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SIX SIGMA IMPLEMENTATIONS IN SERVICE ORGANIZATIONS

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ABSTRACT

Nowadays, companies are facing extreme volatile situations in the market, in which the customer satisfaction and loyalty are pillars of any organization's success. Companies want to improve products and services, processes to get customer's satisfaction, decrease costs and to improve profitability. To reach these targets organizations are using advanced methodologies such as 6Sigma.

6Sigma can be used in the manufacturing sector, service sector & in other fields. This paper deals with explanation of 6sigma methodologies, benefits realized by various industries and presents the detailed review of 6Sigma implementation in service organizations to know how organizations implemented 6Sigma, which tools and techniques were used during DMAIC phases, critical success factors of 6Sigma, key performance indicators of 6Sigma, problems faced during implementation, and potential benefits realized by implementing 6Sigma with the help of existing case studies in those industries.

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I.INTRODUCTION

6Sigma is a disciplined, data-driven approach and methodology consists of tools and techniques to get rid of defects in any process from manufacturing to transactional and product to service. “6Sigma is a quality program that, when all is said and done, improves your customer’s experience, lowers your costs, and builds better leaders”. - Jack Welch. Jack welch implemented 6Sigma as a central business strategy and benefited $2.5 billion per year at General Electric and Motorola, Honeywell, ABB, Bombardier, Sony etc. from the big list. Coming to service organizations this powerful strategy was embraced by big organizations like JP Morgan, American Express, Lloyds TSB, City Bank, Egg, Zurich Financial Services, BT, etc. even though applications of 6Sigma are still limited. In most of the organizations, 6sigma is a measure of quality those who continuously put efforts to reach perfection. 6Sigma was first introduced by Bill Smith while working as a senior engineer and scientist in communication division, as a solution for the problems of high warranty claims at Motorola in 1986. This benefited Motorola not only with achieving 6sigma quality level but also, the focus was on reducing defect rate in the process with help of powerful, practical and statistical tools and techniques. This leads to better productivity, customer satisfaction, better quality of service, decreased the cost of operations and costs of poor quality etc.

M Harry formerly is accredited with the development of the 6sigma concept in the late 1980s (Maguire, 1999). Motorola was honored with the Malcolm Baldridge Award in 1988. Motorola had spent $170 million on worker’s education and training and saved $2.2 billion in terms of costs of poor quality (Antony and Banuelas,2002). General Electric is the successful implementors of the 6sigma projects. According to the Chairman of the Board and CEO of GE (Jeffrey R. Immelt), “It has become a permanent initiative – 6sigma is the way we work”.

II.WHAT IS 6SIGMA?

6sigma is a typical problem-solving approach that concentrates on defects reduction and variation management. Sigma is the Greek alphabet that has become the statistical symbol and measure of the standard deviation. standard deviation is a measure of the variation of the dispersion. The sigma scale of measure is correlated to characteristics such as defects-per-unit, parts-per-million defectives, and the probability of failure. 6 is the number of sigma's measured in a process, when the variation around the target is only 3.4 defective outputs out of one million under the assumption that the process average may change over the long run by as much as 1.5 standard deviations. 6Sigma is a quality improvement program with a goal to decrease the number of defects to as low as 3.4 parts per million and it depends on the use of normal distribution to forecast defective rates. 6Sigma qualities are the benchmark of excellence for product and process quality, popularized by Motorola based on zero defect concept introduced by Philip B. Crosby. It provides a quantitative statistical result of quality useful for understanding, measuring and reducing variation.

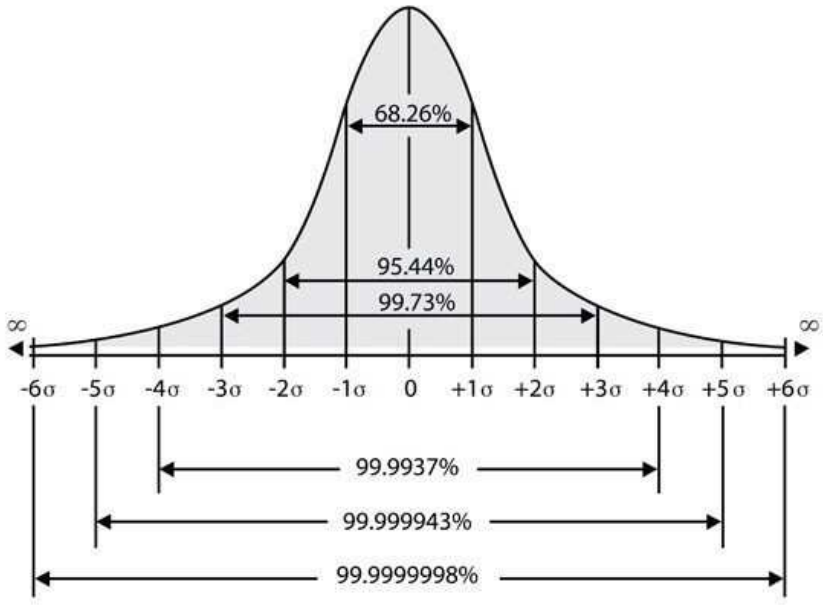

Figure 1. Illustration of 6sigma process

III.WHY 6SIGMA?

