



## DEVELOPMENT OF LEAN SIX SIGMA FRAMEWORK FOR TESTING, INSPECTION & CERTIFICATION INDUSTRY

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### **Abstract**

**Purpose** – The purpose of this paper is to present a study on development of Lean six sigma framework for testing, inspection and certification industry with certain set of tools & techniques that are best suitable.

**Design/methodology/approach** – The study was performed using the soft-positive paradigm with combination of qualitative and quantitative questionnaires distributed to selected companies.

**Findings** – The framework developed & tested in the selected testing, inspection & certification companies reaped the direct benefits which boosted their business objectives. The tangible measured metrics has been improved and demonstrated significant benefits to the companies. During and post implementation the employees and management engagement has been improved which resulted in preventive approach rather the corrective approach.

**Research limitations/implications** – The research is focused and limited to testing, inspection & certification industry and carried out in India. Due to the varied knowledge levels of employees in different geographical areas / countries, the results may vary from region to region.

**Practical implications** – The positive results from implementation of developed Lean six sigma framework encourages the other Testing, inspection & certification companies for implementation and Testing, inspection & certification industry is benefitted.

**Originality/value** – The paper fulfills the framework gap related to testing, inspection & certification industry.

**Category** Thesis research paper

**Keywords** Lean six sigma; Metrics; Key performance indicators; Quality

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### **Introduction**

The driving factors in the global economy markets are efficiency, competitiveness and equal distribution of income to all people around the world. However, the globalization insisting the organizations towards stiff competitive scenario, where goods & services produced is of best quality with lowest price and promptly delivered. Thus, all the organizations have been shifted their continual improvement mode to continuous improvement strategies. Organizations are becoming more agile with execution of Lean six sigma approaches for driving their business growth and profitability.

Lean Six sigma focuses on improving value and delivery times through assisting companies in producing products and services superior, quicker and cheaper. (Jiju, 2011) Lean is based on the qualitative methods and Six sigma is based on the data mining and process variation reduction.

(Mousa, 2013) Lean Six sigma can be used at wide range of projects in a variety of sectors. However, its use in incremental micro-project level is not feasible due to the requirement of highly trained experts for deployment. (Vojislav et al., 2011) Lean means “Speed and Low cost” and Six sigma means “Culture and Quality”. (M.P.J et al., 2010) Lean and six sigma are two great concepts of the century, both are very effective in the process change management and innovation as individual methodologies, but upon integration it will be an excellent tool for exceptional business results. (Jiju, 2014) Lean six sigma is the most productive and robust methodology for facing process inefficiency problems in the higher education sector.

(Jiju et al., 2017) Lean six sigma usage in Europe by public enterprises is in early stages. The gains of using lean six sigma in community enterprises are:

- Costs associated with sudden problem explosions investigations and unnecessary problem-solving efforts in not using a disciplined methodology are substantially reduced.
- Revitalization of organizational culture from being reactive to proactive approach.
- Improved awareness of the customers voice and the associated quality factors which can have the highest impact on customer fulfillment.
- Decreased number of non-value-added operations as a result of methodical elimination, leading to quicker service delivery, quicker TAT and also in reduction of critical process performance attributes to customers and all other parties.
- Most of the managers lack statistical expertise and the skill to apply statistics to problem solving. Lean six sigma provides a basic framework for managers to use practical and demonstrated applied statistical tools and techniques for problem solving.
- Superior receptiveness and tractability to meet customer demands.

(Jiju et al., 2011) Lean six sigma is used as a profound business improvement strategy globally. Its use has started in manufacturing and now it is used in almost all industry sectors, most remarkably in the recent years it sprawled in to the service sector including clinical, healthcare, government and allied services. (Monika et al., 2018) DMAIC which is one of the methods of quality improvement can increase the effectiveness while adequately responding for the emerging problems. DMAIC methodology is selected for Lean six sigma framework based on the ease of adeptness and its implementation success across the industries from manufacturing to service. (Inal et al., 2017) Even most of the laboratories across the world are accredited by the respective accreditation bodies and availability of best infrastructure. There are still lot of gaps which can be a hindrance to the quality and delivery of services. Testing, inspection & certification sector challenges and global competition are examined and interpreted for Lean Six sigma application. Testing, inspection & certification sector business models and process requirements are studied at global and national level for development of suitable Lean six sigma framework.

