Lean Six Sigma approach to increasing operational efficiency: An action research in a meter supply contractor for energy providers

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ABSTRACT

The purpose of this research is to investigate the practical implications of the Lean Six Sigma (LSS) application in a service environment of the power generation sector. A meter supply contractor for a major UK energy provider was selected for the case study. An action research about job completion was conducted through application of LSS methodology. It was found that implementing LSS can minimise causes of the unnecessary job abortion as the defect, and therefore increase the efficiency of the operation in short term with some financial benefits. This research project is limited to a single case study that explores one particular unit of a company in the energy sector. The UK Electricity Supply Industry (ESI) as a service provider for power generation sector has not been targeted by LSS before and this research project has investigated the practical feasibility and strategic benefits of LSS application in this sector. This project was conducted in a customised operation of a service environment and different mixtures and volumes of work over a period could not be controlled, as part of the operations are driven by customer requests. The results also indicated that more data is required to establish if the improvements have been able to reduce the defective rate in the long-term.

1. INTRODUCTION

Many businesses are attempting to boost their operation efficiency to remain competitive in ever increasing demanding and changing markets. Running operations at the lowest cost, with greater reliability and speed and a superior ability to change and continuously improve, are some of the pillars in the development of a competitive operation strategy [1]. The literature has acknowledged the importance of operation efficiency for energy providers [2]. The aim is to deliver products or services to a customer in the most cost-effective, efficient and streamline process whilst ensuring the high quality of product or service. Many methods have been used in the past by companies from different sectors such as Total Quality Management, Just-In-Time, Lean and Six Sigma. One method being increasingly used to increase operational efficiency is through the application of Lean Six Sigma (LSS). The research studies have acknowledged the significant role of LSS to improve key strategic operation dimensions such as speed, cost, quality, cycle time and reliability [1, 3].

The aim of this project is to investigate the benefits of using the LSS methodology in a service supplier to power generation sector to increase their operational efficiency by reducing the number of incomplete operations per opportunity. To achieve this aim the project will follow the Define, Measure, Analysis, Improve and Control (DMAIC) framework commonly used in LSS. By following this framework the project will have a structured approach and will make use of the appropriate tools and techniques associated with Lean Six Sigma.

LSS is a business improvement strategy that has flourished over the last decade and has evolved through the combination of Lean and Six Sigma, both recognised as leading total quality management tools for performance improvement [4-12]. LSS is now regarded as one of the most effective business transformation initiatives available in strategic operations management as well as an affective top-down methodology for improving quality. It eliminates waste factors such as variability and rework time known as defects by accomplishing a near perfect quality level through the systematic removal of causes of the defect [6, 13-16]. LSS focuses on cost and process cycle time from Lean and Kaizen and sustainable process improvement and profitability from Six Sigma [8, 17-19].

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At an operational level, the LSS model aims at clarifying the process of identifying opportunities to reduce variability and improve quality of the process [20]. There have been some limited research studies about application of Six Sigma for some power generation sectors [21, 22]. However, this did not extent to the service environment of the power generation industry, where other suppliers provide service to this sector. The purpose of this research is to develop a broader theoretical view by integrating Six Sigma and Lean principles and to investigate the LSS benefits for a meter supply contractor for energy providers.

2. LSS FOR PROCESS IMPROVEMENT

LSS projects focus on customer needs, financial enhancement [23,24], and improved efficiency [25] by reducing the variation in process, reducing non-value adding activities, better decision making and improved employee morale [13, 20, 26]. Overall, LSS tends to produce substantial improvements in the speed and time performance dimensions [1]. These benefits are being extended to service sector, where the application of LSS appears to be increasingly in vogue [10, 13, 27, 28]. In recent years there have also been a growing number of research outputs highlighting the role of LSS methodology to improve quality, cost efficiency and profitability in manufacturing sector [5, 20, 29-33].

