2. LITERATURE REVIEW

2.1. IT SERVICES INDUSTRY

“Services” is one of the major components of GDP in the developed economies, viz. UK and USA. It now constitutes the majority employer and source of income of the order of 75% of GDP (Hill, 2005; Zeithaml and Bitner, 2003; Zeithaml, Parasuraman and Berry 1990). Though services industry is an important component of the economy, there is lack of focus on delivering the services with desired level of quality as expected by the customers. Quality of service is essential to improve the customer satisfaction rate. Several researchers point out that customer satisfaction rates in the USA are very low in the area of services (Fournier, Dobscha, and Mick, 1998; Fornell, 2008). A study conducted in the United Kingdom for a year, complaints were received on the quality of customer service from eighty six percent of the British adults (Acland, 2005). Declining the level of service quality year on year is the most worrisome (Dickson, Ford, and Laval, 2005).

A similar trend of diminishing quality while increasing cost found in the manufacturing sector is being observed in services sector (Zeithaml, et al., 1990; Quinn, and Gagnon, 1986). The research could draw parallels in these two areas. This may be due to the common organizational and operational processes used in configuring both manufacturing and service organizations. Stringent management control, vague definition of tasks, very low skill and meagre pay for labor force that are followed in mass production logic has been replicated in service organizations (Thompson, 2003; Slack, Chambers, and Johnston, 2006; Johnston and Clark, 2005).

Some service areas such as the IT Services has a great focus on cost control that there may be more stringent administration of Taylor’s principles than that in manufacturing sector which leads to detrimental effects on employee morale, process efficiency and customer service quality (Ellis, and Taylor, 2006). Managing the operations in the services sector is being relooked at with ever increasing competition, operational costs escalation and customer demands (Allway and Corbett, 2002).
2.2. SOFTWARE QUALITY AND ITS SIGNIFICANCE

Quality of software is often treated as inexplicable and subtle topic; software developers consider software quality as an overhead and additional management effort is used to maintain the process documentation (Kenett, and Baker, 1999). Software quality is generally seen as opulence by most of the leaders and managers, if these process implementation overheads can be forfeited, if possible, for additional features or functionality, quicker development and release, or lesser costs. Though software developers and management may not be realizing the importance of software process, studies and experience have shown that software quality is critical to customer satisfaction and value creation. Software companies are facing financial challenges as the operation costs are increasing year on year at the same time there is aggressive competition globally, hence these companies are suffering financial setbacks because of fierce global competition and hence they are constantly working on cost control to become operationally efficient (Phan, George, and Vogel, 1995).

Quality is one of the important facets and an established approach to achieve this differentiation (Humphrey, 1989). Successful software development organizations have found that an organizational commitment to quality expedites software development process, reduces costs and allows new features to be added with greater ease. If the quality of the software developed is low, organizations essentially have to spend more effort in rework fixing the defects in “completed” software which adds to the costs (Bessin, 2004). Hence, companies follow software quality processes meticulously to ensure development of software with very minimal bugs.

It has been proved empirically by researchers and practitioners that quality processes for continuous improvement helped in significant reduction of costs of software development (Kan, Basili, and Shapiro, 1994; Weinberg, 1996; Yang, 2001). For reducing errors and enhancing software quality, there are many processes, methodologies, tools and techniques are being developed (Parzinger, and Nath, 1998). Some of the frameworks, tools and processes include ISO, TQM, SixSigma, CMM, and CMMi. These are being successfully implemented by organizations for continuous improvement of products and services.
2.3. AGILE SOFTWARE DEVELOPMENT METHODOLOGIES

The lightweight methodologies, also known as agile modeling, are gaining significant attention from the software engineering community in the last few years. Unlike traditional methods, agile methodologies employ short iterative cycles and rely on tacit knowledge within a team as opposed to documentation (Awad, 2005).

The name “agile” came about in 2001, meaning it is both light and sufficient. Agile methodology is more of a people oriented, communication and interaction centric approach with collaboration and continuous change. Agile methods does not emphasize on processes, tools, and plans. This does not mean that quality of the output is compromised. Agile methods are a bridge between conventional quality processes and without processes. With Agile methodology gaining importance, software industry adapts to one or a hybrid of the software engineering projects based taking into account various factors while developing the software. The decision on the choice of the methodology may even include the scope, estimates, hardware and software resources, design and architecture to decide upon the heavy weight conventional methodology or agile practice. Agile methodologies are found very useful by practitioners for short cycle time projects.

Agile methods are an answer to the developer communities looking for lighter weight, less documentation processes for quicker and simpler software development processes where in the product features are available to get a feel of the product at an early stage of the overall development.

- Scrum
- Lean
- Extreme programming
- Feature Driven Development
- Dynamic system development method
- Adaptive software development
The prime focus of agile philosophy advocates that the high quality software can be developed through lighter processes without compromising on customer satisfaction. In the current literature review, only Scrum and Lean methodologies to keep focus on the research under study.

2.4. SCRUM

Scrum is a collaborative, interactive, iterative and incremental method or practice for product development. This is a method of software development in a flexible, constantly changing environment where the team members have to manage requirements in shorter life cycles. End of every iterative cycle, a set of functionalities are implemented and the product will have a new set of functionalities. This philosophy helps team work as Scrum originated from Rugby (Schwaber, and Beedle, 2001). In Rugby, the word Scrum is used to represent the method of “getting an out-of-play ball back into the game”

Scrum does not require or provide any specific software development methods/practices to be used. Instead, it requires certain management practices and tools in different phases of Scrum to avoid the chaos by unpredictability and complexity (Rising and Janoff, 2000)

Since Scrum is an iterative short cycle methodology, it is essential to understand various key words, steps, terminologies used in Scrum. A brief description of the key terminologies is given discussed below and is pictorially represented in Figure 2.4.1.

- Product Backlog: This is list of all prioritized features and changes that are yet to be incorporated to the system under development. These feature lists is decided by various stake holders involved: customers, project team and even marketing and sales team at the customer side. This feature list will have only brief descriptions of the functionality. In general, a Product Backlog includes features, bugs, technical details and knowledge acquisition. It is not necessary to have complete lengthy descriptions of the functionalities to begin a project or software development. Product Backlog is maintained by the Product Owner.
• Sprints - Sprints are generally thirty days (short duration) in length. During this period the product will be developed or enhanced to include the changing variables or features such as requirements, time, resources, knowledge, technology, etc. Output of each sprint may result in a working increment of software being developed. In each Sprint, there will be Sprint Planning Meetings, Sprint Backlog and Daily Scrum meetings.

Sprint planning meeting – Sprint planning meeting: Attendees of this meeting are the customers, users, management, Product owner and Scrum Team. The major agenda of this meeting is to decide upon a set of goals and functionality. Based on this, the Scrum Master and the Scrum Team will plan the work allocation in terms of the features and functionalities of the product to be implemented during the Sprint.

Figure 2.4.1: Illustration of the SCRUM process

• Sprint backlog – It includes a list of tasks identified by the team which are to be completed during the sprint. These tasks are majorly the list of features to be assigned to the Scrum team for implementation during the sprint.
• Daily Scrum – This is called a daily stand up meeting. This meeting does not last beyond 15 minutes. Entire Scrum team is supposed to attend this meeting. The agenda of this meeting is to track the progress of the product development and address any major road blocks or show stoppers faced by the team.

The Scrum process is non-hierarchical and hence there is ease of managing the tasks efficiently. The overheads are less and the methodology is lean. From a conventional SDLC process, Scrum is different and hence roles and responsibility too are different. Scrum Master (Project Manager in conventional process) doesn’t have to tell the team what to do, here the team collaborates themselves and make decisions and identifies individual tasks , this is different from the conventional management principles of directing the team what do and ensuring task allocated is accomplished (Schwaber, 2004). Scrum advocates no hierarchies and it is self -organizing, the team takes decisions on their on what to do and accomplish while management ensures smooth flow, removal of hurdles and thus the processes are lean helping significant productivity improvement (Mar and Schwaber, 2005). Scrum teams are generally small teams with clear roles and responsibilities, an approach suited for simple, short term projects or large complex project split into sub projects. Process diversity is the key to success of Scrum (Rising and Janof, 2000).

The Scrum process underscores these situations of both rapid change and steady state. The Backlog is representing the rapidly changing requirements (environment) and the Sprint representing the period of stability, where the team is left to its own devices to get real work done.

2.5. LEAN

Lean definitions and philosophy

Lean is an operational strategy oriented towards achieving the shortest possible cycle time by eliminating waste. Lean manufacturing is derived from the Toyota Production System. There are many definitions for Lean. Some include value added activities and waste reduction.
Lean is the “continuous elimination of waste”. The key word is continuous. The journey to Lean is never ending. All systems have waste. Lean manufacturing classifies these into 7 or 8 categories. Waste is often called “muda”, which is the Japanese word for waste. The waste is removed using the collection of Lean manufacturing tools. Once waste is removed from a system, all that remains is value added activities, which is exactly the customer’s requirements and is willing to pay for.

Various other definitions include the following:

Ohno (1988) characterized the key objectives of Toyota’s early management practice as “production efficiency by consistently and thoroughly eliminating waste,” and “the equally important respect for humanity” (Ohno, 1988).

In 1990, the researchers of the MIT International Motor Vehicle Program (IMVP) published The Machine that Changed the World: The Story of Lean Production. Krafcik (1988) coined the term “Lean Production” to describe an approach that used less of everything—less manufacturing space, tooling, raw materials, inventory and labor—and did it significantly faster and cheaper than traditional mass-production techniques.

In 1996, Womack and Jones published Lean Thinking, which outlined five principles that they believed a lean organization embodied throughout the enterprise: Value, identifying the value stream, flow, pull and perfection.

The word “Lean” implies “cutting the fat” or “trimming waste”, where “fat” or “waste” refer to whatever is not valued by the customer. So another way of expressing the “Lean Manufacturing” goal is to only use materials and processes that add value for the customer.

Lean definition has given many forms according to the views of authors and practitioners. It is obvious that a Lean System cannot be explained in a single sentence. But Lean can be defined generally as “a system which aims in elimination of the waste from the system with a systematic and continuous approach”.

2.5.1 LEAN MANAGEMENT

Ohno (1988) and Shingo (1986) initiated a new process in manufacturing in Toyota for efficient manufacturing and assembly of vehicles called Toyota Production System. The Lean management is the essence of Toyota production system (TPS). However, the history of Lean management is deeper. It was in Henry Ford’s revolutionary mass-production assembly plants where many Lean practices first emerged. The success of Ford startled the whole world financially, industrially and mechanically. In late 1910s, Ford aimed at achieving high throughput or productivity, minimum or near zero inventories and shorter cycle manufacturing. Ohno (1988) studied the achievements of Ford in reducing overall waste in assembly plants of Ford motors. Ohno (1988) implemented the TPS which advocates just-in-time (JIT) production methods. JIT is one of the important elements of Lean production achieved through improved productivity and reduced cycle times of production. TPS remains the forerunner of Lean Management and in particular, Lean Manufacturing is derived out of TPS.

Traditional Production System with Lean

Batch-and-queue model is used in the traditional US production system. In this model, the production volumes are very high and there are long batch sizes which resulted in long non-value added queues between operations. This concept revolves around manufacturing of large volumes based on economy of scale assuming that small batch sizes are not economical. Batching and queuing tends to drive up inventory and lead time, lower quality and creates inefficiency in an operation.

The opposite of batch-and-queue production is one-piece flow that is Lean which emphasizes small batch sizes. The “Pull System” is an integral part of Lean. Manufacturing after receiving customer’s orders means to start a pull-type supply chain operation because manufacturing is performed when demand is confirmed, i.e. being pulled by demand. The make-to-order (MTO) approach is originated where in nothing is made until there is a need from the customer at downstream. This approach is referred as “Pull”. This has become the business model in industries such as personal computer. In Dell, Michael Dell, CEO introduced a “direct sales model” where in Dell readies personal computers for shipment by quickly converting customer
orders (Sheridan, 1999). In Dell, the order is created based on a telephone call or by electronically and this becomes the initial “pull” in the production line. This is a direct sales model allowing Dell to match the customer specifications helping better satisfaction levels.