The main aim of 6sigma is to improve quality (i.e., reducing waste) by supporting organizations to produce better products and services in less amount of time and costs. There is a direct relationship between quality levels and ‘‘sigma levels’’ of performance. For example, the company operates at 6sigma produce 3.4 defects per million and the company operates at 4sigma produce around 6,210 defects per million.6Sigma simply focuses on customer necessities, prevention of defects, a decrease in cycle time, and lowering costs and the benefits from 6Sigma go directly to the bottom line. Unlike cost-cutting programs which reduces value and quality, 6Sigma identifies and eliminates costs which give no value to customers. these costs are very high for Companies, who are not implementing 6sigma. Companies implementing 3 or 4sigma are spending between 25% and 40% of their revenues to fix problems. This is called the cost of poor quality. Companies implementing 6Sigma spending less than 5% of revenues to fix problems. Cost of Poor-Quality values shown in the figure2 below is at the lower end of the range of results reported from different studies. The cost of this gap will be huge. General Electric calculated that gap between 3,4 and 6 Sigma was costing them around $8 billion to $12 billion per year. The reason why costs are related to sigma levels is simple: sigma levels are a measure of error rates and correction needs money. Figure3 shows the relationship between errors and sigma levels. when the error rate decreases exponentially as the sigma level increases.