The LSS success stories in terms of increase in efficiency or Sigma value for process industries such as power generation is not as impressive as manufacturing sector due to less convenience for data collection and improvement [22]. The process and service environment of power generation industry have hardly been focused by LSS research [8, 34]. The increased scope of the Six Sigma literature in service sectors has also been tarnished with more difficulties [10, 12, 35]. The lack of awareness of LSS, lack of strategic orientation, Working Mentality and lack of clear understanding of the defects were recommended as inhibitors that could challenge the application of LSS in service industry [36]. This would make implementing LSS project in service environment of power generation sector even more difficult.

Successful implementation of LSS projects in any organisation including process and service sector depends on many factors including top management commitment, linking LSS to business strategy, training, understanding tools and techniques and selecting the right project [26, 36]. This would emphasise on the importance of LSS methodologies that incorporates the right project selection and practical improvement through utilising tools and techniques. DMAIC (Define, Measure, Analysis, Improve, Control) is the most common and systematic LSS methodology [18], which was adopted for this action research.

3. CASE STUSY BACKGROUND

The case study Company is a meter operator contracted to an energy provider and is responsible for the installation and maintenance of their domestic gas and electrical supplies throughout the UK. One of the main targets for this Company in the coming years is to exchange all of their meters from standard meters to automated meters capable of sending accurate meter readings. The UK government has imposed a target of switching all residential gas and electric meters in the UK to smart meters by 2020. In order to achieve this target the company has recognised the importance of increasing their operation efficiency to comply with their projected business plans.

The Company is now turning to the application of LSS in an attempt to reduce the number of incomplete operations in one area of the company referenced to as Ward A through a pilot scheme. The area covers one team of metering engineers covering customers across North Yorkshire and Cleveland (Ward A). The team consists of one manager and seventeen engineers with various skills and roles. The work volumes constantly vary for the team and for the year 2014 to date the team has seen an average of 1,600 operations per month being issued to engineers.

Therefore, the research methodology for this study will be an action research, in which the LSS DMAIC will be proposed to increase the efficiency. Action research is a practical research strategy, which may be applied in one organisation and is concerned with the management of a change through a cycle of diagnosis, planning, action and evaluation [37]. It is important to note that researchers acknowledged the importance of the prerequisite elements for LSS implementation such as training, cultural change, budget allocation and infra-structure team building [26, 36]; and this project was a loose simulation of a comprehensive LSS project.

The top managers in this process have been closely involved and committed to this practice. There has been minimum disruption or any extra required budget, since one of the researchers have been a current engineer in the Company and has had the role of team leader. Although, there has been certain level of training for some other engineers involved, but there has been no official Belt-Training for this specific project. The whole statistical analysis has been conducted by the authors of this article with the support of literature and also the LSS data analysis software of the Minitab.

4. LSS METHODOLOGY OF DMAIC

DMAIC methodology is an integrated continuous improvement (CI) methodology, which is adopted to guide LSS model application, reduce process defects and variability and to promote simplification, standardisation and waste reduction [1, 38]. The brief introduction of activities and required tools and techniques in each phase of DMAIC methodology of LSS was illustrated in figure 1.