*Lean Production*

Kaikaku is basically rethinking of a process used for eliminating waste along with Kaizen. Kaizen is a methodology used for continuous improvement. Eliminating waste (waste is known as muda in Japanese) by aligning as part of the Lean production goals, thereby creating value by aligning all the activities for achieving perfection. Hence it is imperative that the perfection is the primary objective of Lean production and it is a continuous journey to achieve this (Womack and Jones, 1996). Reducing variability is another aspect of Lean principles. Variability is that of demand, manufacturing and supplier. Variability in manufacturing can be attributed to product quality characteristics and also variation in task times. Lean manufacturing focusses on reducing variations in task times by standardizing work procedures. On Quality and on time delivery are important from a supplier perspective. There is producer-supplier interaction and cooperation needed for achieving reduction in supplier variability.

Lead times can be considerably reduced using Lean production principles for MTO production still meeting on-time delivery. Reducing the inventories across the supply network and making the supply chain efficient by responding to uncertainties in demand even while following a made-to-stock approach (MTS) is required by lowering lead times for improving replenishment times. This is applicable for a company which has a high volume requirement of consumer products for managing the requirements of supply and distribution channels.

Applicability of Lean principles exists even in performing activities which are of overhead or indirect in nature. However, it there are potential risks if Lean management is not implemented across the organization. For instance, a human resource department is given a reward for efficient implementation of lean by optimizing the employees and cutting staff while elimination waste, departments such as purchase or accounting may feel left out as there will also be potential areas of wastage which can be eliminated for reducing costs. So, while implementing Lean, it will be better to have an organizational vision and goal for every department and every
department is taken together for this Lean journey and the entire organization is benefitted in totality.

*Lean Methodology*

The successful use of Lean principles by Toyota has got published in “The Machine that Changed the World” - the Story of Lean Production (Womack, Jones, and Roos, 1990, 2007). This book has helped in transmission of the Lean practices to researchers and organizations (Sanchez and Perez, 2001). Related studies came in subsequently in various other sectors outside of manufacturing (Moore, and Gibbons, 1997). Once the industries began embracing Lean production practices, there is a major paradigm shift happened in industries which look for quick turnaround (Duguay, Landry and Pasin, 1997).

Value creation at lesser cost is the primary objective of Lean methodology while addressing continuous change in customer requirements and their aggressive demands to implement the same (Womack and Jones, 1996). An efficient 5 step methodology is evolved for effecting the Lean transformation in organizations. The methodology is represented in Figure 2.5.1.

1. Identify what the customer really perceives as value.
2. Line up value-creating activities for a specific product/service along a value stream while eliminating activities that do not add value.

![Figure 2.5.1: Illustration of the LEAN process](image.png)
3. Create a flow condition in which the product/service advances smoothly and rapidly towards the customer.
4. As flow is introduced, let customers pull value from the next upstream activity.
5. Lastly, continue the improvement cycle for value creation through waste reduction.

**Lean Implementation**

Changes in the economy are of two types. There are certain changes which are rapid and certain other changes are rather slow based on the micro and macro-economic conditions. With the social media proliferation and the expectations from the consumers are vary vast and customized, the current economy rather modern economy does not depend on the conventional mass production philosophy and also not based on consumption of goods and services. In the current state of continuous changing environment, efficiency, quality and speed overpowers the conventional philosophy of producing more (Fornell, Johnson, Anderson, Cha, and Bryant, 1996). Thus recent trend is towards trimming the firms by downsizing and thereby the operational efficiencies and productivity is achieved in the short term. It is important to note that downsizing may not always give rise to improve productivity. In the long term, the financial performance may suffer in the long term for these downsized firms, as repeat business is majorly driven by the customized service which is labor intensive.

Hence to survive within the competing new economy businesses, the organizations have to focus on:

- Delivering quality consistently beyond the competition
- Investing in technology innovations ahead of competition and
- Keeping costs low compared to the competition (Watson, 1993).

Hence it is important for companies must constantly attempt to produce superior, quicker and cheaper products or services than competition. A lean enterprise is driven by this philosophy and the above elements form the characteristics of it. Hence strategies of organizations can be driven successfully by managers provided they have a complete overview of the several diverse issues for better decision making.
Some of the concerns posed are:

- What kind of transformation and how much of change is required within an organization?
- How best to deal with the organization culture in order to ensure smooth strategy implementation?
- How strategy implementation and various types of organizational structures are related?
- What are the different implementation approaches to be followed?
- What kind of competencies is necessary for the managers to implement an effective organizational strategy? (Certo and Peter, 1993).

Based on the early studies on Lean principles as being implemented in the automobile industry, the major features on which this philosophy is built are:

- Lean is based on efficient set of principles and best practices for continuous improvement by instilling a process of change.
- Lean has a holistic approach where the total enterprise is touched for bringing the change.
- Lean systematically identifies all non-value-added processes and focuses on eliminating these wastes (Womack, et al. 1990).

Lean production reviews all the tasks involved in a production system, segregates all parallel, sequential tasks, direct and indirect tasks and optimize use of skills of workforce encouraging continuous activities. The objective of lean production is to lower costs with a focus on higher quality optimizing raw materials and other inputs (Dankbaar, 1997). In comparison to conventional mass production, Lean production uses less human effort, less space, less investment and less development time.

**Lean Principles**

It is essential to outline the origins on Lean thinking, as there are various inconsistent and contradicting definitions on Lean principles (Buzby, Gerstenfield, Voss, and Zeng, 2002). There is a wider gap in quality observed between the Japanese and western manufactured products in the early 1980s. The most noticeable differences were in the automotive segment. An extensive study has been conducted by Massachusetts Institute of Technology to identify the reasons of
superior quality of products from Japan automotive manufacturers in comparison to western companies. The observations by were that the products from Jap are of higher quality at a lower cost with Toyota delivered the highest productivity (2:1) and the best quality (100:1) products. This is being achieved by Toyota using a totally different methodology referred as “Lean production” (Womack et al., 1990).

2.5.2 LEAN IN SERVICES

Adoption of Lean methodology in services sector was proposed by Womack and Jones (1996). There are several empirical studies conducted to evaluate the applicability in various service sectors and its applicability is established by practitioners (Abdi, Shavarini, and Hoseini, 2006; Atkinson, 2004; Corbett, 2007; May, 2005; Ehrlich, 2006).

Certain Lean principles have been adopted in airline, hospital management and retail industries which could produce encouraging results for companies (Bowen and Youngdahl, 1998). The focus was initially in the areas of process mapping, reducing time spent on redesign and in training as some of the fundamental principles and general practices in Lean thinking though these approaches was not based on Lean improvement as a philosophy.

The application and extensions of Lean principles beyond automobile manufacturing has been initially found in the area of supply chain management (Womack et al., 2007). The inbound and outbound supply chain management was improved using Lean principles. Benefits of Lean supply chain management strategies were proposed by researchers by the late 1990s and early 2000s (Sandelands, 1994; Avery, 2003). Hines (1996) proposed a strategy for developing a network of major suppliers to creating a platform for information sharing to enable companies to build a closer relationship with them and to develop a dependable supply chain thereby reducing the costs.

The benefits of Lean supply strategy may become significant for organizations as a competitive advantage though characteristics of different supply systems may vary (Lamming, 1996). Retail domain adopted these approaches effectively. Since later part of 1990s, building and
proliferating the Lean tools throughout retail supply chains globally, has been supported by Efficient Consumer Response (ECR) movement globally (Lamming, 1996; Jones and Clarke, 2002). Value stream mapping and problem solving has been directly adopted from the automotive supply contexts as tools in retail supply scenarios as the product-flows were similar (Bicheno, 2004). Application of Lean strategy resulted in costs for holding stocks, write-off on perishable goods (Jones and Clarke, 2002; Fernie and McKinnon, 2003). The implementation also helped in increasing the ability to pull products faster through the supply chain efficiently meeting unpredictable demands from customer (Abernathy, Dunlop, Hammond, and Weil 2000).

Handling of patients in healthcare domain has been yet another candidate for implementing Lean in service (Jones and Mitchell, 2007). Another research are has been to implement Lean supply chain for reducing inventory, reducing costs and improving the efficiency in responding to the demands (Kollberg, Dahlgaard, and Brehmer, 2007). In this research, patients are being considered as products and a process is created as if the product or material (patient) is progressing through an assembly line. The process flow is such that admission, initial diagnosis and assessment, identifying the treatment regime and so on and come out of the assembly line with a result a person being cured or not (Seddon, 2003). This process has enabled the use of Value stream mapping and waste reduction (Womack and Jones, 2005). It is interesting to note that the flow of activities throughout the healthcare system has been brought under a process and value stream mapping is used to identify and eliminate the waste in the process to enhance the efficiency of patient handling (Jones and Mitchell, 2007; Swank, 2003; Esimai, 2004; Massey and Williams, 2005; Towill and Christopher, 2005).

Maintaining competitiveness requires continuously improve productivity, “doing more and more with less and less”. Continuous improvement is the life-blood for an organization’s success. Proven methods from manufacturing provide effective solutions for the service sector. Eliminating non-value adding steps, while reducing response times to internal decisions and external requests, dramatically improves operating efficiency.

In a pure service context, many characteristics of Lean approach are being validated, for example, use of Lean methodology in office automation and process mapping in the healthcare systems.
There are many studies have been conducted by researchers of extending Lean methodology into pure service scenarios viz. administrative functions from a typical shop-floor level manufacturing domain implementations. Improvements have been obtained successfully through Lean principles in the areas of office functions such as order processing, invoicing, managing quotation, sales order processing, finance and accounting and human resource management. (Holmes, 2007; Juroff, 2003; Demers, 2002). Some of the studies cited in this respect include (i) improvements obtained using value stream mapping in accounting and order processing divisions in Brent river machine contract manufacturing (Chaneski, 2005) (ii) significant cycle time reduction in sales order processing and tender/quotation processing using process mapping and problem solving and (iii) achieving operational efficiency in the administrative and office functions in Boeing using Lean principles that were used in shop-floor movements (Wallace, 2006).

**Lean transformation**

Studies fund that the process mapping used in manufacturing sector can be effectively used in service context through defining various activities involved in from start to end of a service through a flow chart with focus on customer experience, (Shostack, 1984, 1987). Researches in this area confirm that process maps can be easily developed which depicts the end to end service process and can be successfully used for finding the wastes in the processes, eliminating them for effective improvements (Polonsky and Garma, 2006; Berkley, 1996; Bitner, Ostrom and Morgan, 2007; Fliess and Kleinaltenkamp, 2004.; Baum, 1990; Coleman, 1989).

By using value stream mapping, charting out the various steps involved in service delivery can be easily applied to identify the opportunities for improvement in a customer marketplace through effective user interaction (Womack and Jones, 2005). Lean has been successfully implemented to the admission process using process mapping in a university thereby improving the performance of the admission process (Tischler, 2006). Research also showcases the successful implementation for streamlining the customer order processing in telephone services (Jones, Medlen, Merlo, Robertson and Shepherdson, 1999).
Maleyeff (2006) has conducted extensive studies to identify the similarities in the process flows between service and manufacturing contexts. He has used 60 service systems for this analysis where all the structural overlaps to the extent of mapping to all the seven wastes as defined in Lean principles in a services context. One to one mapping can be seen from manufacturing to services while identifying the wastes: (i) delays to waiting time in queue or for information (ii) reviews to inspection of work to identify oversight or lapses (iii) mistakes to faults and/or exclusions that leads to rework or customer concerns (iv) duplication to that of activities that can be performed together at different parts of the process flow (v) movement to needless transportation of materials or transfer of information or movement of staff (vi) process inefficiency to ineffective use of resources and processes (vii) inefficiency in resource management to wasteful use of personnel, materials or machinery.

There are evidences of research of Lean in service is available, however the explicit implementation of Lean to pure service context is not academically dealt and limited literature is available. Research in service context such as call center service is limited (Dixon, 2002). Applying Lean principles resulted in significant cost savings and cycle time reduction in a single insurance quotation business, (Allway and Corbett, 2002; Buzby et al., 2002). In this case only two Lean tools are being used for measuring cycle time and takt time for processing of quotations where as these Lean principles were not used for optimizing general improvements through increased automations, reducing paperwork, using electronic reminder systems for reporting delays. Though this study helps understanding the benefits of Lean in a pure service scenario, this case focused only on one company and extension this to other similar settings are not explored.

