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Affect of Six Sigma Methdology on Reliability and Quality of Product

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***Abstract*—** Six Sigma at various esteemed organizations merely means a calculation of excellence that strives for near perfection. Six Sigma is a restricted, data-driven move toward methodology for eliminating defects in any process – from developed to transactional and from manufactured goods to service. The statistical representation of Six Sigma describes quantitatively of how a procedure is performed. To attain Six Sigma, a process must not produce more than 3.4 defects per million opportunities. A Six Sigma defect is distinct, no matter at which peripheral of customer stipulation it occurs. A Six Sigma prospect is entire extent of probability for a defect. Six Sigma calculator can be used to design process sigma. Following paper works on different approaches of Six Sigma such as Lean Six Sigma, how it affects the overall customer experience, work and effort when put together in a process. It studies of how Lean and Six Sigma supplement each other and their use at different levels of organization. It focuses on how use of six sigma approach affects reliability; different reliability metrics on which reliability has been measured upon in past and changes which six sigma has induced in. Its overall effect on the working of an organization process and number of failures faced when it is implemented thoroughly.

***Keywords*—** Six sigma, Lean Six Sigma, Reliability metrics

I. INTRODUCTION

Six-sigma is treated as a course that can advance services or products progressively in order to achieve high service worth, economical costs and condensed deliverance times, heading to the satisfaction of customers[4]. Six Sigma Methodology gives out a very stout set of tools that can be implemented on a business problem to find an appropriate fix. [5] Service quality is an unswervingly a sheer important priority for companies that wish to extricate their services in an immensely cutthroat and often relentless domain. In industrialized nations services have become the swaying sector of the economy, also at the same time; products which are made available are supplementary with exhaustive understanding of customer needs. Voice of customer is the star focus of Six Sigma; by listening to the needs of process owner results in advancement to the process [13]. Six Sigma basically require a progression to be in place and operative. It is being argued that that Six Sigma is simply a repackaging of long-established quality management which is subject to the margins and criticism of quality programs (Dahlgaard and Dahlgaard-Park, 2006). Six Sigma at numerous organizations simply paths or routes as a measure or basically, a gauge of quality that strives to achieve near perfection[4]. It is a strictly controlled, data-driven line of attack and tactic for abolishing or rather way to get rid of defects. To attain Six Sigma; a process ought not to create more than 3.4 defects per million opportunities.[1] A Six Sigma defect is described as all or anything that lies in outer space from customer specifications. A Six Sigma prospect is subsequently the total quantity of chances for a defect [3].

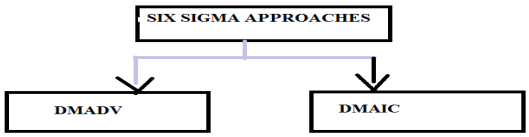

Figure-1: Different approaches of Six Sigma

A. *DMAIC*

- ***D****efine* the system; it involves understanding say of the customer their necessities, the project goals with their concerns and conditions, proper specifications, with particularization of each and every detail [2].
- ***M****easure* key evaluates the aspects of the current process and amass relevant data squarely establishing a clear and concise performance capability baseline for the basis for improvement and advancement. Identify the disparity between ongoing and afoot performance with the condign performance.
- ***A****nalyze* the data to delve and authenticate cause-and-effect relationships. Clinch what the relationships are, and effort to guard that all factors have been considered. Kick around the source cause of the defect beneath exploration. Catalog and formulate the abeyant causes of the given problem
- ***I****mprove* or optimize the current process spot, examine and apply a way out to the crisis based upon data scrutiny using techniques such as mistake proofing. Lie down and put into a solution to the problem; to a certain extent or entirety. Based on PDCA

consequences, endeavor to foresee every preventable risk coupled with the enhancement.

- ***C****ontrol* the potential state progression to make certain that any disparity from the target result is rectified before they consequence in defects . A Control chart can be effective throughout the Control stage to levy the stability of the improvements in workplaces, and assist continuously in monitoring the process. as in figure

Figure 2: DMAIC STEPS

B. LEAN SIX SIGMA

Lean Six Sigma facilitates the formation of high quality, free of defect product and services each and every stage of customer experience. It has major benefits that it is implemented using a smaller amount capital, work and attempt. Lean and Six Sigma supplement each other.

Lean is a method for achieving continuous improvement (*kaizen*) in organizational performance through elimination of waste from the total organizational process, but it cannot continually deliver improved process capability and stability. [9]

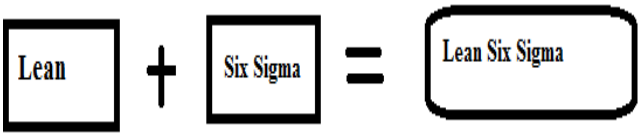

Figure 4: Lean Six Sigma

A Lean Culture (also known as Lean Management) is the groundwork of Lean process enhancement. Lean Culture strives for continuous improvement. It is a amalgamation of defining customer assessment, bring into line everything to a common purpose, and developing employees.