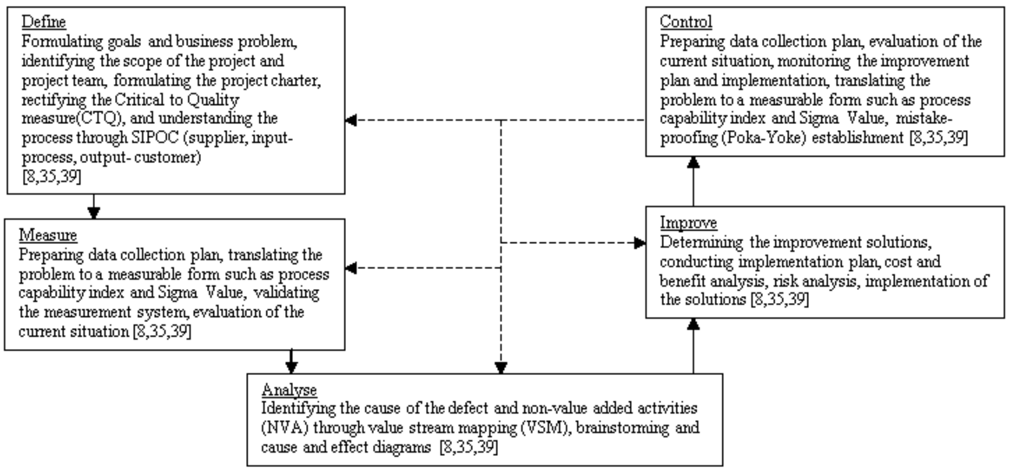


Figure 1 – DMAIC Methodology of LSS with common activities and tools

5. LSS DMAIC METHODOLOGY APPLICATION

Define Phase **-** Having identified the team members and obtained support from top managers and process owner, the project charter was introduced as the first step. This is an important step in LSS project that transforms the initial agreements and facts into a documented project management approach [40]. The problem statement has been issued and objective was articulated amongst team members and managers as:

"*Ward A of the Company maintains its operation by reducing the daily aborted jobs from estimated 9.4% to 7.5% with estimated £ 32,000 benefit per year".*

The high level process map was created to demonstrate visually the processes and activities that could have impact on completing the jobs by engineers.

Measure Phase - The key objective of the measure phase is to understand the process capability, the current position of the process and Critical to Quality (CTQ) metric [41]. The data collection plan was set to ensure about the quality, reliability and accuracy of the data. The Company was able to provide information on the number of operations issued and the number of operations aborted from 60 days between May and June 2014. The company also provided information about the entire 316 aborted operations during this period, which could be recognised as defect. The P-Chart of process capability analysis of the aborted jobs (figure 2) demonstrates the defective%, while as the result of binomial capability analysis (Appendix A) lays below 12%, and is acceptable; the calculated sigma value was reported as 2.75. The P chart has highlighted some out of control variations in some occasions as the result of special causes, which need further investigation.

Analysis Phase - The start of this phase looks at the special-cause variation identified by the P-Chart giving an indication the current process is violated in some occurrences. The job allocation documents for these occasions have been closely reviewed and 36.8% of the jobs on these occasions were aborted under various abort codes coming from different engineers ruling out the external cause.

As the result of Pareto Analysis (Figure 3) for all aborted operations within data collection period, it appeared that

62.4% of the job abortions happened due to the “cancellation by engineers”, “failure of smart meter installation”, and “Cancellation by the customer”. However, further investigation for each individual engineer did not present any clear answer that left researchers to develop Ishikawa diagram and “Cause and Effect XY Matrix” analysis (Appendix B) to identify key potential causes of the defect. As the result of extensive brainstorm with managers and engineers, and also quantitative analysis, it was found that “External Smart System Faults” and “Smart Commissioning Error Codes” could be the most potential causes of the job abortion. The option of the “Wan on Coms Hub not stable” as the third high -ranked element has been considered for the next possible necessary stage of the investigation, since the approach of the researchers was to focus on top two key sources of the problem.