Lean principles are applied for call center management in multiple companies; the results were not encouraging due to negative consequences such as staff morale and performance arising out of leaner call centers (Sprigg and Jackson, 2006). There are many definitions of Lean, in fact some of them are conflicting (Buzby, et al., 2002). Conventionally, Lean is expected to bring in value effectiveness, whereas those definitions applied by Sprigg and Jackson (2006) are opposed to the established notion.
2.5.3 SIGNIFICANCE OF LEAN IN IT SERVICES

IT organizations spend enormous amounts on infrastructure, maintenance, upgrades, administration and so on. Lean approach in IT will enable organizations to achieve accurate business agility, cost reduction and quality service. Lean principles, traditionally used by manufacturing companies to help improve the production process and provide value to the customer, are now being implemented in more service-oriented domains. But the question is to do the principles that originated from manufacturing have a place in IT? By exploring traditional IT operations and the wasteful practices it often employs, the answer is most definitely ‘yes’.

Lean is first and foremost about the elimination of waste and that there is plenty of waste in IT, hence there is applicability for Lean in IT. To add on, IT is supporting broader business needs and therefore there is magnified waste in IT, which includes the following:

- Defective waste: Systems not meeting requirements, software bugs, missed deadlines, blown budgets, substandard project execution and so on. This clearly adds cost to IT with poor customer service.
- Overproduction: Unnecessary working on low-impact squeaky wheel projects that really don’t provide value to the business leads to increased cost with resource misused.
- Waiting: Slow application response, manual procedures, complex approval process, waiting for new hardware, waiting for software upgrades and so on reduce production and revenue.
- Non-value added processing: A good example here is IT keeping track of excessive amounts of technology metrics and then reporting those metrics to business managers. Again, the old business / IT alignment demon rears its head. Unnecessary reporting to managers leads to miscommunication.
- Transportation: Excess data movement, software audits, on-site visits to resolve hardware and software issues leads to higher capital and operational expenses.
- Excess inventory: Unused or outdated software licenses, under-utilized hardware, benched development teams reduces productivity and increased costs.
- Excess motion: Unnecessary processes, recurring IT infrastructure problems results in low production.
• Unused employee knowledge: Un-captured ideas/ innovation, knowledge retention problems, low morale leads to talent leakage, low job satisfaction and increases support and maintenance costs.

Taken individually, each one of the above IT waste elements can have a detrimental effect on business operations.

Based on the study conducted by McKinsey & Company, in software industry, productivity of application development and maintenance can be increased to nearly forty percent using Lean IT principles while attempting the quality and speed of execution. While comparing with manufacturing processes, software application development is similar that of a factory production line, each category of waste in manufacturing can be mapped to that of application development. For instance, rework due to application code bugs to overproduction is a waste in application development and overproduction is equivalent to a feature developed now which is supposed to be developed later. In application development, there are a number of activities which can be automated which can be linked to removal of waste across the production line to increase the flow of production. Even in IT operations, like application development, IT operations can be managed from a services angle, employing tools and techniques to improve design, operate and transit business services in support of an organization strategy.

Applying Lean in IT is an attempt to resolve the problems arising out of IT waste elements, cost-effectively. Lean principles helps in creating new IT service models and switching from company-owned IT hardware, software and services to per-use based models. It focuses on reducing the IT infrastructure and related liabilities to reduce total cost of ownership. It focuses on changes in IT services and payment models to achieve desired business agility and flexibility without any software, hardware and vendor lock-in. It also focuses on achieving guaranteed quality-of-services from various service providers.
Many principles of Lean trace their measurement roots to the automobile industry and, in particular, to Henry Ford's revolutionary Lean production assembly line. Ford's vision was inherently linked to Lean principles, such as the systematic elimination of waste. This Lean principle and measurements achieved progress by Toyota's Ohno (1988), who took Ford's accomplishments and built on them – the TPS (Toyota Production System).

A company wishing to successfully apply Lean must follow the following key points:

- Each employee should arrive at work every day, thinking about how they are going to improve their work environment; with this commitment, there is continuous daily improvement.
- Measurement is essential. Understanding the value stream baseline and the subsequent improvement achieved is critical. Measurement is a key to continuous improvement and provides a basis for understanding your accomplishments.

Lean tools grew out of the need to have mechanisms in place to support the lean way of thinking and to allow flow to permeate a process. Kaizen, Kanban, 5S, Metric and Value Stream Mapping are among the most popular Lean tools.

**Kaizen**: This is a Japanese term for improvement; continuing improvement involving everyone - managers and workers. Imai (1986) – known as father of continuous improvement, first threw the word 'Kaizen' through his book “Kaizen: The Key to Japan's Competitive Success”, it was hungrily swallowed by a world in the throes of transition. Toyota became one of his most committed followers. Imai (1997) introduced an evolved form of Kaizen in his book “Gemba Kaizen: A Commonsense, Low-Cost Approach to Management”, to reassert the importance of the shop floor in bringing about continual improvement in an organization. According to Imai (1986), 90 per cent of all corporate problems can be solved using common sense and improving quality while reducing cost through the elimination of waste. Today, companies around the world use Kaizen for greater productivity, speed, quality and profits with minimal cost, time and effort, to get effective results and become recognized industry leaders.
**Kanban:** Kanban is a Japanese word that means "visual card". It is a Japanese lean manufacturing method which allowed companies like Toyota to outperform their competitors and gain immense growth. A Kanban system is a means to achieve Just-in-time (JIT) production. It is a scheduling system that tells you what to produce, when to produce it and how much to produce. The particular feature of a Kanban system is that it short-circuits normal ordering procedures: as supplies of a Kanban-controlled material are used up, new supplies are requested simply by releasing a re-order card which is sent direct to the supply point (i.e. the manufacturer or stockists). It is often described as a ‘pull’ system, in contrast with traditional ordering procedures, which ‘push’ orders into the system.

**5S:** This was invented in Japan and stands for five Japanese words that start with the letter 'S':

- **Seiri (Sort):** The first S focuses on eliminating unnecessary items from the workplace.
- **Seiton (Set in place):** The second S focuses putting everything in an assigned place so that it can be accessed or retrieved quickly, as well as returned in that same place quickly.
- **Seiso (Shine):** The third S focuses to thoroughly clean the work area and giving it a 'shine'.
- **Seiketsu (Standardize):** The fourth S concentrates on standardizing best practice in your work area.
- **Shitsuke (Sustain):** The fifth S denotes commitment to maintain orderliness and to practice the first 4 S as a way of life.

Therefore, 5S is a structured program to systematically achieve total organization, cleanliness and standardization in the workplace; all of which can be regarded as falling within the Lean portfolio – that is, they are all based around the elimination of waste in one form or another.

**Lean Metric:** In Lean manufacturing, measurements are usually referred as metrics. These metrics is basically the outcomes of an individual or departments with reference to work output. It also enables companies to measure, evaluate and respond to their performance in a balanced way, without sacrificing the quality to meet quantity objectives. The five metrics of lean manufacturing are total cost, total cycle time, delivery performance, quality and safety. Total
cost is basically used to associate cost among one phase to another. Total cycle time is the time required to complete the cycle of production. Delivery performance is a metric used to analyze the organizations ability to meet the customer expectations. Quality metrics focus on the quality of products. Safety as a metric is concerned with examining frequency of accidents and severity of accidents. The type of the metric depends on the organization and can be of following categories - financial performance, behavioral performance and core process performance. Lean metric is used by the organizations implementing Lean for establishing vision and direction which will help the organization to achieve the critical goal of increasing profits.

**Value Stream Mapping:** This tool ties together the lean concepts and techniques. It is a graphical tool commonly used in Lean continuous improvement program to help understand the flow of the material and information within organizations. Value Stream Mapping borne out of lean ideology captures and presents the whole process from end to end in a method that is easy to understand by those working the process - it captures the current issues and presents a realistic picture. The principle aim of Value Stream Mapping is to improve processes. This is achieved by highlighting areas of waste within a process and eliminating such activities. The main benefit of this tool is the process activity is categorized into three main areas - value add, non-value add (but necessary) and waste. Therefore, this tool identifies, demonstrates and decreases the waste in a process.

There are many other leans tools such as Lean Performance Indicator (LPI), Takt Time, Value Stream Costing and so on that also contribute to achieve efficiency at work.

**2.6. SIXSIGMA**

*SixSigma Pedigrees*

SixSigma originated from two major sources, from Motorola Corporation where statistical metric is applied and from TQM. SixSigma has emerged as a comprehensive, business strategy used from a long term perspective and is a focused decision making initiative beyond a mere quality management program.
SixSigma adopted the practice of keeping everyone in the organization owning the responsibility of the quality of the products and services offered as being adopted as a concept from TQM. SixSigma embraced the philosophy of customer satisfaction, training in statistics and Root cause analysis and problem solving from TQM. SixSigma also uses seven quality control tools used in TQM (Sower, Savoie and Renick, 1999). Histograms scatter diagrams, control charts, Pareto analysis, flow diagrams, fish-bone diagram and checklists used in TQM are used in SixSigma as well.

Motorola developed SixSigma metric in 1987. This is developed to improve the product quality as it was found many a time product quality was below standard while designing component parts by engineers. Most of the time, engineers used three sigma rule to compute the tolerance levels of the manufactured components as acceptance criteria. As represented in Fig 2.6.1, statistically the process variation, SixSigma ensures conformance of 99.9977 % of the components to tolerance levels, within a range of 6 standard deviation units which is equivalent to 3140 nonconforming (0.3 %) parts per million (NCPPM)

Motorola was concerned about deterioration of quality while products became more intricate and the customers of demanding for higher quality. For instance, a pager or a cellphone has large number of components. Each component is very important and essential and needs to be of great quality. It was common for a product or service to have very large number of opportunities of defect and operate at 2 or 3 Sigma levels (Harry and Schroeder, 2000). Nowadays, the customer demands are so high that commonly opted three Sigma quality levels were not acceptable for customers of Motorola. For a product that contains 1000 OFDs, 5 % of the products would be defect free, if each OFD is said to achieve three sigma quality levels. This probability calculation is based on binomial probability distribution (Devore, 2000).
While analyzing the linkage between component quality and final product quality, it was observed that a process tends to shift a maximum of 1.5 sigma units while analyzing different lots of products (McFadden, 1993). The Figure 2.6.2 shows a centered process and a process shifted by 1.5 Sigma units.

Table 2.6.1 provides the relationship between component quality and final product quality, assuming that the full 1.5 sigma shift takes place. The table gives the proportion of finished products which are defects free. As the process shifts 1.5 sigma units OFD quality depicts the NCPPM. For instance, a product quality objective of 99.97% by an organization, the decisions are made against the SixSigma metric which is conforming to 3.4 NCPPM.

Ford Motor Company, one of the major auto manufactures, adopted SixSigma in 1999. Every car had nearly twenty thousand OFDs in Ford. To achieve quality standards equivalent to SixSigma, would mean at least one defect in every fifteen cars produced. As per Table 2.6.1, at Ford, if 32% of their cars include at least one defect, the company is said to be operated at 5.5 Sigma level.
SixSigma today is a combination of important characteristics of TQM and SixSigma. Customer centricity and participation from across the organization and effective training has been adopted from TQM. TQM together with SixSigma metric, SixSigma methodology has emerged as a methodology for continuous improvement through defect reduction through fool proof processes to help delivery of products and services. SixSigma has become a philosophy taking the entire organization together using statistical and analytical tools for measurement and reducing variations/variability.
The SixSigma strategy is based on statistical and process related tools combining with quality management principles to achieve significant business mileage by applying it in projects within an organization (Wang, Du, and Li, 2004). There are large number of articles and books published on the basic concepts of SixSigma (Harry and Schroeder, 2000; Hahn, Doganaksoy and Hoerl, 2000). After Motorola has successfully showcased the benefits of SixSigma, it is now being widely used in broader levels of organization including human resource management (Wyper and Harrison, 2000). Business performance enhancement by improving process using SixSigma is a solid approach achieving higher levels of customer satisfaction and financial savings (Haikonen, Savolainen, and Jä`rvinen, 2004). SixSigma is a continuous process improvement philosophy by eliminating variation by identifying and reducing the sources of variation. SixSigma’s target is to achieve less than 3.4 defects or errors per million opportunities, hence the name. The higher the number of sigma’s the more consistent the process output or smaller the variation.