(Mahobiya et al., 2017) The combination of Lean and 6 sigma to process improvement can be effectively implemented in the testing laboratories connected with healthcare sector. It produces the benefits of cost efficacy, superior process quality and improved operational efficacy.

The present Testing, Inspection and Certification (TIC) industry is rapidly expanding across the geographies and necessity for Testing, inspection & certification offerings continue to flourish in all parts of the world, particularly in the developing countries of Asia and South America. This progress is being encouraged by a numerous factor in commercial policies and economic effectiveness, which demands the services to be delivered accurately with lowest cost and on time.

The Indian testing and inspection market is similar to the global scenario, but the process and product regulation by the governments are lesser than compared with the developed economies. Even with the lower regulations, due to the massive population and geographical factors this market is looking promising with the sustained business turnover.

The emerging economic growth spurred with the improved gross domestic product driving the testing inspection & certification market to a positive environment. Along with those the growing trade relationships with different countries leading to the improved business through the supply chain engagement. The increase in private suppliers also contributing to the business growth by increased test / inspection services. In general, the government producers mostly rely on government agencies, now due to private partnerships with the government, testing, inspection & certification sector is benefiting as private suppliers more linear to quick and quality service.

In the recent years, Quality council of India (QCI) is playing a vital role in this industry through managing all the accreditations under one regulating authority and encouraging in application of third-party assessment model for use in government, regulators, organizations and society. QCI is insisting on third party conformity assessments for all the public sector units and government testing related activities, which is creating a new market opportunity for this sector market players.

The testing, inspection & certification industry is not very much matured in implementing Lean Six sigma, big companies like SGS, Bureau veritas etc. uses the services of consulting companies like McKinsey / KPMG for implementation. When it comes to midsize to small companies, they are not that much aware of Lean six sigma and implementation is very minimum. But there is no research evidence in this industry; it is needed to explore this opportunity to undertake this research study for betterment of Testing, inspection & certification industry as a whole. The current state of knowledge base in the field of Lean Six sigma and Testing, inspection & certification industry comprises of various dimensions. (De et al., 2008) Lot of research studies are carried out in the area of Lean six sigma are related to manufacturing and financial services.

The work environment in the testing, inspection & certification industry is also very dynamic in nature and has its vast scope of operations from inspection and testing of bulk commodities like Coal, Iron ore to finished goods of Steel plates, structures etc. The present available frameworks of quality systems like ISO 17025:2017 (Laboratory management system), ISO 17020:2012 (Inspection management system), ISO 9001:2015 (Quality management system) are not supporting in improvement of their processes as per the present competitive customer requirements.

(Mehmet et al., 2012) These quality management systems provide a basic framework for processes to be executed majorly focusing on documentation and record keeping. Although it provides the guidelines on the process improvement requirements but did not emphasize on any methodologies / strategies. The organizations are free to choose the quality improvement methodologies and realize the improved results.

With these rapid developments, organizations can yield the huge returns of implementing the Lean Six Sigma and this research work helps in developing a Lean six sigma framework and in improvement of performance indicators.

### **Methodology**

The research has started with the research questions of

1. Whether Lean Six sigma is applied in the Testing, inspection & certification industry?
2. Are there any specific framework / model available which is suitable to Testing, inspection & certification industry?

After literature review, it is understood that very little research is carried out on Lean Six sigma application in Testing, inspection & certification industry and there is no research done on development of specific framework / model suitable for Testing, inspection & certification industry. Then the study is undertaken on Lean Six sigma tools and its relevance in Testing, inspection & certification industry. (Yousuf et al., 2018 ) DMAIC is a specific methodology more suitable for service industries. Lean Six sigma framework using DMAIC methodology is developed suitable for Testing, inspection & certification industry and tested the framework in Testing, inspection &

certification companies located at Visakhapatnam for validation and documented the findings / outcomes.

(Kirsch, 2004) The guiding philosophy for this research is the soft-positivism paradigm. Although the approach is quantitative in nature, it also has the elements of interpretivism which are of qualitative during framework development.