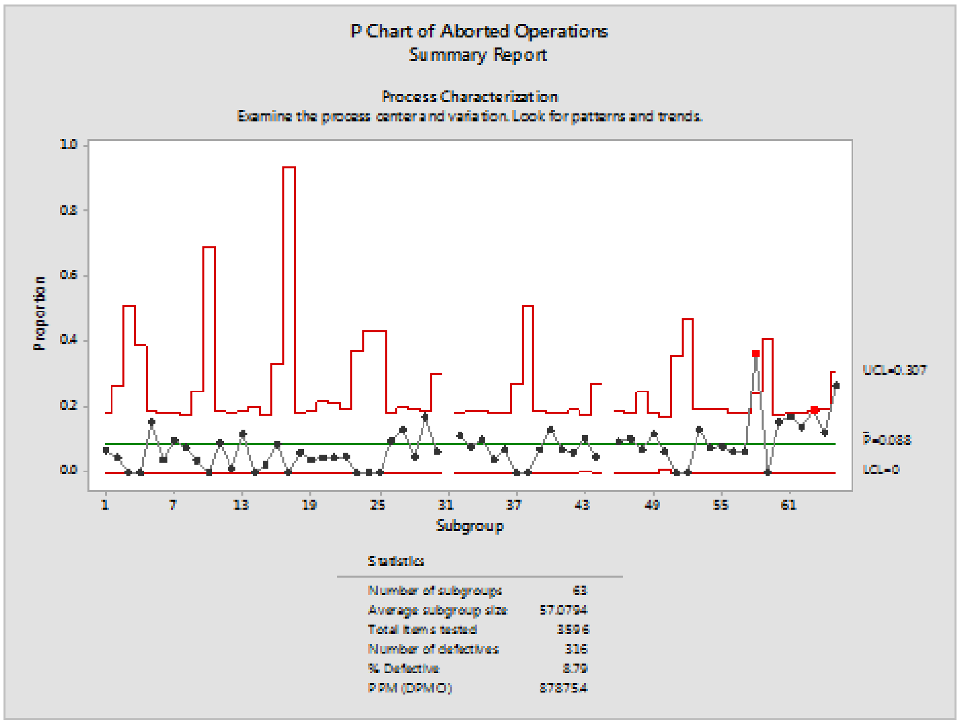


Figure 2 – Process Capability of the operations in relation to aborted jobs

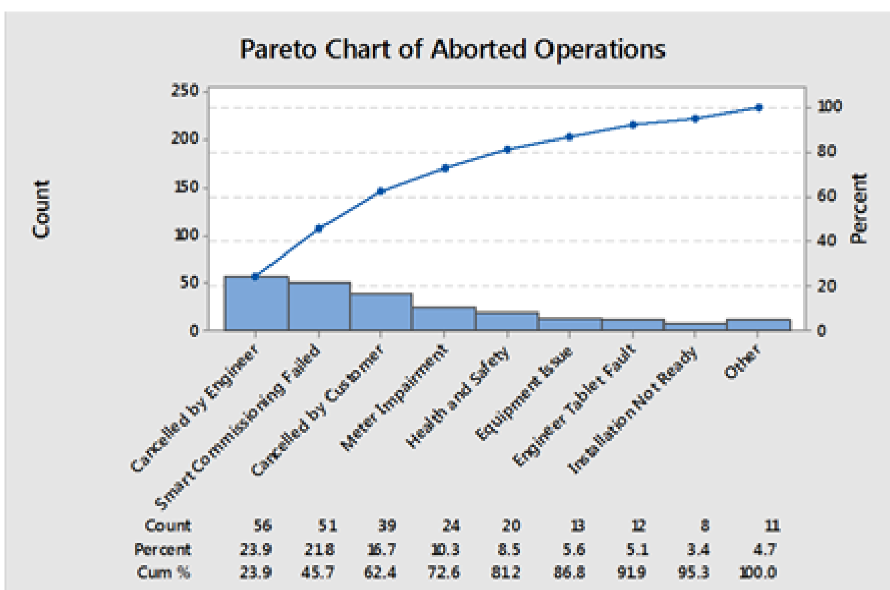


Figure 3 – Pareto Analysis of the sources of the job abortion

Improve Phase - This phase of the LSS project is aimed at identifying, implementing and observing solutions for all the root causes identified during the analysis phase [39,41]. Four different potential solutions have been presented for each of those two major root causes of the defect to be analysed through Analytical Hierarchy Process (AHP) and cost/benefit analysis. The desired solution for the "External Smart System Faults" was to develop the ability in order to enable engineers to commission the meters at a later date through software update. The desired solution for "Smart Commissioning Error Codes" was replacing the old version of troubleshooting guide with a more interactive and comprehensive guide. The implementation of "5 S" system was also piloted with five engineers for their operations environment (Van) as the result of observing numerous issues in job completion such as increased lead time and job abortion related to this. It was suggested that "5 S" system would increase the efficiency of the engineers and the workplace (Wagon), which would promote less opportunity for the causes of job abortion.