Successive and simultaneous improvement projects are selected based on the impact on the bottom-line business performance. The major purpose of the method is to search for

<table>
<thead>
<tr>
<th>Sigma level without 1.5 σ shift</th>
<th>DPMO without 1.5 σ shift</th>
<th>Sigma level with 1.5 σ shift</th>
<th>DPMO with 1.5 σ shift</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.0</td>
<td>317,311</td>
<td>1.0</td>
<td>697,672</td>
</tr>
<tr>
<td>1.5</td>
<td>133,614</td>
<td>1.5</td>
<td>501,350</td>
</tr>
<tr>
<td>2.0</td>
<td>45,500</td>
<td>2.0</td>
<td>308,770</td>
</tr>
<tr>
<td>2.5</td>
<td>12,419</td>
<td>2.5</td>
<td>158,687</td>
</tr>
<tr>
<td>3.0</td>
<td>2,700</td>
<td>3.0</td>
<td>66,811</td>
</tr>
<tr>
<td>3.5</td>
<td>465.35</td>
<td>3.5</td>
<td>22,750</td>
</tr>
<tr>
<td>4.0</td>
<td>63.37</td>
<td>4.0</td>
<td>6,210</td>
</tr>
<tr>
<td>4.5</td>
<td>6.80</td>
<td>4.5</td>
<td>1,350</td>
</tr>
<tr>
<td>5.0</td>
<td>0.574</td>
<td>5.0</td>
<td>232.67</td>
</tr>
<tr>
<td>5.5</td>
<td>0.038</td>
<td>5.5</td>
<td>31.69</td>
</tr>
<tr>
<td>6.0</td>
<td>0.002</td>
<td>6.0</td>
<td>3.40</td>
</tr>
</tbody>
</table>

Table 2.6.1: DPMO to Sigma Level Relationship
opportunities for improvement that have the maximum effect on the bottom-line compared to the net-expenses of the project. SixSigma links customer requirements and process improvements with financial results.

SixSigma is a continuous process improvement methodology which is customer centric, measurable, organized, efficient and practical approach for the business processes of an organization. SixSigma aims at quality improvement and cost efficiency in the business processes using statistical procedures (Antony, and Banuelas, 2003; Snee, and Hoerl, 2003).

Many organizations have embraced SixSigma for improving level of performance matching SixSigma for improving profitability (Breyfogle and Cupello, 2001). Overall variability of the process is controlled and brought well within specification limit. SixSigma level is a metric indicates the performance of a product/process/service with respect to specification. As the sigma level increases, possibility of occurrence of fewer and fewer defects and the product or services quality improves, reduction in cost and improved customer satisfaction.

*What is SixSigma?*

SixSigma stands for six standard deviations from mean. This methodology provides the techniques and tools to improve the capability and reduce the defects in any process. SixSigma methodologies improve any existing business process by constantly reviewing and re-tuning the process. As stated by Breyfogle (1999), sigma level provides a measure of the probability of occurrence of defects and the number of defects which is derived from the standard probability curve.

*What is Process Capability?*

Process capability is defined as the probability of a product or service meeting customer requirements. The process capability index is defined as allowable process spread over actual process spread. In business management, process capability refers to the frequency with which a process (such as the production of an item on an assembly line) can produce output (a finished
product) that falls within a given set of specifications. These parameters are usually specified by a customer. In this way, Process Capability can be thought of as the inverse of a process’s defect ratio. While it is true that even the most efficient processes can produce some degree of output variation, it is important for a process to have a strong capability so that a large percentage of finished products fall within customer requirements.

*Process capability and SixSigma*

SixSigma and Process Capability - both rely on the improvement of customer satisfaction. While SixSigma is known more for beginning the process of customer satisfaction from the get-go, the Process Capability takes a good look at all the processes and then determines how to improve customer satisfaction.

![Normal Distribution](image)

**Figure 2.6.3: Statistical classification of SixSigma**

SixSigma establishes the Upper Specification Limit and Lower Specification Limit (USL and LSL, respectively). These values are typically based on the requirements of the customer and do not imply that the process is only capable of producing output within those parameters. After the values are established, SixSigma professionals develop a series of averages for production using real time data. After all the variables have been processed and analyzed, the standard deviation is determined. Then, using a capability index, one can determine whether or not a process is capable of meeting or exceeding the requirements of the customer.
Thus: $C_p = \frac{(USL-LSL)}{6\sigma}$ where USL and LSL are the process upper and lower specification levels (Figure 2.6.3, adapted from Pande, Neuman and Cavanagh (2000)). In a normal distribution, 3 sigma yields a $C_p$ of 1.0 which is equivalent to 66,807 defective parts per million. For a process which is SixSigma provides a rate of 3.4ppm outside the limits. The higher the Sigma, the less the process creates defective parts. SixSigma could be treated as the quality measure for organizational business processes developed as a cost effective methodology where the focus is reducing defects (Bicheno, 2004). Thus the main objective of SixSigma is measuring and reducing the variability which in turn reduces the number of defects (Eckes, 2000).

SixSigma is a statistical process developed as a technology-based approach which is a broad business improvement approach over the past ten years (Keller, 2005). It has resulted in an:

- Process within the organization
- Increased collaboration among the staff by increased ownership for workers with commitment from managers (Keller, 2005).

The need for quality improvement coupled with business strategy, major corporations have deployed the SixSigma methodology Keller (2005).

*SixSigma, a business strategy*

The literature is limited on the benefits and quantitative effect outside a manufacturing environment (Bicheno, 2004; Tennant, 2001). The methodology needs to be changed to align to the services areas within and outside of manufacturing without losing its uniqueness (Hallowell, 2003). This is visible while we deploy Design for SixSigma in comparison to SixSigma methodology in manufacturing (Hallowell, 2003).

In the world of globalization and growing cut-throat market environment, the quality, skills and knowledge give competitive advantage to any organization. The global market is very competitive and to survive, organizations need to produce products and services of high quality to achieve customer satisfaction and loyalty to stimulate top-line business growth. In an attempt to manage this change, industry leaders embraced SixSigma business strategy as a framework and solution for pursuing continuous improvement in process, customer satisfaction and
organizational profit. This approach to reduce the defects has made substantial impact on many organizations, resulting in enhancement of performance and a vast improvement in business profits, employee morale, quality of products and customer loyalty (Snee, 2004; Antony, Kumar, and Madu, 2005a; Antony, Kumar, and Tiwari, 2005b; Kumar, Antony, Hari and Wang, 2006a; Kumar, Antony, Singh, Tiwari, and Perry, 2006b; Antony, 2007).

SixSigma is a methodology evolved to find and remove the defects or errors in processes, systems, products or services in an organization with a focus on key performance parameters which are critical to customers (Snee, 2004). There has been tremendous application of SixSigma ever since this program was conceptualized and implemented by Motorola in 1980s worldwide (Antony, 2007; Antony, et al., 2005a, Antony, et al., 2005b). The objective of SixSigma methodology was evolved as a quality improvement platform to reduce defects (near defect free, say 3.4 defects in million opportunities) and achieve high level of quality at Motorola using DMAIC processes and tools (Kumar, Antony, Hari and Wang, 2006a; Kumar, Antony, Singh, Tiwari, and Perry, 2006b).

*Success stories of SixSigma*

SixSigma has been evolved as a methodology for defect free products in a manufacturing scenario. Today, it extends to various other domains and areas outside of manufacturing. SixSigma has used effectively in services, public sector, government, non-profit organizations and healthcare (Antony, et al., 2005a; Antony, et al., 2005b; Montgomery, 2005; Pande, et al., 2000; Pyzdek, 2003; Breyfogle, 1999). While achieving quality improvement through SixSigma implementation, it also helps in cost / financial savings. Motorola could save approximately 5.4 billion dollars saving from 1990 through 1995 outside of manufacturing processes. It has been found that it is very challenging to achieve quality improvement in service processes and other non-manufacturing areas (George, 1992).

Financial and Health care services are two areas where SixSigma application is getting extended (Hoerl, 2004). The application of SixSigma in service organization is found rising tremendously from beginning of 2000 in Europe. SixSigma in services is focusing on efficiency and effectiveness of the services provided.
The aim of SixSigma in services focusses on customer satisfaction through improved customer experience like any other industry is to analyze and find the reasons of defects, devise process improvements to lower these defects (Antony, 2004a, 2004b).

SixSigma was adopted by GE after seeing the successes in Motorola. GE capital is a financial subsidiary of GE which is the pioneer in implementing SixSigma with an objective to enhance profitability and customer satisfaction (Antony, 2006). Other financial institutions which joined the bandwagon are Citicorp, UBS, Bank of America, Lloyd TSB, Bank One, HSBC and Zurich Financial (George, 2003). With the help of GE, Commonwealth Health Corporation implemented SixSigma and could gain considerable financial benefits (Thomerson, 2001). The company realized productivity improvements of the order of 33.5%. Financial savings were of the order of 1.25 million US dollars by achieving reduction of cost per radiology procedure by 21.6% (Thomerson, 2001). Some of the healthcare organizations who had taken cue from Commonwealth Health Corporation for implementing SixSigma include Charleston Area Medical Centre (Western Virginia), the University of Michigan Medical Center and Palomar Pomerado Health (San Diego, California) (Sehwail and DeYong, 2003).

Most of the quality improvement programs were emanated from manufacturing industry. Even in the case of usage of SixSigma methodology services industry, adoption of SixSigma methodology was slow as it was felt that this methodology is suitable only for manufacturing industry applications. The challenge for services organization is on how to measure defects as the services are being provided by human beings, in comparison to measuring a defect in manufacturing systems (Antony, Kumar and Labib, 2007a; Antony, Antony, Kumar and Cho, 2007b).

A common view among people engaged in service organizations that SixSigma requires complicated statistical tools and techniques. The truth is that SixSigma is not about a collection of statistical tools and techniques. In fact, service organizations do not simply need many of the tools and techniques of the SixSigma toolbox. The majority of the process and quality related problems in service organizations can be readily tackled using the simple problem-solving tools
of SixSigma such as process mapping, cause and effect analysis, Pareto analysis, control charts and so on.

SixSigma is a proven tool effectively used by corporate entities for business improvement for accruing cost savings, customer delight and enhanced profitability (Lee-Mortimer, 2006). The power of SixSigma is tested across the world by many business houses (Hutchins, 2000). GE, Honeywell, Motorola, Sony and many such organizations have taken advantage of SixSigma strategy for operating profit margins of the order of billions of dollars (Snee, 2000; Antony, et al., 2005a, Antony, et al., 2005b)

SixSigma has become very popular among corporate houses globally as it generated significant return on investment by implementing this (Szeto, and Tsang, 2005). Motorola reported 1 billion dollar financial savings in 1998 and 16 billion dollar in 2005 (Ingle and Roe, 2002). SixSigma implementation helped Volvo in their car manufacturing division in Sweden generating a profit of 55m euros (Magnusson, Kroslid and Bergman, 2003). A companywide SixSigma implementation program in 2000, helped Dow Chemical’s achieve earnings of the order of 1.5 billion dollar by end of 2002 (Motwani, Kumar and Antony, 2004).

All the quality improvement initiatives where continuous improvement of products and services are aimed at will help improve customer satisfaction and thereby connecting directly to the customer. Usually, considering the voice of customers is taken care by organizations in the quality improvement programs (Peterka, 2005). Customer centricity in these programs help delivering a better product or services which can in turn help in financial savings both the organization and the customer. Productivity improvement or defect free products are resulted through SixSigma implementation through effective communication, information sharing and interaction with customers and stakeholders. Voice of the customers is captured in a SixSigma program using tools like cause and effect measurements and using quality function deployment.

A significant challenge in today’s IT service operations is to be both efficient and highly effective in terms of return on investment by cost optimization. Time and quality based competition focuses on eliminating waste in the form of time, effort, defective units and inventory in manufacturing-distribution systems (Antony, et al., 2005a; Antony, et al., 2005b). In
addition, there has been a significant trend to emphasize quality, not only in the production of services but also throughout all the areas in the company.