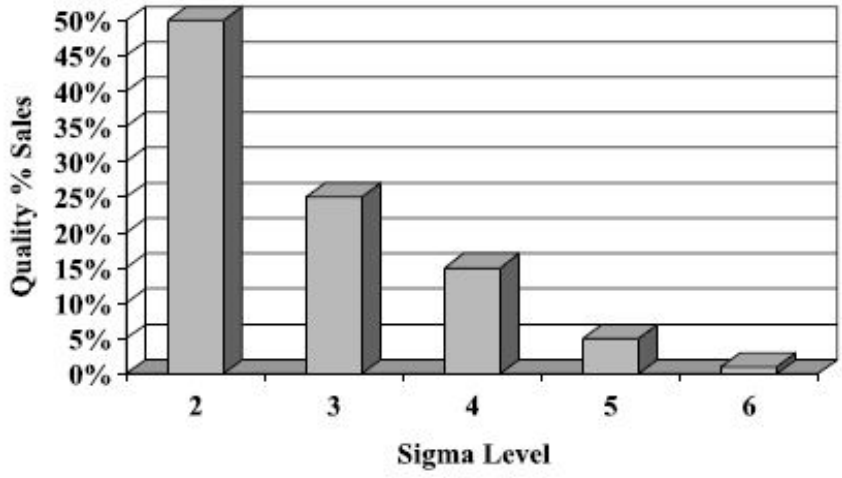

Figure 2. Cost of Poor Quality versus Sigma level

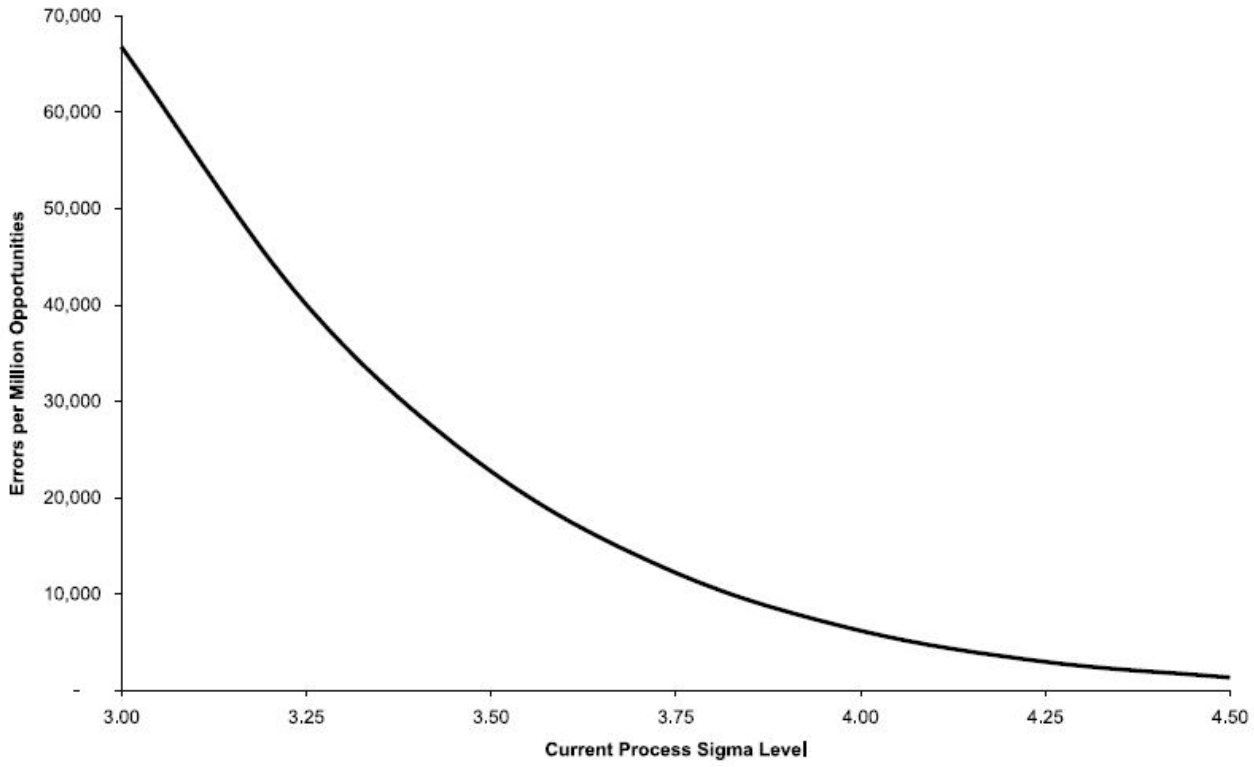

Figure 3. Error Rate Versus Sigma Level

IV.SCOPE OF 6SIGMA: -

6Sigma can be applied among many sectors and industries. See the table for the reference

Aviation	IT	Telecom	Retail	computers
Automobile	BFSI	FMCG	Health care	Sports
Online Retail	BPO	Fashion	Media	Government
Hospitality	Pharma	Petroleum	Education	Chemical
Restaurants	Supply chain	Entertainment	Real estate	Mining

Table 1. Scope of 6Sigma

6sigma can be applicable using **SIPOC framework**

SUPPLIER - the provider of inputs to our process.
Input -Material, resources, data required to execute the process.
Process - predefined set of activities that transform an input to a specified output.
Output - product or services that result from the input.
Customer – recipient of the process output.

Table 2. SIPOC Framework

V.6SIGMA ORGANIZATIONAL STRUCTURE

6Sigma has belt kind of organizational structure. It consists of Champion, Master Black Belts, Black Belts, Green Belts and Yellow Belts.

Figure 4. 6Sigma Organizational Structure

i. Yellow belt

- He is a part-time team member.
- Provides supporting roles.
- Helps in data collection, validation, monitoring and effectiveness.
- Basic understanding of analytical tools.

ii.Green belt

- Part time team member.
- Drives fewer complex projects.
- Understand basic working knowledge for Lean 6Sigma project.
- Works under the guidance of black belt, trained to analyze & solve quality problems.

iii.Black belt

- Generally full-time person for lean 6Sigma projects and drives complex projects.
- Train and educate green/yellow belts, understanding team dynamics and assigning responsibilities to the team members.
- Communicate with the champion.

iv.Master black belt

- Assistant and advisor to champions
- Support black belts
- Monitors and removes bottlenecks
- Spread expertise about lean 6Sigma in the organization.

v.Champion

- Leader of the organization
- Sponsor of the projects
- Promotes and support projects with resources.
- Takes decision on bottlenecks.

VI.METHODOLOGIES OF 6SIGMA

i.DMAIC Process

DMAIC cycle is the core tool for 6Sigma projects and is a closed- loop process that deletes unproductive stages, often concentrates on new measurements/metrics and uses technology for continuous improvement. The DMAIC methodology should be used when a product or process is in existence in the company but is not meeting customer requirements or is not performing adequately.

It consists of 5 phases (Define, Measure, Analyze, Improve and Control.)

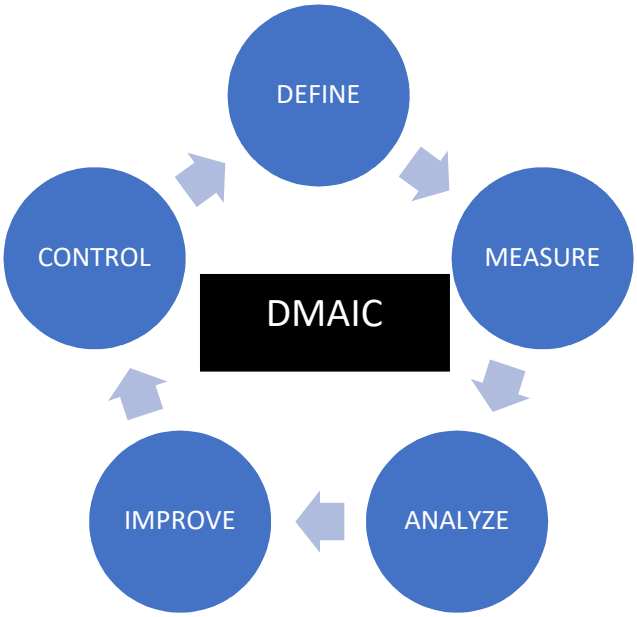

Figure 5. DMAIC cycle

Define – define the project goals & customer requirements.

Measure – measure the process to determine the present performance

Analyze – analyze the collected data & find the root causes of defects or variations.