Control Phase - The purpose of the control phase is to ensure the improvement made are successfully and sustainably implemented and communicated to those who work with the process and to ensure that improvements are monitored [39,41]. The implementation of two solutions was planned to start and last for two weeks as a pilot scheme. All engineers were notified about the upcoming changes via email, delivered presentations in the monthly meeting of the ward, technical operating procedure and signing acknowledgment documents of the new changes. The implementation of the improvements to the engineers commissioning software was predicated to cause some initial disruption to the process. Therefore, the new set of data was collected after two weeks of the initial implementation. The collected data indicated the improvement in the process. The defective% reduced to 7.86% representing the sigma value of 2.91. The P-Chart of process capability analysis of the process after improvement (figure 4) depicts no more excessive violation to the process due to minimising the root causes of the aborted jobs. However, the variation in the process is still high, which could be as the result of the nature of this service provision process. The Binomial Capability comparison analysis summary report was presented in appendix C.

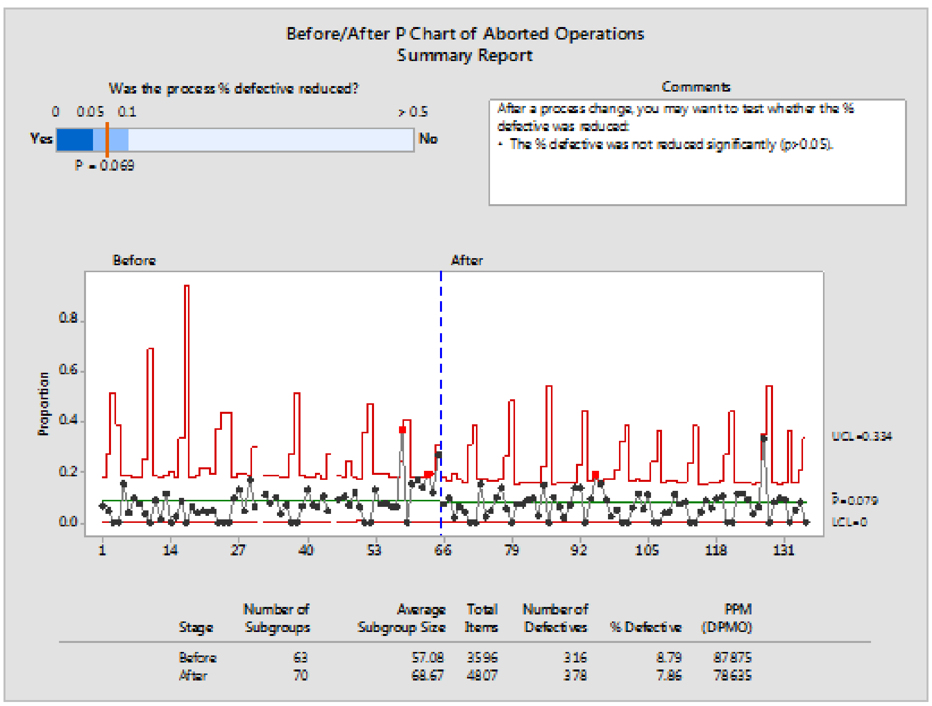


Figure 4 – Before/after P-Chart of the aborted jobs

6. CONCLUSION REMARKS

The implementation of LSS seems to be successful for this pilot study, which was conducted in one single ward of a service provision Company. Although, the sigma value shows slight change, but the financial benefits was estimated more than £25,000, which has been acknowledged by the management team as acceptable, given the size of the project and also the customer satisfaction and operation efficiency impact. The 5S system and the updated integrated version of troubleshooting guideline have had significant share in improvement. It seems more data is required for better investigation of the impact of the new software to reduce the smart commissioning error and therefore further reduction of the aborted jobs. The project has identified that in the short-term the rate of defect has been reduced resulting in operational efficiency of the team. Therefore, the project has been able to confirm that LSS could be applied in different wards and sections of the service providing suppliers of the power generation sector with the short term benefits. However, this needs to be investigated in broader view and in the long – term planning approach. This project has also been conducted in a very restrict environment with a limited information allowed to be exposed followed by cautious behaviour of managers and engineers to participate. This study would recognise another avenue for deploying LSS research in a new area, where the existing research studies of Six Sigma has failed to penetrate appropriately.

REFERENCES

[1]E. Drohomeretski, S. E. Gouvea de Costa, E. P. De Lima, and P. A. De Rosa Garbuio, "Lean, Six Sigma and Lean Six Sigma: an analysis base don operations strategy", International Journal of Production Research, Vol. 52 No. 3, pp. 804-824, 2014.