While software industry is becoming matured, need for quality improvement program is ever increasing to beat the competition. SixSigma though has created significant footage in other industries; software industry is looking at SixSigma as a methodology to develop defect free software (Mahanti and Antony, 2006). It has been observed that typical software development process is operating approximately at 2.2 Sigma to 3 Sigma. Mission critical software used in space programs and passenger aircraft manufacturing operates in a range of 4.1 Sigma to 5.2 Sigma. If single line of code represents an opportunity for defect, in a generic software product development process, approximately 66803 defects are likely to be found per million lines of source code. By implementing SixSigma in a software development process, only 3.4 defects are produced in a million lines of software code developed (Hong and Goh, 2004).

SixSigma is applied in software context to reduce errors, effort overrun, schedule overrun, and thereby reducing variation in the software development process (Mahanti and Antony, 2006). Processes such as CMM, CMMI, and TQM have been used in software development and have shown significant improvement (Jalote, 2000; Issac, Rajendran and Anantharaman, 2004).

There are many success stories of Six Sigma implementations reported in the manufacturing domain globally. One such example is reported by Black & Decker Corporation on operational improvement through effective application of Six Sigma (ApplianceMagazine.com, 2003). By applying SixSigma streamlining the restructuring process, the company declared on 30, January 2003, that the Power Tools and Accessories segment has achieved 38 percent increase in operating profit from 4th quarter of previous year.

Success stories of SixSigma implementation and subsequent improvements in processes can be found in both academic journals and trade publications. The focus of these publications has however been on industrial (manufacturing and services) processes.
SixSigma is a quality initiative focusing on defect reduction with a goal of decreasing the number of defects to 0.0003 percent or below which is equivalent to 3.4 parts per million opportunities. According to statistics, it represents the amount of variation about a process mean (Henderson and Evans, 2000).

The higher the sigma, the fewer the deviation from the norm—that is the fewer the defects. At one sigma, two thirds of what-ever is being measured falls within the curve. Two sigma covers about 95 percent. At SixSigma, you are about as close to defect-free as you can get.

From a business standpoint, SixSigma is defined as a business strategy for improving the profit margins by improving the operational efficiency thereby meeting or exceeding customer expectations (Kwak and Anbari, 2006).

More definitions of SixSigma include:

SixSigma is a quantitative methodology using a statistical approach for reducing the defects per million opportunities to 3.4 (Bolze, 1998). This methodology involves measuring, analyzing, improving and controlling the processes.

SixSigma is a methodology attempts to achieve near perfection in every process or product of a company through a statistics based approach (Paul, 1999). This is a very methodical way of collecting related data and applies statistical analysis to identify the errors and its sources and eliminating them (Harry and Schroeder, 2000). As per the description available in Minitab tool, SixSigma is a data driven process for eliminating defects though improvement of processes there by achieving customer satisfaction with a focus on profitability.

SixSigma is a customer centric methodology which is beneficial to even employees, shareholders and suppliers with a focus on reducing defects thereby raising the quality levels and improving the financial performance of enterprises (Chua, 2001).
2.6.2 SIXSIGMA IN SERVICES

According to Dan Mailick, VP of SixSigma, JPMorgan Chase, “SixSigma is every bit as applicable to service processes as it is to manufacturing.” Since its development by Motorola in the late 1980s, SixSigma has gained considerable attention, especially since its adoption by high profile companies such as General Electric (GE) in the mid-1990s; SixSigma has spread like “wildfire” (Caulcutt, 2001; Goh, 2002; Chakrabarty and Tan, 2007). Many organizations in manufacturing and services, public and private, large and small have joined the SixSigma band wagon. In addition to Motorola and GE, many other Fortune 500 companies such as American Express, Boeing, Caterpillar, Fidelity Investments, Honeywell International, J.P. Morgan Chase, Johnson and Johnson, Kodak, Lockheed Martin, Maytag, Northrop Grumman, Sony and Texas Instruments have applied SixSigma to a myriad of projects. The SixSigma has spread from the US to the European Union, Japan and Canada. It is also gradually becoming popular in India and other less developed countries in Asia, Middle East and Latin America (Thawani, 2004). Table 2.6.2.1 summarizes recent studies that report SixSigma applications broken down by specific service industry or sectors. It includes examples from service industries as well as from service operations of manufacturing companies.
<table>
<thead>
<tr>
<th>Service</th>
<th>Problem</th>
<th>Outcome</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Healthcare</td>
<td>Increase number of radiology procedures and reduce cost per procedure in a hospital (Thomerson, 2001)</td>
<td>Significant improvement in radiology throughput and reduction in cost per radiology procedure</td>
<td>33% increase in radiology throughput</td>
</tr>
<tr>
<td></td>
<td>Safety of patient is poor due to overdose of medicines and errors in laboratory procedures</td>
<td>Reduced medication and laboratory errors</td>
<td>22% decrease in cost per procedure US$1.20 m in savings</td>
</tr>
<tr>
<td></td>
<td>Overcrowded emergency department</td>
<td>Lesser time to move a patient from the emergency room to hospital bed</td>
<td>Improved patient safety significantly a profit of $600K per year</td>
</tr>
<tr>
<td>Banking</td>
<td>Reduce customer complaints</td>
<td>Major reduction in customer complaints and rise in customer satisfaction levels</td>
<td>10.4% increase in satisfaction levels, 24.5% decrease of complaints</td>
</tr>
<tr>
<td></td>
<td>Excessive call backs (internal and external) plus unacceptable credit processing time (Rucker, 2000)</td>
<td>Reduction in call backs (internal and external), credit processing time is reduced</td>
<td>Internal call backs is reduced by 80%</td>
</tr>
<tr>
<td></td>
<td>Significant flaws in customer facing processes</td>
<td>To reduce these flaws</td>
<td>Improved customer satisfaction, increase in process efficiency. Reduction in cycle time by around 30%</td>
</tr>
<tr>
<td></td>
<td>High returned renewal credit cards per month in a leading bank (Bott, Keim, Kim and Palser, 2000)</td>
<td>Significant reduction in the number of renewal credit cards</td>
<td>Defect rate reduced from 13,500 DPMO to 6,000 DPMO</td>
</tr>
<tr>
<td></td>
<td>Excessive market losses on trading errors, high costs associated with electronic order corrections, etc. in an investment banking unit</td>
<td>Reduced trading errors significantly, Reduced costs associated with order corrections, etc.</td>
<td>Several millions of dollars in savings, Improved employee morale within the banking unit</td>
</tr>
</tbody>
</table>
Table 2.6.2.1: Application of SixSigma in service industries (Contd.)

<table>
<thead>
<tr>
<th>Service</th>
<th>Problem</th>
<th>Outcome</th>
<th>Benefits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financial services</td>
<td>High administrative costs</td>
<td>Reduction in administrative cost</td>
<td>Savings generated from this project are approximately $75,000 per year</td>
</tr>
<tr>
<td></td>
<td>Unacceptable wire transfer processing time to customers</td>
<td>Reduced wire transfer processing time by 40%</td>
<td>Savings generated from the project are around $700,000 per year</td>
</tr>
<tr>
<td></td>
<td>Problems in accounts receivables within an accounting department</td>
<td>Improved cash flow</td>
<td>Annual savings are estimated to be well over $350,000</td>
</tr>
<tr>
<td>Utility services</td>
<td>Poor service delivery</td>
<td>Improved service delivery</td>
<td>Annual savings from the project is of the order of over $1.5million</td>
</tr>
<tr>
<td></td>
<td>High contract complaints resulted in customer dissatisfaction and high costs</td>
<td>Reduced the number of complaints after SixSigma methodology was introduced</td>
<td>Complaints reduced from 109 to 55 on average per year</td>
</tr>
<tr>
<td>Miscellaneous</td>
<td>Poor delivery performance in a logistics company (Thawani,2004)</td>
<td>Reduced the number of delayed deliveries</td>
<td>Sigma quality level of the process improved from 2.43 to 3.94, improved customer satisfaction and increased market share, resulted in savings of $400,000 approximately</td>
</tr>
</tbody>
</table>

Use of SixSigma applied in the services sector has been dealt by researchers, academicians and practitioners and large number of expressive and focused articles being written by them (Patton, F., 2005; Antony, 2006; Chakrabarty and Tan, 2007; Hensley and Dobie, 2005; Antony, et al.,
There are theoretical studies done by scholars evolving conceptual models examining the prerequisite of an organization for implementing SixSigma successfully. Dobie (2005), in his research study assessed ability of organizations for implementing SixSigma methodology. This conceptual model conducted a survey in a public transit company and that data was used to examine the feasibility of SixSigma implementation there. Chakrabarty and Tan (2007) studied the present status of application of SixSigma in services using available information, both qualitative and quantitative, in the literature. This study was much focused to find out the key performance indicators and critical success factors which are critical to quality on successful implementation of SixSigma in service industry and brought out its authenticity as a management/quality practice. Biolos (2002) researched on applicability of SixSigma which is popularly known as a manufacturing industry practice into an entirely different domain as services sector clearly bring out the approach to be used while applying to services.

**SixSigma success factors**

Success factors of successful implementation of SixSigma in the major global organizations include efficient leadership, strong commitment from the management, ready to embrace a cultural change within organization with a focus on aligning the projects identified for SixSigma implementation to the business objectives of the organization, identifying the right team, encouraging team work, identifying the right methodology (DMAIC or DNADOV) for the organization, planned trainings on SixSigma, tools and techniques (Eckes, 2000; Antony and Banuelas, 2002, Antony, et al., 2007b). It also highlighted the importance of linking SixSigma to customer centricity, accountability in both financial and quality terms. There are studies conducted on the success of Sixsigma in small and medium enterprises (Wessel and Burcher, 2004; Antony et al., 2005a; Fahmy, 2006). The benefits, critical success factors and challenges of Six Sigma implementation are studied and documented from a service context (Antony, et al., 2007a). Most of the research on SixSigma is found in USA. There are also focused studies are being conducted in Taiwan, Germany, UK, Singapore and South Korea (Ho and Chiang, 2006: Taiwan; Wessel and Burcher, 2004: Germany; Kumi and Morrow, 2006; Antony et al., 2007a: UK; Pheng and Hui, 2004: Singapore; Kim, 2006: S. Korea).
Biolos (2002) and Antony, (2006) has conducted detailed analysis and suggests important aspects to be considered while choosing and implementing Six Sigma in services sector. This study helps in providing insight into the challenges and directions to overcome these challenges while evolving a strategy in implementing SixSigma in services.

- Identify the process which provides optimum leverage from use of SixSigma
- Customer centricity is key to successful implementation of SixSigma
- Essential to identify the pain/problem areas
- Analyze and find the root cause of the problems to be addressed through SixSigma
- Important to define service defect and the measurement of the defect
- Evaluate the benefits of SixSigma implementation before and after through effective measurement
- Bear in mind that SixSigma implementation is a long term commitment
- Risk identification, analysis and mitigation plan to be performed at the start and throughout the project
- Measure the benefits and costs incurred every phase of the project
- Roles and responsibilities of team needs to be identified and communicated clearly

Though there is enormous literature available on application of SixSigma to services, the literature has not dealt effectively on the benefits of it the customer. Evaluation of quality ends at the customer satisfaction levels as it is directly linked to the quality and cost to quality. Hence voice of customer and customer expectations are to be mapped and linked to SixSigma implementation.

**Limitations**

The literature survey brings out an important fact evidence of evolution of a proven service quality model or a conceptual service structure is missing (Hensley and Dobie, 2005; Kim, 2006). It is clear that the benefits of SixSigma application to services sector will be very limited unless the nature of services are clearly understood and articulated and how to measure the
quality in services; viz customer satisfaction, financial savings and so on as these benefits seem to be complementary.

2.6.3 ROLE OF SIXSIGMA IN IT SERVICES

Today, some of the largest IT service organizations are looking trim because of the process methodology called SixSigma. Sixsigma analyses a practical problem (normally called a pain area in the process, methodology, etc.) and arrive at a quantifiable statistical solution which is converted back into a practical solution. The measurements such as defects per unit, parts per million defects and the probability of occurrence of a defect, failure or error can be translated into a Sigma value in statistics (Mahanti and Antony, 2006).