(Siti, 2010) The view of positivism is generally recognized and appreciated in the almost all the research strategies. It always presumes that there are basic social facts which have an empirical truth apart from the values of the individual. The quantitative data collection and analysis is done on the developed Lean Six sigma framework validation case study which has considered the facts objectively and evaluated. All the questionnaires are provided to the testing, inspection & certification companies independently without any personal interference and the data is measured by objective methods. Most of the positivist methods like representative survey, formal questionnaires are deployed for case study. Finally, statistical methods are used for objective evaluation of the results which are significant for positivist approach.

Sample design: The study is focused on Testing, inspection & certification industries of Visakhapatnam district. A sample of nine Testing, inspection & certification companies out of total available companies of around 26 are selected by using purposive sampling in the first phase of survey (data collection). In the second & third phase of survey four companies agreed to participate in the detailed survey, study and implementation in their organizations.

Primary data: A well-structured three questionnaires are designed to collect data from the employees of the selected Testing, inspection & certification companies which are referred in Appendices at the end of the thesis.

Secondary data: The data is collected from company annual reports, test reports, ILC reports and Proficiency testing programs reports from the Testing, inspection & certification companies

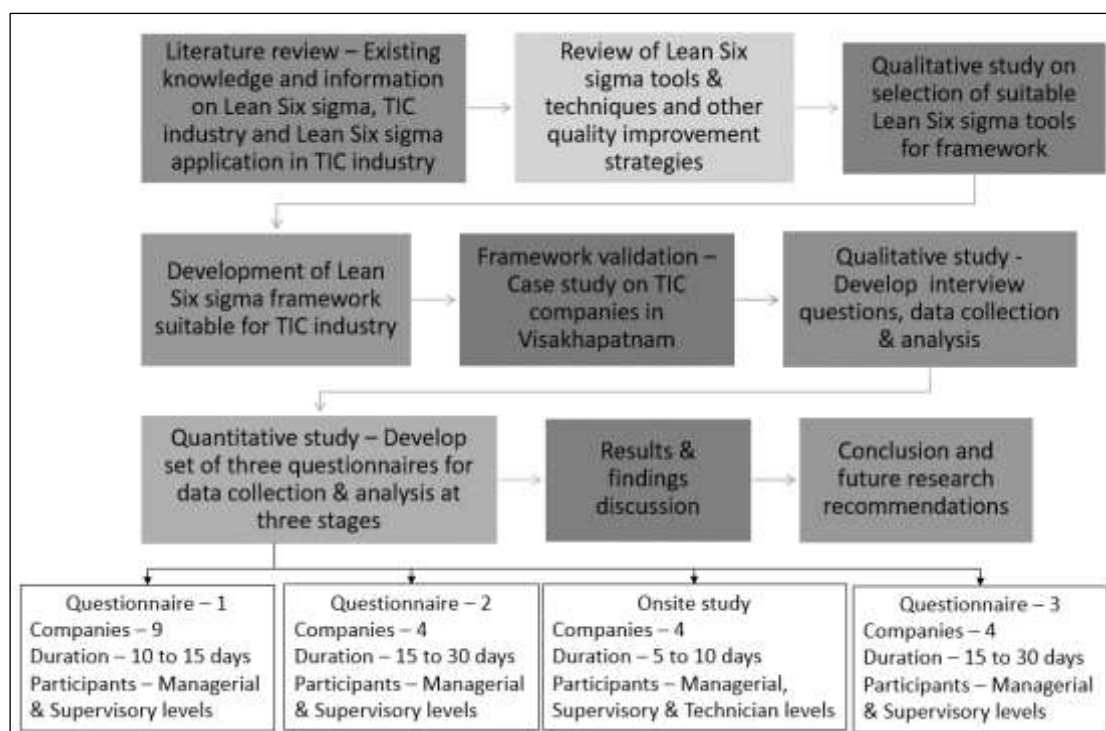


Figure I - Overall Research Design

The data obtained from initial survey (primary) and reports (secondary) is analyzed using statistical and analysis tools for process gaps and improvement opportunities. Then an action plan is devised and implemented for improvement. The post implementation data is collected from the survey and

reports. The results are validated with the statistical tools (paired sample t-test & others) and recorded the improved results. The control measures are developed to sustain the benefits and concluded the findings.