[2]S. Kitamura, M. Kazuyuki, Y. Izui, T. Miyamoto, and S. Takai, "Operation Optimization of Factory Power Generation Plant Considering an Uncertainty", Electric Engineering in Japan, Vol. 189 No. 2, pp. 822-830, 2014.

[3]D. Näslund,"Lean, Six Sigma and Lean Six Sigma: Fads or real process improvement methods?", Business Process Management Journal, Vol. 14, No. 3, pp. 269-287, 2008.

[4] M. Assarlind, I. Gremyr, and K. Backman,"Multi-faceted views on a Lean Six Sigma application", International Journal of Quality and Reliability Management, Vol. 30 No. 4, pp. 387-402, 2013.

[5] F. K. Wang, and K. Chen, "Application of Lean Six Sigma to a panel equipment manufacturer", Total Quality management, Vol. 23 no. 4, pp. 417-429, 2012.

[6]B. Choi, J. Kim, B. Leem, C. Y. Lee, and H. K. Hong "Empirical analysis of the relationship between Six Sigma management activities and corporate competitiveness", International Journal of Operations and Production management, Vol. 32 No. 5, pp. 528-550, 2012.

[7] R.J. Hilton, and A. Sohal,"A conceptual model for the successful deployment of Lean Six Sigma", International Journal fo Quality and Reliability management, Vol. 29 No. 1, pp. 54-70, 2012.

[8] E. Atmaca, and S. Girenes, "Lean Six Sigma methodology and application", Qual Quant, Vol. 47, pp. 2107-2127, 2013.

[9] T.Y. Lee, W.K. Wong, and K.W. Yeung, "Developing a readiness self-assessment model (RSM) for Six Sigma for China enterprises", International Journal of Quality and Reliability Management, Vol. 28 No. 2, pp. 169-194, 2011.

[10] C. Delgado, M. Ferreira, and M. C. Branco,"The implementation of Lean Six Sigma in financial service organisations", Journal of Manufacturing Technology management, Vol. 21 No. 4, pp. 512-523, 2010.

[11] J.J. Dahlgaard, and S.M. Dahlgaard-Park, "Lean production, six sigma quality, TQM and company culture", TQM Magazine, Vol. 18 No. 3, pp. 263-281, 2006.

[12] R. McAdam, and S. Hazlett, "An absorptive capacity interpretation of Six Sigma", Journal of Manufacturing Technology Management, Vol. 21 No. 5, pp. 624-645, 2010.

[13] A. Biranvand, and A. A. Khasseh,"Evaluating the service quality in the regional information Centre for science and technology using the Six Sigma methodology", Library management, Vol. 34 No. ½, pp. 56-67, 2013.

[14] Q. Zhang, M. Irfan, M. Khattak, X. Zhu, and M. Hassan, "Lean Six Sigma: A literature review", Interdisciplinary Journal of Contemporary Research In Business, Vol. 3 No. 10, p. 599-605, 2012.

[15] J. Maleyeff, E.A. Arnheiter, and V. Venkateswaran, "The continuing evolution of Lean Six Sigma", The TQM Journal, Vol. 24 No.6, pp. 542-555, 2012.

[16] J. C. Chen, Y. Li, and B. D. Shaddy, "From value stream mapping towards a Lean/Six Sigma continuous improvement process: an industrial case study", International Journal of Production Research, Vol. 48 No. 4, pp. 1069-1086, 2010.

[17] S. A. Sarkar, A. R. Mukhopadhyay, and A. K. Ghosh, "Root cause analysis, Lean Six Sigma and test of hypothesis", The TQM Journal, Vol. 25 No. 2, pp. 170-185, 2013.

[18] V. Gupta, P. Acharya, and M. Patwardhan, "Monitoring goals through lean six sigma insures competitiveness", International Journal of Productivity and Performance Management, Vol. 61 No. 2, pp. 194-203, 2012.

[19] M.P.J. Pepper, and T.A. Spedding, "The evolution of LSS", International Journal of Quality and reliability Management, Vol. 27 No. 2, pp. 138-155, 2010.