Improve – improve the process by eliminating the main causes of variations.

Control – control the process future performance.

Steps	Key processes
Define	Define the requirements and expectations of the customer Define the project boundaries Define the process by mapping the business flow
Measure	Measure the process to satisfy customer's needs Develop a data collection plan 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 Prioritize opportunities for future improvement
Improve	Improve the process to eliminate variations 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 Implement the improvements of systems and structures

Table 3. Phases of DMAIC process (McClusky, 2000)

a.Define (D): This phase is to identify the problem, requirements & objectives of the project. The aim of the project should focus on strategic issues which are aligned with the organization's business strategy and the customer's requirements. This phase includes: define customer's requirements as they relate to the project. Explicit Customer needs are called as Critical-To-Quality characteristics; develop defect definitions in a precise manner; perform a base line study that gives the general level of the performance measure before the project implementation; build a team character and champion; calculate the financial impact of the problem on the organization and get the approval of the project from the senior management.(1)

b.Measure (M): This phase is to understand the present performance by identifying the best way to measure present performance and to start measuring it. These measurements should be useful & relevant to identify and measure the source of variation.

- Identify the performance requirements of relevant Critical-To-Quality characteristics.
- Map relevant process with identified input and output so that at each process steps, the relevant outputs and all the potential inputs that might impact each output are connected to each other. create list of potential measurements.
- Analyze capability of the measurement system and establish the base line of process capability.
- Identify where errors can occur in measurements.
- Start measuring the inputs, processes & outputs and collecting data.
- Make sure that the problem exists based on the measurements.
- Refine the problem or aim from the analysis phase (2)

c.Analyze (A): This phase is to generate the hypothesis and for validation. Data collected from measure phase is analyzed in this phase so that hypothesis about the main causes of variations in the data can be generated and then validated. In this phase practical business. problems are changed into statistical problems & analyzed as statistical problems. This includes:

- create hypothesis about root causes of variation & critical inputs
- find the root causes & critical inputs that have the significant impact and validate the hypothesis by using multivariate analysis. (3)

d.Improve (I): This phase concentrates to develop ideas to eliminate the main causes of variation, testing, and solution standardization. This phase includes:

- Find possible ways to eliminate causes of variation and check critical inputs.
- Determine the relationship between variables.
- Define the upper and lower specification limits (based on engineering or customer requirements) of a process to judge the acceptability of a specific characteristic, and if followed strictly results in defect-free products/services and modify the relevant process or optimize the critical inputs. (4)

e.Control (C): This phase is to establish standard measures to maintain performance and to solve problems, including problems with the measurement systems. This phase includes:

- Measurement systems validation.
- Check process long-term capability.
- Deploy process control with control plan to ensure that problems occurred are not reoccurring again by monitoring the process continuously that creates the products/services. (5)

ii.DFSS Process

DFSS means Design for 6Sigma. The phases of DFSS are not globally recognized like DMAIC. DFSS is an approach than a defined methodology. Because every company or training organizations will define DFSS differently. Many times, a company will implement DFSS to match their business, industry & culture; sometimes they will implement the version of DFSS used by the consulting company supporting in the deployment.

DFSS is used to design or re-design a product/service from the beginning. The anticipated Sigma level for a DFSS product or service in a process is at least 4.5 (1 defect for 1000 opportunities) But can be 6 Sigma or higher depending on the product/service. Producing such a low defect level from product/service launch means that customer requirements (CTQs) must be completely understood before the completion of the design and implementation. (6)

DFSS methodology is called DMADV, and holds the same number of letters, number of phases as the DMAIC methodology.

It consists of 5 phases (Define, Measure, Analyze, Design and Verify):

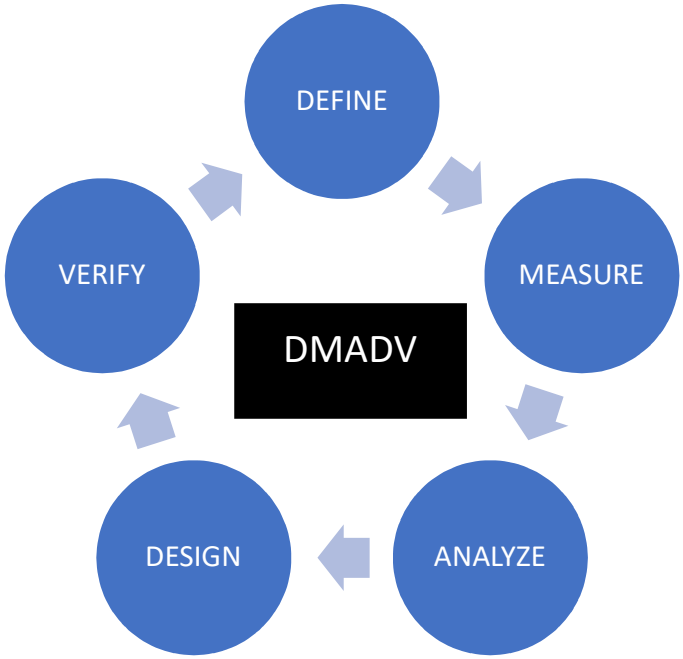

Figure 6. DMADV cycle

Define – Define the project goals & customer requirements.