### Analysis

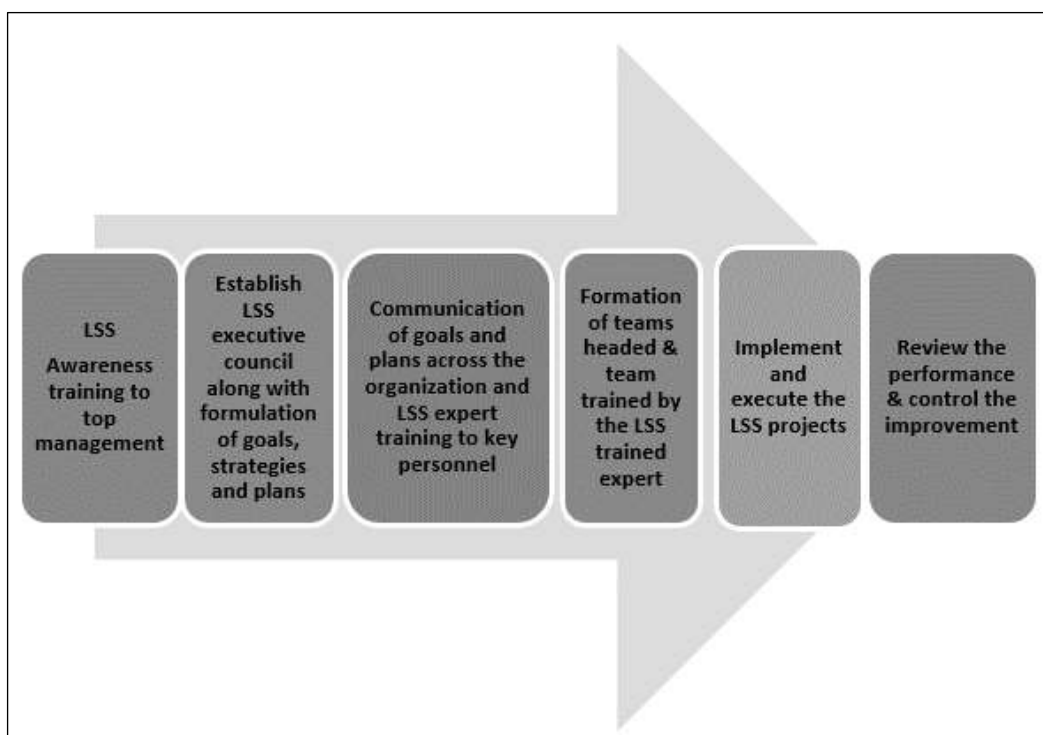
The analysis of study is carried out in three stages – Development of Lean Six sigma roadmap, Development of Lean Six sigma framework and deployment in Testing, inspection & certification companies for results evaluation.

Development of Lean Six sigma roadmap:

Lean Six sigma is a powerful tool to capitalize the business and process improvements in any kind of industry. (Chugani et al., 2016) Organizations can use Lean Six sigma to support their compliance with environmental regulations and save costs while also meeting quality management and operations standards.

But it is highly recommended that it can only benefit when it is properly deployed into the organization with adequate planning and scrupulously. (Rathilall et al., 2018) The following factors are key for successful deployment of Lean Six sigma:

- Top management commitment
- Adequate awareness and training programs across the organization
- Top management dedication for allotment of resources
- Development & measurement of bottom-line indicators
- Encouraging the team culture
- Long term goal plans
- Employee motivation and retention programs



## Figure II - Lean Six sigma (LSS) deployment roadmap

Development of Lean Six sigma framework:

The following requirements are considered during development of the framework.

a. Compliance to regulatory requirements.

- Confidentiality
- Integrity
- Management commitment
- Impartiality
- Infrastructure
- Technical competence
- Document control
- Quality control

Risk management

- b. Lead time reduction.
- c. Test result accuracy. (Repeatability & Reproducibility)
- d. Quality in reports.
- e. Compliance to external party requirements.
- f. Process / technology innovation.

The following factors are considered in selection of the tools into the framework:

- Relevancy to the practices in the technical aspects
- Consideration of the knowledge and education level of the staff
- Target organizations process maturity
- Ease of usage
- Bottom level expertise in controlling and monitoring the practices
- Statistical knowledge of the managerial staff
- Type of data availability
- Interaction channels and modes available in the processes

Different factors are considered for various stages of the framework and the tools are selected based on the merits over the factors. It is imperial for any methodological structure that the information flow is of paramount importance and is duly taken into consideration.