[20] A. Thomas, R. Barton, and C. Chuke-Okafor,"Applying lean six sigma in a small engineering company – a model for change", International Journal of Manufacturing Technology management, Vol. 20, No.1, pp. 113-129, 2009.

[21] S. Goel, V. Chen, "Integrating the global enterprise using Six Sigma: Business process reengineering at General Electric Wind Energy, "Production Economics, No. 113, pp. 914-927, 2008.

[22] P. Kaushik, and D. Khanduja, "Application of Six Sigma DMAIC methodology in thermal power plants: A case study", Total Quality management, Vol. 20 No. 2, pp. 197-207, 2009.

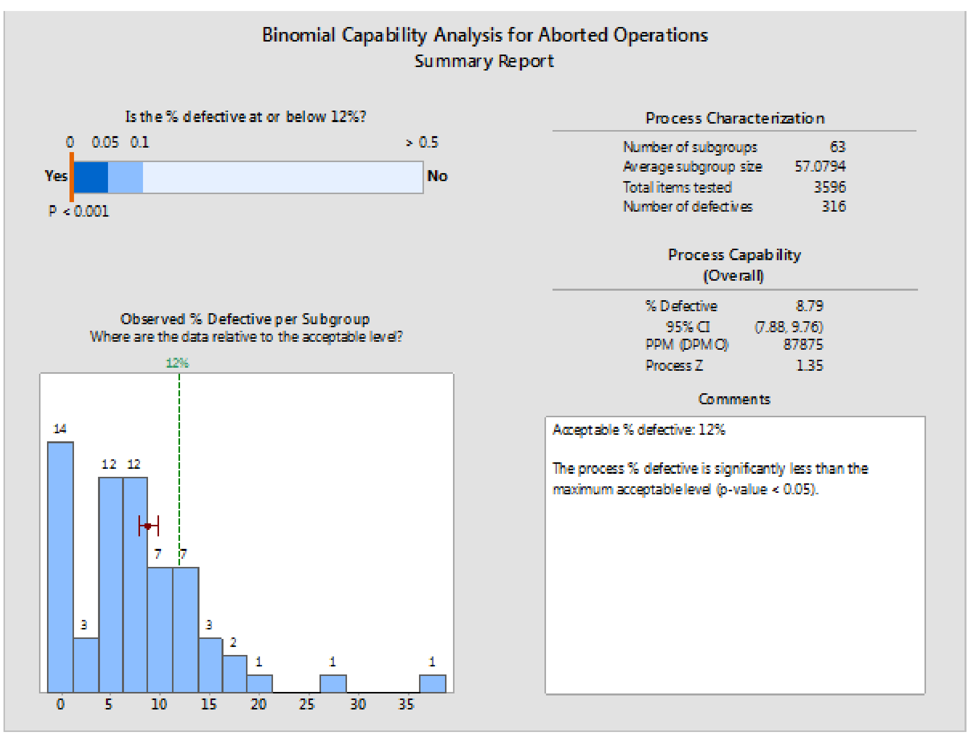
[23] S.M. Shafer, S.B. Moeller,"The effects of Six Sigma on corporate performance: An empirical investigation", Journal of Operations Management, Vol. 30, pp. 521-532, 2012.

[24] M. Cournoyer, A.O. Nobile, G.M. Williams, RA. Monsalve-Jones, C.M. Renner, and G.L. George, "Application of lean six sigma business practices to an air purifying respiration process", Journal of Chemical health and Safety, March/April, 2013.

[25] K. Jayaraman, T. L. Kee, and K. L. Soh,"The perceptions and perspectives of Lean Six Sigma (LSS) practitioners", The TQM Journal, Vol. 24 No. 5, pp. 433-446, 2012.