Measure – Measure and determine customer requirements and specifications; benchmark with competitors and industry.

Analyze – Analyze the process options to meet the customer requirements.

Design – Design the process to meet the customer requirements.

Verify – Verify the design performance and the capability to meet customer needs.

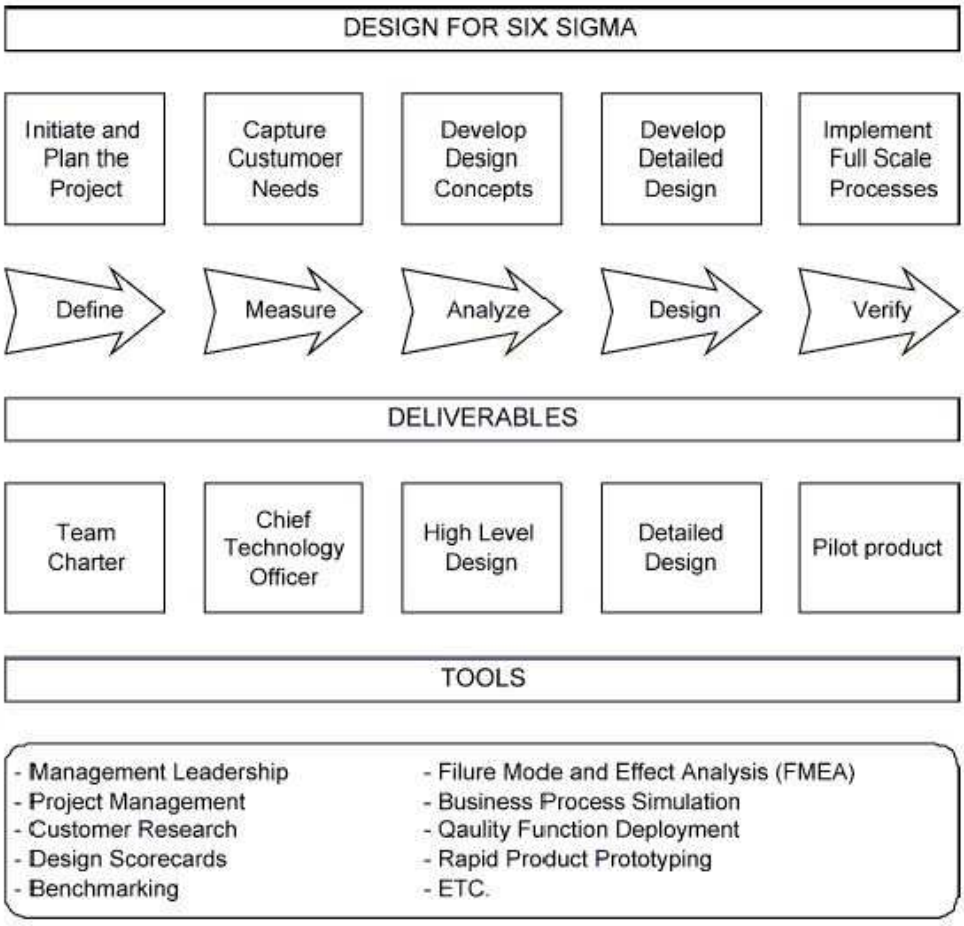

Figure 7. DFSS Process (Hekmatpanah, Sadroddin, Shahbaz, Mokhtori, Fadavinia, 2008)

There are different methodologies to use in DFSS as follows (Chakraborty, Tan, 2012).

- **IDOV** (Identify, Design, Optimize, Validate)
- **ICOV** (Identify, Characterize, Optimize, Validate)
- **DCOV** (Define, Characterize, Optimize, Verify)
- **DMADO** (Define, Measure, Analyze, Design, Optimize)
- **DMADV** (Define, Measure, Analyze, Design, Verify)
- **DMADOV** (Define, Measure, Analyze, Design, Optimize, Verify)
- **DCCDI** (Define, Customer Concept, Design, Implement)
- **DMEDI** (Define, Measure, Explore, Develop, Implement)

iii.DIFFERENCES BETWEEN DMAIC & DFSS:

- Ferryanto explains that “DFSS is a methodology that considers the issues highlighted by the end customers at the design stage while DMAIC solves operational issues” (2005).
- The benefits of DFSS cannot be evaluated easily and will be obtained in long time, on the other side benefits of 6Sigma are quantified in financial terms and obtained more quickly.
- El-Haik and Roy clarify the differences that “The DMAIC methodology tends to provide incremental improvements in comparison to DFSS where there can be radical improvements” (2005).
- “The projects improved through DMAIC methodology are constrained by the assumptions made during the development and design stages, whereas DFSS builds quality into the design by implementing preventive thinking and tools in the products development’s process” (Smith,2001).

