (seconds)	31	5.5
Percentage Improvement (%)	N/A	46

As can be seen from Table I, there has been an enhancement in the process after the implication of Six Sigma with the help of DMAIC tool. There has been an improvement of 46 per cent on the overall procedure which have actually benefitted the company in various ways as the cycle time was reduced and the overall cost has reduced further.

IV. CONCLUSION

In this paper, Six Sigma has been clearly outlined by focusing in the aerospace industry. The tools of each of the Six Sigma were clearly provided thus giving a broad idea to the reader. Moreover, it can be seen that in order to manage the quality management there is in need of Six Sigma which enhances the process and solves problem of the industry. Furthermore, the implementation and expansion Six Sigma techniques are being conducted widely in the aerospace industry from the last couple of years. As it allows the industries to know the shortcomings and also work on the shortcomings for a better development. As seen from the case study provided, the firm has benefitted by the implementation of Six Sigma by the reduction on unnecessary costs and time. Also, the process of how the aerospace industry implemented the Six Sigma was also clearly outlined.

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