[26] G. Manville, R. Greatbanks, R. Krishnasamy, and D. W. Parker, "Critical success factors for Lean Six Sigma programmes: a view from middle management", International Journal of Quality & Reliability Management, Vol. 29 No. 1, pp. 7-20, 2012.
[27] J. Antony,"Readiness factors for the Lean Six Sigma journey in the higher education sector", International Journal of Productivity and Performance Management, Vol. 63 No. 2, pp. 257-264, 2014.
[28] A. Shokri, D. Oglethorpe, and F. Nabhani, Evaluating Six Sigma methodology to improve logistical measures of food distribution SMEs", Journal of Manufacturign Technology management, Vol. 25 No. 7, pp. 998-1027, 2014.
[29] M., Kumar, J. Antony, and M.K. Tiwari, "Six Sigma implementation framework for SMEs – a roadmap to manage and sustain the change", International Journal of Production research, Vol. 49 No.18, pp.5449-5467, 2011.
[30] J. Antony,"Can Six Sigma be effectively implemented in SMEs?" International Journal of Productivity and Performance Management,Vol. 57 No. 5, pp. 420-423, 2008.
[31] J. Antony, M. Kumar, and C.N. Madu, "Six Sigma in Small - and -medium sized UK manufacturing enterprises", International Journal of Quality & Reliability Management, Vol. 22 No. 8, pp. 860-874, 2005.
[32] T. *Hughes, N. O'Regan, and M.A. Sims,"The effectiveness of knowledge networks, an investigation of manufacturing SMEs", Education + Training, Vol. 51 No. 8/9, pp.665-681, 2009.*
[33] P. *Kaushik, D. Khanduja, K. Mittal, and P. Jaglan,"Application of Six Sigma methodology in a small and medium – sized manufacturing enterprise", TQM Journal, Vol. 24 No. 1, pp. 4-16, 2012.*
[34] M.G. Aboelmaged, "Reconstructing Six Sigma barriers in manufacturing and service organisations", International Journal of Quality and Reliability Management, Vol. 28 No. 5, pp. 519-541, 2011.
[35] S. *Bhat, E.V. Gijo, and N.A. Jnanesh, "Application of Lean Six Sigma methodology in the registration process of a hospital", International Journal of Productivity and Performance Management, Vol. 63 No. 5, pp. 613-643, 2014.*
[36] A. G. Psychogios, J. Atanasovsky, L. Tsironis, "Lean Six Sigma in a service context ", International Journal of Quality and Reliability Management, Vol. 29 No. 1, pp. 122-139, 2012.
[37] M. *Saunders, and P. Lewis, "Doing Research in Business and Management", 1st edition, Prentice Hall Financial Times, Harlow, UK, 2012.*
[38] A. *Tenera, and L. C. Pinto, "A Lean Six Sigma project management improvement model", Social and Behavioral Science, Vol. 119, pp. 912-920, 2014.*
[39] F. Algassem, Q. Yang, and J. Au, "Application of Lean Six Sigma principles to Food Distribution SMEs", American Academic and Scholarly Research Journal, Vol. 6 No. 4, pp. 251-258, 2014.
[40] M. L. George, D. Rowlands, M. Price, and J. Maxey, "Lean Six Sigma Pocket Tool Book", 1st Edition, McGraw Hill, NY, USA, 2005.
[41] E.V. Gijo, J. Scaria, and J. Antony, "Application of Six Sigma Methodology to reduce defects of a grinding process", Quality and Reliability Engineering Inetrnational, Vol. 27, pp. 1221-1234, 2011.

Appendix A



Appendix B

XY - Prioritization Matrix				
Output Variables (Y's)	**Cancelled by Engineer**	**Smart Commissioning Failed**	**Cancelled by Customer**	
Importance Score	**3**	**9**	**3**	
Input / Process Variables (X's)	**Table of associations scores (X's-Y's)**			**Weighted Score**
Job Closed Under Wrong Code	3	3	3	45
Job Incorrectly Raised	3	3	3	45
Job Closed With No Description	1	1	1	15
Space Issues on Smart Install	0	3	0	27
External Smart System Fault	3	9	3	99
Poor Signal Strength for Smart	0	3	0	27
Smart Commissioning Errors Codes	1	9	3	93
WAN on Coms Hub not Stable	0	9	0	81
Engineer Late to Appointment	1	0	9	30
Customer Cancelled with Office yet Job not closed down	1	0	9	30
Customer No Longer Requires Jobs	1	0	9	30

Appendix C