The DFSS approach can exploit any of the many possible methodologies. The fact is that all these DFSS methodologies use the same advanced design tools which are partly different from DMAIC tools and DMAIC cannot (theory of creative problem solving, axiomatic design, Quality Function Deployment, Failure Modes, and Effects Analysis, benchmarking, Design of Experiments, simulation, statistical optimization, error proofing, Robust Design, etc.).

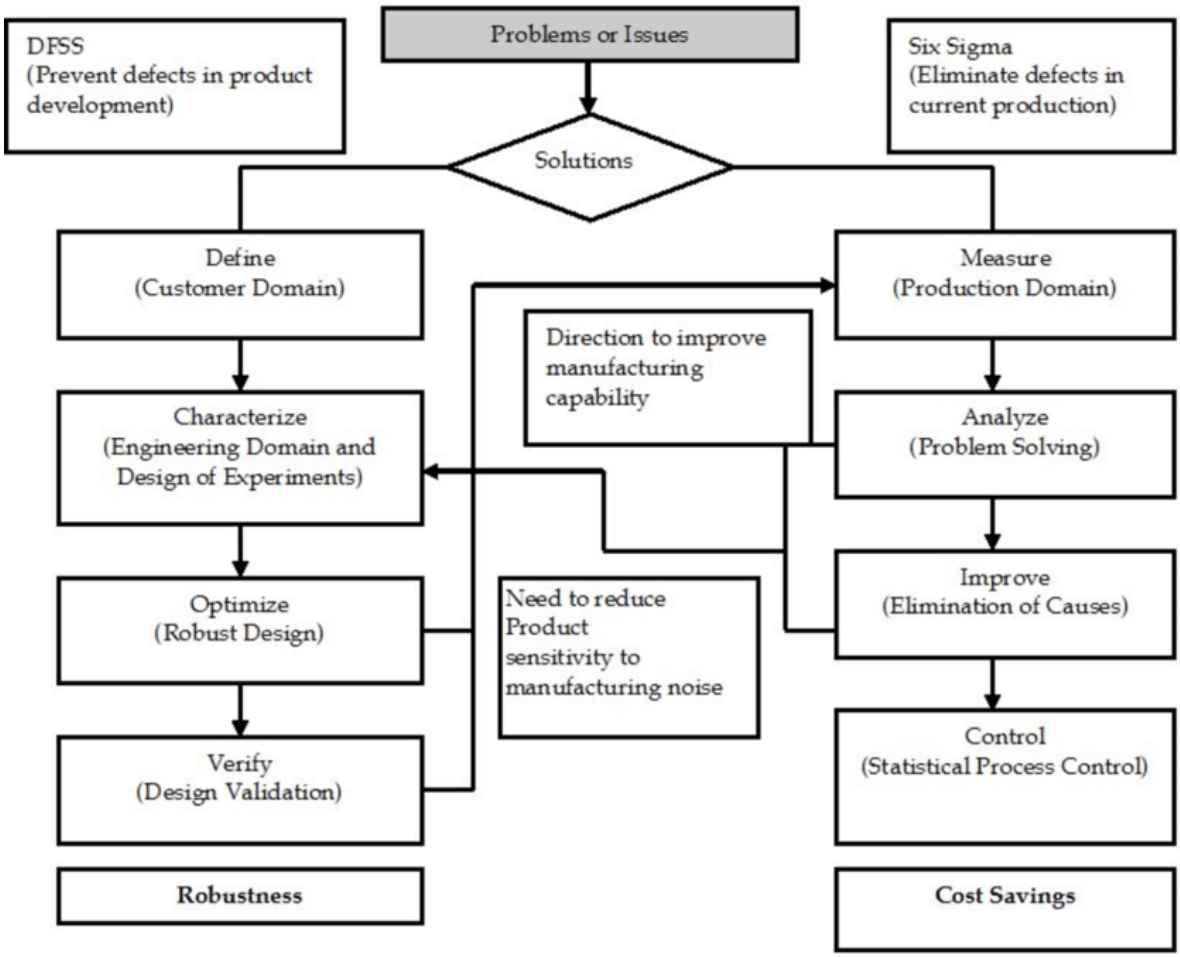

Figure 8. DFSS Vs DMAIC (Ferryanto, 2005)

VII.BENEFITS OF 6SIGMA

- Organizational recognition
- Organizational ethics improvements
- Marketplace viability increased
- Defects reduction
- Appreciation of shareholders and customers
- Increased reliability and predictability of software products and services

The implementation of 6 sigma gives some potential benefits (Antony & Escamilla, 2003):

- Proper understanding of customer needs and expectations
- Product/service design & development time reduction
- Development of reliable products, processes & services
- Improves process efficiency, stability & performance etc.
- Reduction in cost of poor quality

In addition, from the literature, we can conclude that 6 sigma has certain advantages over organization and its workers (Düğme, 2008.)