Lean categorizes each and every movement that we do into three types:

- **Value Add** – These are the behavior that a customer would be eager to disburse for; these basically, assist to create the final form or principle of the finished piece of writing.
- **Non Value-Add, but essential** – These are the things that are required to be finished, but that won't carry any worth to the completed article.
- **Waste** – These are the events that transport no importance to the article and are consequently are unnecessary.

Figure 3: DMAIC Approach

Benefits

- Cost reduction
- Shorter cycle times
- Improved customer service
- Greater employee productivity
- Increased profit margins

The base of lean methodology has its foundation on the Toyota Production Systems **(TPS);** whose three key features are *1)* Cost diminution from beginning to end by waste abolition *2)* Continuous improvement (kaizen) of procedure *3)* Employee association.

Lean Six Sigma extends a sagacity of possession and responsibility for company employees. This amplifies their efficiency at present results for at all enhancement project they are drawn in. This benefit increases the chances of continued success of one's business.

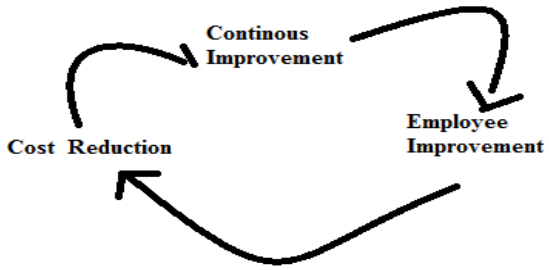

Figure 5: Lean Six Sigma Process

Matrices of judgment of Lean Six Sigma [9]:

Time Matrices

- Lead time
- Processing time
- Response (wait) time

Cost Matrices

- Cost per transaction
- Cost savings
- Cost avoidance
- Labor savings

B. DMADV

Define design goals that are dependable on customer demands and the venture strategy in context to accountability and possessions for unravelling the problem. Identify reckonable goals from the perception of both the organization and customer.[8]

***M**easure* and recognize CTQs (characteristics that are **C**ritical **to Q**uality), Calculate product competence, manufacture process potential, and compute threats.

***A**nalyze* produce or procedure performance through an assortment of statistical and basic QC tools. Develop design substitutes, recognize the finest amalgamation of requirements to make available value within constraints, develop abstract designs, evaluate, select the best works and develop the best available design.

***D**esign* involves identifying critical process parameters conducting failure analysis and formatting the potential risks; capability analysis is conducted to determine design stoutness and statistical scrutiny is used to institute forbearance for precarious parameters.

Verify step slots in the product testing from beginning to end using pilot tests that reveal the worth of the product as well as its production inclination [9]. Pilot tests are used as a measure from authenticating the niceties for alteration to bursting production over and above the accomplishment of the control measures.

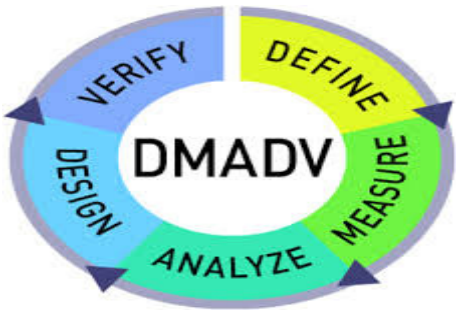

Figure 6: DMADV Approach

D. FAILURE

A failure[4] tally to an incidence where the outfitted activities of a line up digress from the necessities. A failure is set off only in action and as such it is dynamic in nature. It is dissimilar from a fault even though both concepts are associated.

-A fault or a "bug" is a curriculum failing, which prompt a failure when such program is carried out under explicit prepared conditions.

E. Different Types of Failure [2]

- **Numerical Failure** – This occurs when a bad result gets calculated.
- **Propagated Numerical Failure** – This occurs when a dire or bad result is being used in other calculations.
- **Control Flow Failure** – This comes into play when control flow of thread is diverted
- **Propagated Control Flow Failure** –This happens when a bad control flow propagates through code.
- **Addressing Failure** – This failure occurs when bad pointer or array index.
- **Synchronization Failure** – This happens when two sections of code misinterpreted each other's state.