SixSigma methodology is:

- Customer centric
- Based on quantitative analysis of data
- Assimilates well with software quality processes (CMM, CMMi methodologies)
- Measureable
- Effective in defect reduction from processes or products

There are two methodologies of Six Sigma used in practice. They are:

(i) DMADOV – Define, Measure, Analyze, Design, Optimize and Verify
(ii) DMAIC – Define, Measure, Analyze, Improve and Control

Design for SixSigma uses DMADOV methodology

SixSigma is a disciplined, data-driven approach and methodology for eliminating defects in any process—from manufacturing to transactional and from product to service. It is a measurement-based methodology that focuses on process improvement and variation reduction. It is based on the organized application of a set of statistical/analytical and problem solving tools/techniques.
For an industry that changes so often, IT services are unusually concerned with using a process like SixSigma for process improvement. They have their own solutions, no matter how tedious they might be and this causes many companies to balk at something they don’t think they need.

Software development processes can be fully characterized by three simple measurements (Janieszewski and George, 2004):

- time – the time required to perform a specific task;
- size – the size of the product produced; and
- defects – the number of defects, the type of defects, time to eliminate defects and so on.

However, SixSigma within the IT industry can actually create a continuous improvement process for companies, allowing them to spend less time fixing errors one by one and more time doing things that are productive for the organization. Problem solving is the purpose of many IT services in the first place and SixSigma simply serves to enhance that purpose.

**Implementation Challenges**

SixSigma is a data intensive approach to support software products within the specifications needed by customer. In a typical software development scenario, a software product is not useable until the integration of the software components and final user acceptance testing. Since SixSigma is a quantitative philosophy, there are challenges in applying this to software development as quantification of certain parameters is difficult. It is important to have right metrics both product and process to be evolved during the course of software development to effectively use SixSigma (Janieszewski and George, 2004). Since software development is cognitive and the software development solely depends on analytical reasoning and problem solving of intellectual minds, it is important to visualize and document the process whereas SixSigma tools do not address this directly (Card, 2000; Hong and Goh, 2003; Hong and Goh, 2004). Another reason, software development processes are not matured in comparison to manufacturing and other engineering domains which are evolved over many centuries (Aggarwal, 2004).
In software services industry, nearly ninety percent of the processes are repetitive and tangible process improvement can be achieved. Base of a survey conducted by Software Engineering Institute in 1999, it was noted that very few software organizations have established SixSigma practices in their organizations. There are many software development organizations, more than a million, in the world. Of which less than forty organizations are using matured processes for software development in which six or seven organizations are using SixSigma for process improvement frequently (Paulk, Goldenson and White, 2000). Another study, shows that less than twenty percent of nearly two hundred software companies use SixSigma to improve the quality of their products or services (InformationWeek, 2003). The research survey conducted in UK in 2004 within software industry, among the software industry among fifteen responded to the survey, there were ten companies using SixSigma methodology for process improvement. The study also showed that requirement analysis phase is a very important area for application of SixSigma and tools like Voice of Customer could be effectively used to understand the customer requirements at the beginning itself followed by maintenance and testing (Antony and Fergusson, 2004).

*Achieving SixSigma*

SixSigma is a proven methodology to enable significant improvements in business processes by clearly understanding customer specifications of the product and realize the product with eliminating defects to near zero, in the processes, products and services (Hayes, 2004).

SixSigma brings is a sequential problem-solving procedure, the DMAIC strategy (Design, Measure, Analyze, Improve and Control) and statistical tools offering a powerful methodology that ensures that potential causes are not overlooked and viable solutions to chronic problems can be discovered. SixSigma DMAIC is a data driven quality strategy using to improve the processes. DMAIC is an acronym for Define, Measure, Analyze, Improve and Control. In DMAIC approach, for every DMAIC cycle, the processes are analyzed to identify where defects occur and how it takes place, quantify the defects and remove or reduce these defects.
Design for SixSigma (DFSS) is derived for software development and it is an extension of the standard DMAIC (define, measure, analyze and control) process (Hallowell, 2003).

Since the SixSigma methodology is adopted from manufacturing industry into the software industry, it is essential to understand the application of SixSigma tools for improving the software quality through SixSigma training customized to Software Development Life Cycles (SDLC) to help identification and use of significant metrics which provides insight into how to meet financial objectives of the business (Gack and Robison, 2003). As implementation of SixSigma in software is different, it is indeed vital to have major pain areas which are directly applicable to the trainee’s needs to make best use of the training. The duration of the training programs for SixSigma black belts is generally six months. (Goyal and James, 2003).

*SixSigma and CMM in IT Service*

In software industry, process capability and continuous improvement in an organization is achieved through Capability Maturity Model (CMM) or Capability Maturity Model – Integration (CMMi) adopted and further developed by Software Engineering Institute. In this model the process maturity is categorized into different levels. SixSigma can be used for defect reduction through process improvement in specific process areas over and above CMM (Paulk, Curtis, Chrissis and Weber, 1993). This is being encouraged by Software Engineering Institute. Software process maturity helps to predict the organizations ability to meet specific project goals, viz. on time, on budget, with desirable levels of quality. Level 1 maturity organizations, projects experience exceptionally wide deviations in schedule from the plan, not meeting the
expected functionality requirements, hence not meeting the quality benchmarks resulting in customer dissatisfaction. When the organizations improve on their maturity levels, the variability between the plan and actual results reduce thereby a better quality product is achieved. Thus CMM acts as an effective tool for process improvement without getting at the subject of changes in organizational behavior and management accountability whereas SixSigma addresses these including the tools to identify the root causes of the defects and fixing them (Hayes, 2004).

Once the CMM process is implemented, SixSigma can be used as a quantitative methodology for further improvement of the process and it is not a replacement for CMM (Hayes, 2004). In a CMM Level5 maturity organization, SixSigma can be directly applied for continuous improvement of the key process areas. Hence, SixSigma and CMM are independent to each other (Card, 2000; Murugappan, Keeni and Blending, 2003). Organizations have used SixSigma to attain hire capability maturity levels (Heinz, 2004), for example, Northrop Grumman Mission Systems took advantage of SixSigma implementation to move from Level 3 to Level 5 capability maturity in their software processes. While CMMI aims at process maturity for organizational transformation, SixSigma focusses on reducing the process variations through measurements for process improvement (Gack and Robison, 2003; Janieszewski and George, 2004).

Constraints

In a software development scenario, implementations of SixSigma are with an objective to minimize the defects as a goal. For the software development process to achieve SixSigma standard will be a costly proposition and hence it is unlikely that the true SixSigma level of 3.4 defects per million opportunities, is achieved. SixSigma is used in IT service as a tool for continuous improvement. The software product delivered to customer does not meet the requirements and is having major defects can cause customer dissatisfaction and loss of business to competition (Hong, and Goh, 2003).

There is proliferation of application of SixSigma across manufacturing industries, however, is limited in service industries. The reason cited is that service processes are neither seen, nor tangible and not measurable. However, this is rather not true as SixSigma tools have been used
effectively for health care, banking and call center services (Hensley and Dobie, 2005). There is
initiation of the use of SixSigma methodologies in services such as education and hospitality.

2.6.4 QUALITATIVE ANALYSIS OF SIXSIGMA IN SERVICES

Rework exists in services as in manufacturing. Rework occurs if the product does not meet the
specifications or requirement for which the product is developed. Examples are such as a
software product not meeting the end user requirement, contacting a customer to verify an order,
penalty for incorrect service or substandard service (Does, Heuvel, Mast and Bisgaard, 2002).
There are many success stories of implementation of SixSigma in services by GE Capital Corp,
Mount Carmel Health System, GE Medical Systems, Virtua Health, Citibank and Bank of
America (Jones, 2004; Henderson and Evans, 2000, Rucker, 2000). There are traces of
applications in call centers such as DuPont de Nemours (Bott, et al., 2000; Wyper and Harrison,
2000) and technical support services by Caterpillar (Schmidt and Aschkenase, 2004). Analysis
shows that the SixSigma implementation to be successful proper identification of key
performance indicators (KPIs) and critical success factors (CSFs) are essentials to achieve the
outcomes which are critical to quality (CTQs). These factors are discussed now.

Critical Success Factors (CSFs)

CSFs refer to “identification of the specific areas in which desirable results will warrant fruitful
competitive performance for every component of the organization” (Coronado and Antony,
2002). They include the following:

- Top management commitment

It is essential that top management commitment is needed for successful implementation of
SixSigma. To meet the expectations of such implementation the focus and periodical review by
leadership, else the initiatives will stall and fall considerably short of the expectation or it will
fail. There is evidence in the literature that this is an important factor to achieve successful
implementation of SixSigma (Coronado and Antony, 2002).
Thus the “top-down” approach is to be initiated by a specific group or division or from the ground (Goh, 2002). The involvement of the leadership helps to influence and restructure business functions and the cultural change needed to be instilled in individual employees toward quality (Henderson and Evans, 2000).

- Education and training

It is essential to come up with a strategy for training processes that helps in creating a team of certified Six Sigma Black Belts, Green Belts, etc. (Goh, 2002). The hierarchy to SixSigma training and certification is set up much like martial arts with black belts, yellow belts and green belts (Johnson and Swisher, 2003). Only through effective training, fundamentals, tools and techniques of SixSigma is well understood so that implementation of SixSigma will become smooth and effective (Kwak and Anbari, 2006).

- Cultural change

SixSigma is driven through a cultural change with the organization and involves a change in behavior. It is often known that the it is a breakthrough management strategy while SixSigma is applied and it necessitates change in company values and culture (Caulcutt, 2001). Hence the top management ensures a thorough review of organization’s structure and infrastructure and a substantial change may be necessitated (Coronado and Antony, 2002). There needs to be a clear organization wide communication plan and there has to be a plan in place to motivate individuals to understand and disseminate this change to overcome resistance and to educate the team and customer on the benefits of SixSigma (Kwak, and Anbari, 2006). While the organizations drive results through SixSigma and the repeated successes will benefit employees and customers there by the stakeholders will begin appreciating this disciplined, data driven methodology there by the culture of the organization will slowly change positively.

- Customer centricity

Customer focus is one of the major requirements in applying SixSigma. This is emphasized in terms of critical to quality characteristics. SixSigma is highly sensitive to requirements for
customer satisfaction (Goh, 2002). How to meet the requirements of customers? What are they looking for? What keeps them awake at night? Which of your customers are best customers? Understanding what customers really care about is fundamental to SixSigma, because processes have to perform at a measurable level that consistently meets the customer’s needs (Coronado and Antony, 2002). Customer expectations and requirements are often unspoken and vague so we need to translate these into a measurable output.

- Performance metrics

Right metrics of measurement is very important while implementing SixSigma. It is at times difficult to identify what to measure. Hence at the beginning of SixSigma initiative, it is important to have clarity and agreement on the metrics to be used for measurement of the performance (Sehwall and DeYong, 2003). The secret for successful SixSigma is to establish a clear set Measures of Excellence (MOE) and Measures of Performance (MOP). While MOE assess the process and people effectiveness from a customer perspective, MOP, in turn, assess the efficiency of people and processes from a stakeholder’s point of view (Goh, 2002).

- Linking to financial benefits

Implementation of SixSigma and its success of these in terms of financial benefits and measurement performance have helped organizations in identifying the selection of such projects (Henderson and Evans, 2000). Outcome of the SixSigma project in terms of financial benefits as a measure of achievement makes it easily motivating for employees (Goh, 2002). SixSigma implementation initiates cost avoidance, increases profitability, generates additional revenue. Risk management is bolstered and organizations get a quick return on their investment. Although SixSigma training is relatively expensive, the financial benefits of supporting it greatly outweigh the upfront costs.

- Work processes

It is important to have an understanding of the work processes across the service organization. Since the measurement of the work processes provides a direct understanding of the SixSigma implementation to customer satisfaction, organizations spend considerable time and effort in this regard. A half-hearted attempt is seen in some organizations they quantify only part of what is
central to the customer. An organization is ready for SixSigma implementation programs if an only if these organizations have robust measurement systems in place (Hensley and Dobie, 2005). All these factors are applicable to services sector as in manufacturing.

**Critical To Quality (CTQs)**

CTQs convey quality of a product or service that is derived from the voice of the customer. They are the key measurable indicators of a product or service whose performance standards or specification limits must be met to satisfy the customer. It aims to align improvement or design efforts based on customer requirements. In layman terms, CTQs are what customers expect of a product or service. They are the spoken needs of the customer. Customer satisfaction is key to the success of any SixSigma improvement philosophy in service processes.