- Common language throughout the organization
- World class standards
- Cycle time reduction
- Quality perceived by the customer increases
- Bottom line cost savings
- Employees knowledge & skills improvement
- Wide range of tools & techniques

Company/Project	Metric/Measures	Benefits/Savings
Motorola (1992)	In-process defect levels Depot maintenance	150 times reduction
Raytheon/Aircraft integration Systems	inspection time	Reduced %88 as measured in days
GE/Railcar leasing business	Turnaround time at repair shops	62% reduction
Allied Signal (Honeywell)/Laminates plant in South Carolina	Capacity Cycle time Inventory On-time delivery	Up %50 Down %50 Down %50 Increased to near %100
Allied Signal (Honeywell)/Pendix IQ brake pads	Concept to shipment cycle time	Reduced from 18 months to 8 months
Hughes Aircraft's Missiles Systems Group/Wave soldering operations	Quality Productivity	Improved 1000% Improved 500%
General Electric	Financial	$2 billion in 1999
Motorola (1999)	Financial	$15 billion over 11 years
Dow Chemical/Rail delivery Project	Financial	Savings $ 2.45 million in capital expenditures
DuPont/Yerkes Plant in New York (2000)	Financial	Saving of more than $25 million
Telefonica de espana(2001)	Financial	Saving and increases in revenue 30 million euro in the first 10 months
Texas instruments	Financial	$600 million
Johnson & Johnson	Financial	$500 million
Honeywell	Financial	$1.2 billion

Table 4. Benefits/Savings recorded from 6Sigma (Kwak, 2006)

VIII. 6SIGMA TOOLS & TECHNIQUES USED IN SERVICE ORGANIZATIONS

DMAIC is the commonly used methodology in 6Sigma. It comprises of several tools and techniques at different phases. The success of 6Sigma depends upon the different tools and techniques selection at each phase.

Phase	**Common 6Sigma tools used in Service Organizations**
Define	Brainstorming, Project charter[7],[8],[9],[10]; SIPOC diagram[8],[10],[11],[12],[13]; Process map/Flow chart[8],[11],[14],[9],[10],[15],[16],[12],[17]; VOC analysis[7],[13]; Stake holder analysis, Benchmarking[9]; QFD[9].
Measure	Histogram[14],[15],[16]; Quality Function Deployment (QFD); Pareto diagram, Gage Repeatability and Reproducibility (GR&R); Control Chart[13]; Run charts; Time value analysis; Process capability analysis[7],[8],[11],[14],[9],[16],[17]; [12]; MSA[8]; FMEA[12].
Analyze	Histogram [9],[16],[12]; Capability Analysis Normal[8]; Solution Tree; Multi-Vari Chart; One-Way Analysis of Variance; Fisher's Exact; Regression[16]; FMEA[13]; DOE[9],[16]; Run Chart[12]; 5 why analysis; SPC[18]; Scatter plot; Value steam mapping[7], Pareto Chart[8],[10],[11],[14],[15].; Cause and effect analysis[8],[14],[9],[10],[15],[16],[17],[12].
Improve	FMEA [8]; Tolerance Parallelogram; Crystal Ball Simulation; Design of Experiments, 5 why analysis, Optimization [9], Brainstorming [11], [9]; Process capability analysis [11], [9]; Prioritization matrix [8], [10], [15].
Control	Mistake Proofing [9], [13], [16]; FMEA [9]; Control Charts [7], [9], [11], [13]; Process (Low Volume); Pre-control; Control Plan [7], [8], [10], [14], [15], [18], [16], [17], [12]; SOP; Scorecard [9]; PUGH analysis [10].

Table 5. Tools and techniques used in different phases of 6Sigma implementation in service organization.

From the literature review, observed that in Define phase, process map and project charter tools; in Measure phase the process capability and histogram; in Analyze phase cause and effect analysis, Pareto chart; in Improve phase prioritization matrix, brainstorming and process capability and in Control phase control plan, mistake proofing & control chart was widely used.

IX.CRITICAL SUCCESS FACTORS OF 6SIGMA IN SERVICE ORGANIZATIONS

Critical success factors are crucial for implementing 6Sigma in any environment, there are some difficulties in applying 6Sigma in the service sector. Some of the critical success factors from the literature review is mentioned below:

- Top management commitment [19], [20], [21], [22], [23], [24]
- Customer focus [19], [20], [21], [22], [23], [24]
- Project selection and prioritization [19], [20], [21], [22], [23], [24], [25]
- Cultural change [19], [20], [21], [22], [23], [25]
- Organizational readiness [19], [20], [25]
- Education and training [19], [20], [21], [22], [23], [25]
- Company-wide commitment [19], [20]
- Understanding of 6Sigma methodology [19], [20], [22]
- Linking 6Sigma to business strategy [19], [20], [22]
- Linking 6Sigma to human resource [20], [22]
- Linking 6Sigma to customer [22], [23], [25]
- Linking 6Sigma to supplier [22]
- Team involvement [20], [21], [25]
- Organization understanding of work process [19], [20], [23]
- Attaching success to financial benefit [19], [20]
- Communication [20], [21] Data system [20]
- Structured approach [20]
- Bottom line focus [20]
- Employee empowerment [21]

- Ongoing evaluation and monitoring system [21]
- Project management skill [22]
- Organization infrastructure [24].