The framework is designed with the structure comprising of the different Lean six sigma phases and the tools & techniques of Lean Six sigma used for the metrics measurement and improvement.

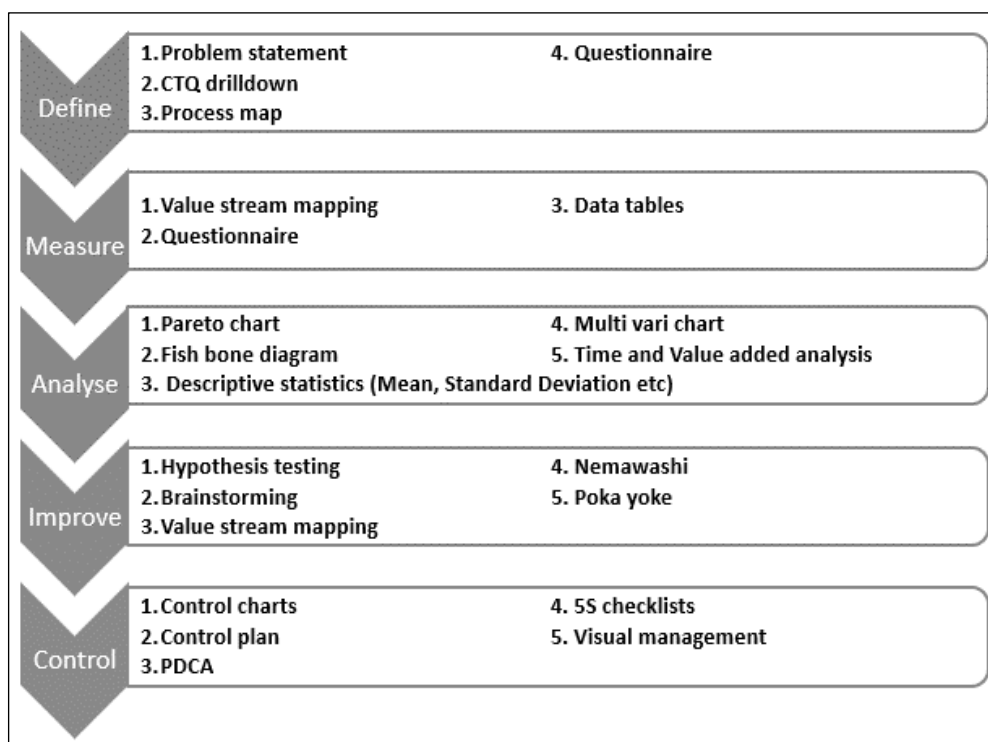


Figure III - Lean Six sigma framework suitable for testing, inspection & certification sector

Each tool in the framework is selected from various available tools based on the critical success factors and operational suitability. The framework is validated with the implementation in the testing, inspection & certification companies at Visakhapatnam and the outcomes are measured for effectiveness.

The failure factors and industry requirements are critically examined and infused into the framework development process. The metrics are devised to measure the effectiveness of the Lean six sigma framework during deployment.

After critical review of the requirements and limitations, the following measurable metrics are selected in to the Lean Six sigma framework design for effective results.

- a) **Turn around time (TAT)**- The TAT is described as the cumulative amount of time taken for a report to be produced. It includes the start time at which the job is started to test report generated and distributed to the customer.
- b) **Repeatability of test results** – It is the difference value between the consecutive tests conducted in the same laboratory conditions of the same sample.
- c) **Reproducibility of test results** - It is the difference value between the tests conducted in the different laboratories of the same sample.
- d) **Reports error rate** – The mistakes / errors occurred in the certificates / reports which was reported to end customer. It is calculated as the ratio of number of certificates reported with errors to total number of certificates reported
- e) **Customer satisfaction**–The degree of satisfaction perceived by the customers for the provided services by a company as measured by the objective survey evaluation.