F. Reliability Metrics

– Reliability is the possibility that the system is in operational condition as it should be over a predetermined phase of time [6].
– Availability is basically a chance that the system is operational at each and every point in time:

$$\text{Availablity} = \frac{\text{Uptime}}{\text{Uptime} + \text{Downtime}}$$

Figure 7: Formula for availability

Reliability Metrics[17]

- **Probability of Failure on Demand (POFOD)** is occasion that a transaction call would fail. ·
- **Rate of Occurrence of Failures (ROCOF)** It relates to the failure intensity.
- **Mean Time to Failure (MTTF)** is the average time between consecutive system failures.
- **Availability** is the probability that the system will be effective at a given time.

Reliability models characterize the occurrence of software failures as a stochastic process [12]. ·Software failures are differentiated by studying failure occurrence time or number of failures happening at precise time. Software reliability models take for granted that failures are self-governing and sovereign of each other [5].

-Let us denote by M (t) the random process representing failure occurrence at time t: ·

- The expected number of failures at time t is computed by the mean value function:

$$\mu(t) = E[M(t)] \quad (1)$$

Availability is differentiated by defining some basic concepts that portray quantitatively the equipped state of the system. These include:

MTTF (Mean Time to Failure): average time it takes for a system to fail.

MTTR (Mean Time to recover): average time for the system to recover; correspond to the average time to repair the system.

MTBF (Mean Time between Failures): average time between consecutive system failures.

Based on that observation, Duane developed his model as follows [15].

If N (T) is the number of failures by time T, the observed mean (average) time between failures MTBF, at time is:

MTBF=T/N (T)

The equation of the line can be expressed as:

$$y = mx + c \quad (2)$$

Setting:

$$y = \ln(MTBF_c) \quad (3)$$

$$x = \ln(T) \quad (4)$$

$$m = \alpha \quad (5)$$

$$c = \ln b \quad (6)$$

Yeilds:

$$E(MTBF_c) = bT^{\alpha} \quad (7)$$

II. RELATION OF SIX SIGMA WITH RELIABILITY

In relation to reliability, focus of six sigma lies in discovering defects and eliminating failures. These failures basically represent defects in the reliability process. The elimination of these failures (defects), which is the removal of the original cause of the failure, would result in enhanced reliability performance [14].

Unraveling reliability problems engages different processes such as data scrutiny, emerging with original persistence strategies, improving out of order designs and putting in place broken work processes[7]. In a lot of reliability applications, the user is looking out for breach in show of performance, which is focal point of the Six Sigma methodology [10].

The Six Sigma emphasis on the use of stout statistical data analysis tools like failure modes and effect analysis (FMEA) links failure modes and causes (defects) to safeguarding, dependability and operations actions which is a central factor in handling reliability issues. FMEA works in following steps

A. Finding Failure Modes

The first step in FMEA is to find out the applicants. The correct people with the exact knowledge.

B. Criteria for Analysis

An FMEA uses three measures to review a problem: 1) The relentlessness of the outcome on the customer, 2) How recurrently the difficulty is probable to take place and 3) How simply the trouble can be identified. Contributors must put and concur on a ranking between 1 and 10 (1 = low, 10 = high) for the rigorousness, incident and exposure spot for each one of the failure means.

C. Setting Priorities

Once all the failure modes have been evaluated, the team then should regulate the FMEA to list failures in sliding RPN sort. This highlights the region where counteractive actions can be paced concentration to. If resources are restricted, practitioners have got to set main concern on the prime tribulations earliest.

D. Making Corrective Actions

When the main concern has been settled upon, one of the team's last steps is to produce suitable counteractive measures for reducing the happening of failure means, or in any case for improving their finding. The FMEA leader should dole out accountability for these procedures and position objective finishing point dates.

Once counteractive events have been accomplished, the team should get together another time to reconsider and rescore the rigorousness, chance of incidence and possibility of uncovering for the apex failure modes. This will facilitate them to establish the helpfulness of the curative actions taken. This assessment may be helpful in case the team decides that it needs to enact new corrective actions. The utilization of Six Sigma is employed in associating reliability projects to a company's gross profit

line of the income statement which will be supported by management.

Six Sigma principles have been established themselves to be very flourishing in dropping defects and attaining very high quality standards in every field be it new product development or service delivery.
Six sigma concepts are very tightly coupled with the branch of mathematics i.e. statistics. The prime metric of triumph in Six Sigma techniques is the Z-score which stands on the scope of "variation" or in other words the standard deviation [19].
A **z-score** (aka, a standard score) specifies how many standard deviations an element is from the mean. A z-score can be evaluated ted from the following formula.

$$z = (X - \mu) / \sigma$$

Where z is the z-score, X is the value of the element, μ is the population mean, and σ is the standard deviation.

Here is how to understand z-scores.