X.KEY PERFORMANCE INDICATORS OF 6SIGMA IN SERVICE ORGANIZATIONS

A Key Performance Indicator (KPI) is a measurable value that determines how effectively a company is achieving key business objectives and the goal of organization should be aligned with the 6Sigma initiative. Organizations use KPIs to evaluate their success at reaching targets. some of the important key performance indicators of 6Sigma in service organization identified from literature review are:

- Efficiency [19], [26]
- Cost reduction [19], [26], [27]
- Time to delivery [19], [20], [26], [27], [28]
- Quality of service [19], [20], [26], [27]
- Employee satisfaction [19], [20], [26]
- Customer satisfaction [19], [20], [26], [27]
- Reduce variation [19], [20], [26], [27]
- Financial benefit [19], [20], [27], [28]
- Cycle time [27], [28]
- Waiting time [27]
- Inventory turnover [28]
- Operational cost [27]
- Productivity [28]

XI.DIFFICULTIES WHILE IMPLEMENTING 6SIGMA IN SERVICE ORGANIZATIONS

Some of the problems that come about when implementing 6Sigma in the service organization are:

- It is harder to collect data in service industries and the fundamental problem is with the accuracy and completeness of the data [31], [7], [29]
- It is harder to measure due to various things that happen when customers and service providers interact [31], [7], [29]
- It may be more difficult to control and measure 6Sigma in the service industry due to the difficulties that arise from the various sub-processes [31], [29]
- The data are not as reliable (less precise) since the data are collected through more direct ("face to face") means [31], [29]
- In a service-focused environment, organizations struggle to identify processes which can be measured in terms of defects per million opportunities [31].
- The data collection process takes more time due to the need for a large sample size for statistical validity reasons [31].
- It is often the case that we do not describe activities in process terms. The use of flowcharts and process maps are therefore uncommon in many service processes [31].
- Service processes are subject to more noise or uncontrollable factors (psychological factors, sociological factors, personal factors, etc.) as compared to manufacturing processes [31].
- Service processes in general are much more dependent on human and organizational change than the changes to manufacturing processes [31].

XII.BENEFITS OF 6SIGMA IN SERVICE ORGANIZATIONS.

6Sigma can be implemented to solve various problems in the service organizations like hospitals, banking sector, call centers, transport organizations, hotels, education institutes etc.

Service Organization	Problems	Benefits/Savings
Not Specify	To reduction in employee turnover ratio [7].	Reduction in turnover from 35 to 25 percent and cost savings of $1.3 million on an annual basis [7].
Call Centre	To increase in first-call resolution ratio, reduction in operator turnover and streamlining of processes [11].	Significant reduction in call center operators' turnover and streamlining the underlying processes by eliminating unnecessary operations [11].
Hotel	To upgrade the hotel industry overall international Competitiveness [30].	Significant reduce the overall cost [30].
Hotel	To minimizing the losses due to shortage or excess worker [14].	Hotel saved 35000 $/month [14].
Logistics	To improve and bring betterment in the service processes for timely delivery of products and services [9].	Reduced the process down time and improve 6Sigma level [9].
Airport	To improve check-in service performance in Hang Zhou Xiao Shan airport [15].	The overall time of Check-in procedure has been significantly shortened by original 60 seconds to 40 seconds [15].
Call Centre	To develop sustainable business improvement [18].	6Sigma has been developed which enables service-based organizations to develop sustainable business improvement [18].
Financial Institute	To decrease the number of days it takes from the time a company submits a request, to the time it is approved in throughput [16].	Reduced from 20 days to 15 days, resulting in a 25 percent improvement in throughput [16].
Financial Institute	To reduce number of keying-in errors, resulting in better data accuracy and improved customer satisfaction [10].	6Sigma approach can account for a reduced number of keying-in errors, resulting in better data accuracy and improved customer satisfaction [10].
Educational Institute	To improve the admissions to placements ratio by considering all the necessary factors [12].	Through 6Sigma approach a significant improvement of admissions to placements by considering the necessary factors [12].
Educational Institute	To improve a university library Process [17].	LSS was leveraged to improve a university library process [17].

Table 6. Benefits/Savings recorded from 6Sigma in service organizations.

XIII.CONCLUSION

Points concluded from the literature review:

- 6Sigma is a systematic approach to achieve breakthrough improvements in service organizations.
- Selection of various tools and techniques at each phase decides the success of 6Sigma. Selection of tools depend on the type of problem.
- 6Sigma was successfully implemented in hospital, banking, transportation, education, Hotels, call centers etc.
- Crucial success factors of 6Sigma in service organizations are Top management commitment, Customer focus, Project selection, Cultural change and prioritization [20].
- The key performance indicators of 6Sigma in service organizations are the customer satisfaction, time to delivery, reduction in variation, service quality, financial benefit.
- Data collection in service organizations, accuracy, and completeness of the data are major problems while implementing 6Sigma.

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