The CTQs breaks down customer requirements into quantified requirements. There is limited discussion on CTQs in the literature around SixSigma in services. There are similar or common CTQs exist across various services contexts though services are widely different, the analysis from various literature (Kwak and Anbari, 2006; Jones, 2004; Sehwall and DeYong, 2003; Rucker, 2000). There is a brief discussion on CTQs is given below:

- **Time**

  Time is an important parameter as in services sector; customer is involved in the process directly. Service time, waiting time and cycle time are typically considered in services sector.

  - Service time is the time required to service a customer request
  - Waiting time generally is the time taken where a customer waits in the system to get the work completed
  - Cycle time is the total time including service and waiting time.

- **Cost**

  Like time, cost is also an important parameter from the customer’s perspective. In fact, cost and time are linked. Customers may be willing to pay more for a service that gets completed in a
lesser time depending on the urgency. Generally, a trade-off between cost and time is, thus, important for services.

- **Employee behavior**

Employee behavior is very important and is very sensitive from a customer point of view. If employee behaviors are negative, it may impact the productivity and hence the customer satisfaction. Continuity of awarding services to a specific vendor solely depends on the employee behavior.

- **Information**

Accurate and timely information is essential for delivery of all the services. For example, the call center services need to handle information needs for the customer. From a customer satisfaction perspective, the right information at the right time is important for efficient delivery of the services.

Although various scholars have written on SixSigma in Information Technology services, the studies have a very narrow focus. While some studies focus on implementing SixSigma for improving productivity of the team based on extensive data analysis, others focus on integrating the SixSigma methodology in reducing defects of the software solutions provided to customers. In the following paragraphs we discuss some of the key studies and their findings.

**Key Performance Indicators (KPIs)**

KPIs are a measure that is used to track the performance of the organization to a high level (strategic) goal. The KPIs measures used by the organization are an important consideration in the selection of SixSigma projects. In other words, it is a metric that is related to a target value. They show the ratio between actual and targeted values. It shows actual data of a particular outcome. For example, if a production target is 1000 items and if 750 have been currently produced, the KPIs comparison results show that 75% of the target is achieved. Therefore, KPIs is a guiding light for any organization.
KPIs are very important aspect which needs attention while dealing with services sector. The major KPIs are the following:

- **Efficiency**: Efficiency is a direct measure of performance. In other words, it is accomplishing a job with minimum time and efforts. It is doing things right. On time delivery of services at a cost effective way denotes the efficiency of the implementation in a services scenario. Achieving greater efficiency is the objective of any organization. Higher the efficiency higher is the profitability (Eckes, 2003).

- **Cost reduction**: Reduction in cost can be achieved through waste elimination viz. reduction in errors, mistake proofing the processes, improving the productivity by optimizing the time take to complete a task. The cost reduction path has to be adopted in all the organization activities to increase profits and reduce waste.

- **Time-to-deliver (Antony, 2004a)**: A successful delivery is directly tied to time. The reputation of any organization is made or broken by their delivery times. Monitoring on time delivery allows you to flag negative trends and enable faster customer service using time as a metric allows for improved quality and decreased costs as process times are reduced through systematic barrier removal. Example: the timely delivery of information or document as per customer requirement.

- **Quality of the service**: This is a measure of the customer satisfaction. Delivering what customer needs is a measure of quality. There are two aspects for quality; technical and functional aspect (Hensley and Dobie, 2005). The actual output of a service is the quality requirement from a technical feature point of view whereas the service process is the functional which is the interface between customer and the service provider, i.e. the service process (Ghobadian, Speller and Jones, 1994).

- **Customer satisfaction**: The customer satisfaction is a very qualitative parameter though the output of a service can be measured. Moreover, customer satisfaction varies from customer to customer, and service to service. While services call center is offered , customer satisfaction depends on the timeliness of the information received where as a
patient admitted in a hospital, feels satisfied based on the comfort and assurance that the doctor or the staff nurse provides (Sehwall and DeYong, 2003). The retention rate of customers could be used as a direct measure or an indicator of the customer satisfaction levels.

- **Employee satisfaction**: Employee satisfaction is also an intangible measure. Organizations performance is directly proportional to employee satisfaction as the productivity of the organization depends on this factor. Employee attrition rate is a direct measure of employee satisfaction (Eckes, 2003). Employee satisfaction is directly proportional to employee retention rate. Since the financial performance improvement due to SixSigma is shared with the employees that could improve the morale of the people who participates in SixSigma initiatives. This may result in higher employee satisfaction and the retention could improve (Henderson and Evans, 2000).

- **Reduced process variation**: Reduction in the variation of processes is a direction measure of improvement in quality. SixSigma aims to contain the variability of the output in a process or product similar to statistical process control to help achieve improved standards and consistency (Raisinghani, 2005). Examples of reduction in variation in a services scenario may be, reducing the time required for processing, or the errors in a billing process and erroneous laboratory test results or the inaccuracies in the decision cycle of a credit process in a bank (Sehwall and DeYong, 2003; Rucker, 2000).

- **Financial benefits**: Implementation of SixSigma can help in achieving significant bottom line performance (Henderson and Evans, 2000). Bottom line performance is a direct measure of operational efficiency and is an excellent indicator of the impact of benefits of SixSigma implementation (Goh, 2002).

## 2.6.5 SIGNIFICANCE OF SIXSIGMA IN IT

Automation of the processes through IT has been the focus in all organizations and industries. For large organizations Chief Information Officers will be responsible for managing the IT requirements. As part of the automation, there will be mission critical components in business
are to be treated as a core area as any failure in these components can stall the entire business process. Hence these software projects are treated differently as this becomes one of the major interfaces between the company’s customer and its products and/or services.

A survey conducted by Standish group to analyze the on-time, on-budget delivery of around 8000 software projects, it was found that planned budget exceeded nearly ninety percent, there was a schedule overrun of 120 percent twenty five percent of projects got cancelled due to substandard quality, delays and budget overruns. The software developed was failing on meeting the requirements are of the order of 80 percent. Failure to deliver due to flaws in the software development life cycle was of sixty five percent (Grady, 1996).

A division of HP released a product with defects identified during the test phase due to market pressures. This has become very expensive for HP as they need to resort to another costly update of the product and continuous repairs and changes were needed due to not meeting quality standards (Grady, 1996).

Most of the mission critical requirements of systems are being performed through end to end software or partly by a software system. Some of the applications, such as the software used in Nuclear power plants for public safety, needs to be perfect or fool-proof (Schwartz, 1996). Software malfunctioning had caused major mishaps in the past (Schmitt, 1991). It is essential to improve the quality standards of software development to ensure that it meets the requirements in all respect. SixSigma becomes very relevant as a methodology to build defect free software in a cost effective way.

2.6.6 SIXSIGMA TOOLS AND METHODOLOGIES

The origins of sigma as a statistical method dates back to Frederick Gauss who introduced the normal distribution in statistics. “Three sigma” has been used as a measurement for output variability or variation by Walter Shewhart (Shewhart, 1931). If the process variation goes out of this limit, there will be intervention needed in improving the process. Three sigma is equivalent to a process yield 99.973 percent which is equal to a defect rate of 2,600 per million
opportunities. Most of the manufacturing units used three sigma until early 1980s when Motorola introduced SixSigma.

Motorola was the birth place of SixSigma that revolutionized the scope and use of quality systems. Statistical process control, gage repeatability, failure mode effect analysis and reproducibility studies are some of the fundamentals to SixSigma (Catherwood, 2002; Henderson and Evans, 2000). SixSigma is a framework which integrates quality tools to derive quantitative financial performance with the help of top management support (Hahn, Hill, Hoerl and Zinkgraf, 1999).

**DMAIC:** DMAIC is a fundamental component of the SixSigma methodology, which seeks to eliminate defects from the business process, resulting in a more efficient, streamlined company. DMAIC stands for Define, Measure, Analyse, Improve and Control, which are five steps to be followed in sequence that make up a part of the SixSigma process.

1. **Define** is identifying the problem and project goals at various levels which may consist of strategic objectives and require improvement.
2. **Measure** involves determining the relevant data which allows a business to judge how much it has improved.
3. **Analyze** verifies cause and effect relationship. It aims to eliminate the gaps between current performance and desired levels, using statistical tools.
4. **Improve** finds ways to make the system better, cheaper, faster and optimizes the current process.
5. **Control** ensures to correct the errors before they result in defects.

DMAIC is a proven methodology while applying to existing processes as this SixSigma methodology unifies all features of project management and financial analysis. DMAIC methodology is an efficient process framework to handle existing process improvement for achieving the defined performance measures to achieve desirable benefits (Kwak and Anbari, 2006; Goel, Gupta, Jain and Tyagi, 2005; Raisinghani, 2005).
**DFSS:** Design for SixSigma (DFSS) is a rigorous approach to designing products and services that gets it right the first time. The result is product designs that consistently meet customer requirements, projected costs, targeted release dates and production capabilities.

DFSS is applied mainly for new processes. DFSS comprises of several of methodical and comprehensive approaches to product, process and service design (El-Haik and Roy, 2005; Basu, 2004; Coronado and Antony, 2002; Stamatis, 2002a, 2002b; Harry and Schroeder, 2000).

While there a few common tools for DFSS and DMAIC such as quality function deployment and Voice of Customer, tools such as the theory of inventive problem solving and axiomatic design are used only in the DFSS methodology.

### 2.7. INTEGRATION OF LEAN AND SIXSIGMA

*Summary*

Lean Methodology can be summarized to:
- Optimize inputs, reduce wastage and enhance outputs
- Maximize productivity of any process.
- The outputs are to meet the customer specifications
- Produce the correct customer requirement at the first time
- Establish “continuous improvement” in every process

SixSigma Methodology can be summarized to:
- Select projects to solve problem with and objective to maximize financial savings
- Collect the voice of the customer while analyzing the problem for a solution
- Study the business process and document, including inputs and outputs
- Collect samples and analyze the variations
- Minimize variations to ensure sustainable quality
Comparison

Organizations have been striving to identify continuous improvement methodologies or tools for improving the operations efficiency, reducing cycle time, reducing defects in the products of services. With these objectives industries in US have chosen SixSigma and Lean management as they are the most widespread methodologies or industry practices in US and Japan. SixSigma was originated at Motorola Corporation. This was effectively used subsequently in US by major industries like AlliedSignal and GE. Whereas Lean Management was founded by Toyota in Japan and this has been adopted by some of the US companies like Harley-Davidson and Danaher Corporation. While SixSigma focuses on a quality improvement regime where in defect reduction being the motto, the Lean management aimed at elimination of waste through a well-defined methodology.

Blending the Methodologies- Lean SixSigma (LSS)

George (2002) defines the best candidate for Lean SixSigma as: “The tasks and actions that cause the quality issues which are critical to customers and causes very long time delays in any process provide the highest opportunity for improvement in cost, quality, capital and lead time”.

While introducing Lean as a continuous improvement philosophy as an ongoing activity to SixSigma project, the project becomes an ongoing process. While the workforce is empowered to make changes for incremental improvement, SixSigma uses statistical tools to measure the variability and the success of changes in an ongoing way.

Both SixSigma and Lean management have evolved into comprehensive management systems. In each case, their effective implementation involves cultural changes in organizations, new approaches to production and services, a high degree of training and education to employees from upper management to the shop floor. As such, both systems have come to encompass common features, such as an emphasis on customer satisfaction, high quality and comprehensive employee training and empowerment.
With disparate roots but similar goals, SixSigma and Lean management are both effective on their own. However, some organizations that have embraced either SixSigma or Lean management might find that they eventually reached a point of diminishing returns. That is, after re-engineering, the operating and supporting systems for improvement, by solving major problems and resolving key inefficiencies, further improvements are not easily generated. These organizations have begun to look elsewhere for sources of competitive advantage. Naturally, Lean organizations are examining SixSigma and SixSigma organizations are exploring Lean management. The term Lean SixSigma has recently been used to describe a management system that combines the two systems (Sheridan, 2000). Essentially Lean SixSigma integrates two methodologies to optimize natural resources by reducing waste, reducing defects through effective and proven processes.