- A z-score less than 0 stand for an element less than the mean.
- A z-score superior than 0 characterizes an element greater than the mean.
- A z-score equal to 0 correspond to an element equal to the mean.
- A z-score equal to 1 characterize an element that is 1 standard deviation larger than the mean; a z-score equal to 2, 2 standard deviations greater than the mean; etc.
- A z-score equal to -1 correspond to an element that is 1 standard deviation less than the mean; a z-score equal to -2, 2 standard deviations less than the mean; etc.
- If the number of elements in the set is large, about 68% of the elements encompass a z-score between -1 and 1; about 95% have a z-score between -2 and 2; and about 99% have a z-score between -3 and 3.[13]

III. RELATED WORK

It seems the basic disparity between Six-Sigma and Reliability is the reach and profundity of the projects. In six-sigma, the "belt" is put in the picture to continually fine the scope so that an in-depth and thorough analysis takes consign. In reliability, the scope is broader by design. The scope must encompass an entire system.

A. Quality

The concept of "QUALITY" is very much related to that of reliability. Quality is a stagnant concept since it deals with how strongly the product adheres to the given arrangement and customer necessities [16]. It does not consider the deprivation of the systems and devices over phase of time due to various levels of stresses.

"Belt" approach is not only about making sure about great quality in production, but also about shows potential in delivering righteous quality. It is all about reassuring the fundamental customers that the services and products being provided are of best quality. Concept of Six Sigma actually came into existence while trying to resolve reliability problem.
In reality, reliability engineering and six-sigma employ much the equivalent advancement in solving problems[14]. In fact, at Kennecott Utah Copper, six-sigma classes are skilled in a reliability component, and a lot of "belt" applicants are reliability engineers.

B. KEY PARTS OF SIX SIGMA APPROACH

1) Strategic planning - A strategic plan help uphold a alert, extended time apparition of the organization's assignment and intention, and aid decisions about the allowance of human and financial resources.

TEN STEPS TO STRATEGIC PLANNING

1) STEP *1.1)* Prepare to plan. STEP *1.2)* Clarify mandate and scope of work. STEP *1.3)* Analyze the external environment. STEP *1.4)* Analyze the internal environment. STEP *1.5)* Identify the strategic issues. STEP *1.6)* Define the strategic aims. STEP *1.7)* Define strategies to address each strategic aim. STEP *1.8)* Identify the resources required to achieve the strategic aims. STEP *1.9)* Draw up an internal capacity building plan. STEP *1.10)* Cost the plan [11].

2) Project Assessment and Selection-These actions help recognize and prioritize Six Sigma projects based on an organization's enduring and instant goals

- Guarantee that the right projects are elected as per organizational desires
- Realizes victorious project closure
- Meet the expense of better progress of Six Sigma projects
- Ensures improved sustain from key stakeholders

3) Project Execution and Coaching Support- Project implementation and training to maintain and lend the

necessary support to the Green Belts and Black Belts executing Six Sigma projects and facilitate the implementation of process enhancement projects of strategic importance to the organization. Key activities include the review of Six Sigma

Key benefits of project execution and coaching support are listed below:

- Improved project closure rate and motivated work force
- Reduced cycle time to achieve process
- Improved ability to assess the voice of customers, voice of the business, and voice of the process

4) Information management – It establishes a structure for project governance, reporting, appropriate information distribution, and knowledge organization. Tracking, scrutinizing, and reporting of Six Sigma deployment progress, and smooth the progress of review meetings between senior executives and Key benefits of information management are listed below:

- Improved tracking, monitoring, and reporting of Six Sigma progress in the organization
- Quick accessibility to information
- Efficient knowledge management
- Improved reuse of best practices in the organization
- Achieve best in class process improvements

5) **Learning and Development-** It helps the organization to educate their associates on the Six Sigma philosophy and improve the Six Sigma DNA within the listed below are the key benefits of Six Sigma-centric learning and development measures:

- Increase in the depth of Six Sigma knowledge
- Enhanced awareness of Six Sigma within the leadership teams
- Creation of a learning culture within the organization
- Enhanced ability for comprehension and analytical levels of the work force In recent years, a number of manufacturing and service companies have realized that Six

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CONCLUSION

This paper unearths of how six sigma methodologies place a have an effect on reliability and quality, previous reliability metrics which have been used to measure reliability and new ones in use interlinked with the six sigma and lean six sigma approach. It has been seen that using lean six sigma approach to a good extend increases the level of quality in a product as divides the quality prospect into belt system making the goal to reach a particular level more sophisticated and steeply. Also, with reliability different metrics such as z-score and FMEA have changed the outlook of how we look up at measure reliability of a product with these methods are optimistic ones, they are more about dropping defects in a product and moving towards perfection and not about failures a product gives . These methods decide of how near to perfection a particular product has reached.

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