## Results

The developed Lean six sigma framework has successfully implemented in the Testing, inspection & certification sector on selected sample companies. The journey provided several valuable lessons

for future research work. The framework is welcomed by the companies and implemented with dedicated efforts. The achieved results from this project (case study) are positive and improved the overall performances of the measured metrics. The improved performance metrics resulted in increased business & reduced costs, which helped the company's management in achieving their business objectives. Lean six sigma involved all levels of employees in process improvement and improved the teamwork culture. Moreover, the employee morale and confidence has been improved which is an intangible benefit.

The designed framework is deployed in the Testing, inspection & certification companies on real time basis and collected data on the improvement results. The entire research results are summarized below.

Table 1 - Research case study improvement summary

S#	Performance metric	Before	After	Improvement
1	Turnaround time (TAT)	1975 mins	1845 mins	6.6 %
2	Customer satisfaction index	81%	95%	14%
3	Repeatability of test results	Overall mean variance - 14.91	Overall mean variance - 6.63	55%
4	Reproducibility of test results	17%	100%	73%
5	Reports error rate	3%	0.60%	80%

During and post implementation the employees and management engagement has been improved which resulted in preventive approach rather the corrective approach.

### Conclusions and discussion

The present research contributed in understanding the needs and expectations of the Testing, inspection & certification industry relevant to the application of Lean six sigma and enumerated the requirements and limitations for development of the Lean six sigma framework suitable to Testing, inspection & certification industry. The different tools and techniques of Lean six sigma are discussed for their application to various problems / cases and some specific tools and techniques are selected for the framework based on their benefits and suitability to the Testing, inspection & certification industry.

After development of framework, it is validated through implementation in selected few Testing, inspection & certification companies and the results are documented. The obtained results showed a significant improvement in all the metrics measured and proved the suitability of the developed framework for Testing, inspection & certification industry.

The specific conclusions of the research are summarized in this section.

- **The relevance and application of Lean six sigma in Testing, inspection & certification industry is studied and presented the business drivers for Lean six sigma contributions:** The following business drivers which insists in Lean six sigma application.
  - ❖ Increasing trend in regulatory compliances through accreditation and certification requirements
  - ❖ Growing consumer awareness on third party inspections considering as a value addition rather than cost incurrence
  - ❖ Government initiatives for outsourcing inspections especially in developing countries



- ❖ Increasing trend in commercial obligations towards third party inspections
  - ❖ Ever increasing consumer demands in technology innovation and digitalization
  - ❖ Growing export and import markets as a global phenomenon especially in developing economies
- **Testing, inspection & certification industry requirements are collected and analyzed for Lean six sigma application and framework development**
  - **The Lean Six sigma framework is developed suitable for Testing, inspection & certification industry:** The framework design is very simple and robust to achieve the sustained improvements. The tools and techniques used in the framework are easy to use and result oriented with proven track record. A roadmap is also designed which in conjunction implemented which delivered the incredible results.
  - **The Lean Six sigma framework is tested in Testing, inspection & certification companies and measured the effectiveness:** The framework is implemented / tested in the selected Testing, inspection & certification companies; they reaped the direct benefits which boosted their business objectives. During and post implementation the employees and management engagement has been improved which resulted in preventive approach rather the corrective approach.

There are numerous areas of future research opportunities related to Lean six sigma framework design and application. The present research is focused on Testing, inspection & certification industry operational processes, but there is lot of scope for exploring it in management processes too. There is a scope for research in critical cultural challenges in implementation of this framework to apply for scalability.

The developed Lean six sigma framework can be applied in allied service industries is potential research. The framework suitability and customizations in Testing, inspection & certification allied services are to be the research questions to answer. Even the monetary benefits measurements from the outcomes / benefits are to be researched for management attention and commitment.

There are several challenges encountered during the research process with the limitations of different natures. The sample and sample size selection are also limited due to the extensive requirement of the data and availability with the Testing, inspection & certification companies. Due to time constraints, limited number of companies are selected in a particular city (Visakhapatnam) for empirical research. With the lack of Lean six sigma expertise among the employees of the selected Testing, inspection & certification companies, difficulties are faced during the data collection and implementation even after providing awareness trainings. Due to the requirement of highly technical & specialized skills in Lean Six sigma, the sampling method is limited to purposive sampling taking account the company branding and maturity factors.

### **Conflicts of interest**

The authors declare no conflict of interest. This research had no funding from any one / sources.

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