2.8. LEAN SIXSIGMA IMPLEMENTATION IN A FLEXIBILITY FRAMEWORK

Globalization process inherently makes the business environment highly turbulent and enormous interest has been received on the concern of ‘change’ by practitioners (Sushil, 2005). Continuity and change are the twin characteristics of any software development process as it evolves from the traditional Life cycle approach to incorporating and managing flexibility from an end-user perspective. Business requirements constantly change till the release of a software product though the features of continuity are evident in the software development process itself. The idea of Lean, as borrowed from the Lean manufacturing context, is an agile methodology for managing change while the SixSigma approach emphasizes continuous improvement as part of a defect reduction strategy. We propose a software development approach that holds together the aspects of both continuity and change under a flexible management system and illustrate the application of the continuity - change framework using an integrated Lean SixSigma for software development in a practical context.

Flexible Management is one strategy for maximizing profitability at project level, organization level which includes lean manufacturing and Lean SixSigma. Flexible management strategies are incorporated by a business to make defect free products/ models in a shorter cycle time (Lasserre, 2003). This often involves methodologies viz. Lean, SixSigma and can help make a system more profitable by utilizing it more efficiently.
Recent propagation of the philosophy about combining Lean methods with SixSigma approaches for continuous improvement has attracted the attention of academia and industry. The continuity forces are normally associated with the ‘processes’, whereas the change forces largely emanate from ‘flexibility’ (Sushil, 2001). SixSigma is representative of continuity forces and Lean is representative of the change forces (Pillai, Pundir and Ganapathy, 2012).

In simple terms, flexibility is the opposite of rigidity. Flexibility is the ability to adapt to new, different or changing requirements (Sushil, 2000). Flexibility in Lean management is a measure not of a sub-system but of an entire value stream from the end customer through the supply chain and back to the end customer (from request to fulfilment). A Lean measure of flexibility entails planning and capacity building that is based not on forecasts but on real customer demand (Volberda, 1998). Thus, it represents the ability of this value stream to deliver consistently every product within commitment date.

In order to deliver better manufacturing, Lean manufacturing SixSigma strategy must remain completely flexible. This flexibility may indicate the necessity for employing methodologies and tools that deliver optimum results for every stage of the Lean SixSigma process (George, 2002).

Cost reductions, faster time-to-market, better products and differentiated services are now the important pillars in managing any software development process. Cost reduction and seamless productivity improvement by ensuring optimal developmental cost are becoming more relevant that before. In this changing business environment, software engineering approach is undergoing a shift from the traditional Software Development Life Cycle (SDLC) approach to newer models that can provide higher predictability and risk reduction by ensuring that business deadlines are met. Recently the germination of the idea about combining Lean methods with SixSigma approaches for continuous improvement has attracted the attention of academia and industry. The continuity forces are normally associated with the ‘processes’, whereas the change forces largely emanate from ‘flexibility’ (Sushil, 2001). SixSigma is representative of continuity forces and Lean is representative of the change forces.

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2.9. LEAN SIXSIGMA FOR SOFTWARE APPLICATION SUPPORT

During their evolution, IT organizations typically mature through three stages: technology provider, service provider and strategic partner (Salle, 2004). Research suggests that large enterprises spend an average of 73% of their IT budget on Application Support and Maintenance activities of existing system (Humphrey, 1989). Clearly, IT Service management presents high potential for cost savings in global enterprises.

Good IT service management is essential to achieve business benefits from IT at an agreed and controlled cost. Without good IT service management, it is common for IT projects to fail or go well over budget at project stage, for on-going IT costs of ownership to spiral out of control and for businesses to fail to achieve the benefits they expected (Pigoski, 1997).

Pigoski (1997) makes an argument contrary to the typical definition of software maintenance as: “the totality of activities required to provide cost-effective support to a software system”. His view of totality thus encompasses activities in the pre-delivery stage in addition to the traditional emphasis on the post-delivery stage. Pigoski’s (1997) view includes planning for post-delivery operations, supportability and logistics determination in addition to post-delivery activities such as software modification, training and help desk support. According to Pigoski (1997) the following functions should be specified within a software maintenance organization’s charter: management, software modification, software configuration management, training, documentation support, user liaison and help desk, testing, quality assurance and technical assistance.
Organizations resort to research on usability of other proven frameworks or methodology to be adopted over the ITIL to achieve productivity improvements and cost reductions. There is evidence of frameworks, based on the Lean methodology, which can be used to guide ITIL processes optimization. Attempts have also been made by integrating the SixSigma quality methodology with IT service management to offer the methodology and tools for measuring quality and improving processes (Chan, Durant, Mae Gall and Raisinghani, 2009). There are empirical studies are effectively conducted on integrating ITIL with Lean philosophy for improving IT processes.

Studies also show the use of Lean SixSigma in software application development in IT service organizations. Su, Chiang and Chang (2006) proposed an integrated Lean SixSigma philosophy for improving service quality. This study was focused on the motivation for combining these two mutually exclusive disciplines and defended on a theoretical angle. They also report an experimental study conducted for Information Technology helpdesk service scenario to illustrate the implementation processes and the effectiveness of this philosophy for service quality improvement. Our earlier study showed that application of Lean SixSigma is a great tool for continuous improvement providing considerable cost-advantage and productivity in software application development (Pillai et al., 2012).

Chan et al. (2009) proposed a framework for improving IT service management by combining SixSigma with ITIL processes in the e-services and mobile applications. Studies have reported compelling benefits in aligning ITIL with SixSigma (Chan et al., 2009). Based on the white paper by GE, on combining ITIL with SixSigma, these two approaches are highly complementary and can be used in combination effectively to continually improve business processes (Fry and Bolt, 2004).

2.10. ITIL

ITIL was developed by the British Government during the 1980s trying to increase efficiency, value and success in the delivery of programs and projects in the public sector. Over the years, ITIL became popular and, nowadays, its credibility is highly recognized. Its practices are aligned
and have contributed to the ISO 20000 Service Management standard, the first international standard for IT service management (ITSM) (Reiner, 2007).

ITIL is the most widely adopted guidance for IT service management worldwide. It is a non-proprietary best practice that can be adapted for use in all business and organizational environments. ITIL’s value proposition centers on the IT service provider (internal IT or external supplier) understanding a customer’s business objectives and priorities and the role that IT services play in enabling these objectives to be met. ITIL adopts a ‘lifecycle’ approach to IT services, focusing on practices for service strategy, service design, service transition, service operation and continual service improvement (Betz, 2007)

2.11. ALIGNING ITIL WITH LEAN

Lean is a methodology to organize, manage, develop and improve business processes with the aim of doing more with fewer resources. Lean thinking is used in the manufacturing world as a major approach in reducing or nullifying the waste in the overall operations. It is used as a tool for enhancing the efficiency of existing process by removing operations or activities which are not important. To achieve this, Lean principles find out the non-value added activities and the time spent for the same. It emerged after the World War II in Toyota’s manufacturing environment, however, in the last few years, it has been applied in the services industry (Fillingham, 2008). Since Lean thinking is used successfully in manufacturing industry, ever since the Toyota Production System, organizations understood the power of Lean principles and have applied very well in non-manufacturing domains to improve the process efficiency especially in support and other services common to the information technology domain. As in manufacturing processes, non-value added processes and the time spent for this was not taken very seriously. It is this abuse or misuse of time is what Lean solves identifying it as waste in the processes.

Lean is based on the principles of specifying value, mapping the value stream, enabling continuous flow, pull strategies and pursuing perfection. Following these principles enables quicker and more flexible processes allowing the delivery of services with higher quality and
more value to the customer (Sayer and Williams, 2008). In this paper, the expression “value” is used to describe any feature or service for which the customers would be willing to pay for.

Lean can address a wide range of sources of waste in end-to-end manual or systemized transactional processes including:

- Overproduction—too many transactions in the process;
- Over processing—too much non value-added activity;
- Waiting—too much time between value-added activities;
- Ownership issues—usually, too many owners complicating the decision making process;
- Unnecessary movement—too much movement between value-added activities;
- Underutilization of human resources— the skill set deployed is too narrow.

The popularity of ITIL is majorly from its ability to efficiently handle customer service and processes. Continuous improvement is part of the ITIL objectives, though ITIL does not propose any tool or methodology for this. On the shortcoming part, there are challenges in implementing ITIL as it consumes considerable time for implementation. Moreover, there is no mechanism within ITIL to measure efficiencies nor it does report or speak on management or leadership issues within an organization. The initial implantation is complex though the advantages thereafter are significant. ITIL uses available best practices most of them derived out of compiling the past successful processes. It is a process driven by the organization, top management decides and gets this implemented. Basically ITIL is a top down approach for refining the processes where the commitment from each member of the organization is essential. Considerable time needs to be spent by each one in the organization for redesigning and redeploying the processes which makes the ITIL implementation challenging.

Lean as a process improvement discipline and ITIL as a process improvement framework neatly complement each other in the IT world. Lean ITSM focuses on using Lean principles along with ITIL based service management practices. Since ITIL does not have a continuous improvement philosophy within its framework, it attempts to leverage Lean principles for lowering the operational costs by improving and leveling the processes within the IT function. It can be easily understood that Lean and ITIL both have a common aim of improving the processes used while
delivering IT services by an organization. In fact Lean brings in the added advantage of making the processes Lean and thereby the implementation becomes cost effective in managing the IT infrastructure. Lean ITSM can free up resources that can be used elsewhere.

2.12. COMBINING ITIL WITH SIXSIGMA

Organizations have identified that TQM and SixSigma complement each other and these can be used for driving competitive advantage and thereby organizational success (Su and Kano, 2003). The SixSigma invented by Motorola, has been thoroughly tested by Allied Signal and improved further by General Electric (GE). At present, application of Sixsigma found relevance in non-manufacturing domains. Significant savings can be cited in transactional processes, service, support, health care, financial services and other non-manufacturing areas (Reichfield and Sasser, 1990). The SixSigma principle is normally applied to create high quality performance while proving overall reliability to the customers. It follows the principle that when defects are removed, total quality is improved.

Methods, Tools and Techniques are vital to the success of any SixSigma project. SixSigma can be accomplished using two key methodologies: DMADV and DMAIC - both inspired by Deming's Plan-Do-Check-Act Cycle. Every stage of a SixSigma project recipe requires a mix of these methods, tools & techniques.

DMAIC is used for continuous improvement to solve business critical problems so as to improve conformance to the processes in a disciplined and structured fashion (Harry and Schroeder, 2000). Most of the quality methods and processes evolved from TQM (Breyfogle, 1999). There are tools getting added from other areas to improve operational efficiency from disciplines such operations research (Hoerl, 2004).

Continuous improvement is an integral part of the ITIL (Damiano and McLauglin, 2007). Integrating SixSigma will enable IT management in ITIL to use the tools and methodology defined in SixSigma methodology (Chan et al., 2009). Through adoption of SixSigma principles
in ITIL helps IT managers concentrate on their business strategy and customers, manage proactively based on facts and strengthen collaboration across the enterprise (Chan et al., 2009).

2.13. COMBINING ITIL WITH LEAN SIXSIGMA

Lean SixSigma builds on the knowledge, methods and tools derived from decades of operational improvement research and implementation. Lean approaches focus on reducing cost through process optimization. SixSigma is about meeting customer requirements and stakeholder expectations and improving quality by measuring and eliminating defects. Lean SixSigma approach draws on the philosophies, principles and tools of both. Lean SixSigma primarily focuses operational improvement – refining existing processes to reduce costs, improve performance and provide better customer value. Lean SixSigma drives transformational, sustainable bottom line results (Arnheiter and Maleyeff, 2005) through the use of proven methodologies that increase process speed, eliminate waste, reduce variation and improve customer satisfaction.

Lean SixSigma’s goal is growth not just cost-cutting. Lean SixSigma is suitable for services as:

- Service processes are usually slow and therefore expensive. Slow processes reduce quality, drive costs up and customer satisfaction down.
- Service processes are slow because there is far too much work-in-progress (WIP). Complexity increases WIP. Some WIP spends 90% of its time in in-boxes waiting to be worked (Thomas, Barton and Chiamaka, 2009)
- Usually 80% of the delay is caused by less than 20% of the activities (Breyfogle, 1999)
- Most steps in a service process add no value in the eyes of the customer.

As productivity improvement and lowering costs are important and essential for all the IT organizations, the future of IT service management needs to adopt tools and methodologies used for achieving these parameters within the organization. Hence Lean SixSigma becomes relevant in IT management which integrates the power of LeanSixSigma with ITIL for process refinement for the entire portfolio of services. Combining Lean SixSigma with ITIL represents a significant stride toward the impending IT service management.