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Process improvement in service sector using simulation and lean six sigma: A case study

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Abstract
India post is one of the most important service organizations in the country with world's largest postal network. National Sorting Hubs (NSH) are a part of India Posts which focus on processing speed post mails only. Speed post mail service is one of the premium products of India post. The safe and timely delivery of the Speed Post mail item is only possible through The efficient processing in Sorting Hubs helps the safe and timely delivery of Speed post mails In the present scenario due growth in E-commerce market India post is facing high completion from courier companies. In this study the current mail processing system in NSH Trivandrum is studied. The present mail processing system is unable to process all the incoming Speed mail In this paper the current mail processing system is analyzed using simulation technique in order to find out the bottlenecks and Lean Six Sigma's DMAIC (Define- Measure- Analyze - Improve- Control) is applied on the identified process for improvement.

Keywords: lean six sigma, national sorting hub, service sector, simulation

1. Introduction
Lean Six Sigma is a process improvement technique which combines the concepts and tools of both lean and Six Sigma. Lean concept mainly focused on reducing wastes in a process such as excess processing, waiting, unnecessary transportation, and waiting. The Six Sigma focus on improving a process by reducing variability in a process. Studies shows that combination of lean and six sigma concepts can be effectively employed in service organisations in order to improve customer satisfaction and improve process efficiency.
The study starts with analysing in depth the current mail processing system and collecting the relevant data for conducting a simulation study. The simulation study is conducted to find out the problem areas and process variations. Finally DMAIC methodology is applied to the identified process for improvement and results are obtained.

2. Literature review
Literatures are collected from different areas like Lean Manufacturing, Six Sigma, Intergration of lean and six sigma, Simulation, DMAIC methodology and waiting time reduction. The collected literatures are reviewed and classified in to the following sections.

A. Lean in production and management
According to Abdulmalek and Rajgopal [1] lean production is the process of determining different wastes in and implementing the techniques required for minimizing lead time. They also identified that Lean production identifies different types of wastes as waiting, over processing, excess transportation etc. Leite *et al*. [10] mentions that lean uses a mix of tools for services that best serves in an operation. Golinska [7] in his study identified that lean production is a managerial concept which is well established and it helps organizations to provide the customer satisfaction and to reduce waiting time.

B. Integration of lean and six sigma
Higgins [8] explains that every type of opportunity in an organization for improvement is grabbed by lean and Six Sigma integration. According to Mika [12] lean and six sigma approaches are completely incompatible with one another and can be effectively applied in any type of organizations. According to Arnheiter and Maleyeff [4], both lean and six sigma approaches strives to achieve quality throughout, whether it is the process, the product, training and education or customer service.

C. Application of lean six sigma in service sector

Allean *et al.* [2] explained the application of six sigma in a hospital in United States for improving the discharge time. McAdam *et al* [11]. Conducted a case study in call center for reducing waiting time and the results shown that Lean Six Sigma can be effectively applied in service centres like call centre. According to Kwak and Anbari [9] Lean Six sigma has been implemented in the manufacturing sector years ago and recently, the financial, healthcare, construction, engineering and education, as well as the research and development sectors have all been improved by the application of Lean Six Sigma.

D. Application of simulation in service sector

Azadeh *et al.* [5] in their article presented the optimisation of the train timing and schedule using simulation and fuzzy model approach. Al-Saleh [3] used Areana simulation and time study techniques for productivity improvement in a motor vehicle service centre. Eskandari *et al.* [6] improved the patient discharge process in Tehran hospital using utilised simulation study.

3. Overview of methodology

The methodology followed in this study includes the following steps.

- Analysis of current mail processing system in NSH Trivandrum.
- Collection and analysis of relevant data.
- Simulation study of the current mail processing system.
- Identifying the bottleneck process.
- Applying DMAIC methodology on the Sorting process.
- Simulation of the improved process.

4. Analysis of current mail processing system

A detailed analysis of present mail processing system in NSH Trivandrum is done. The analysis conducted shown that a Speed Post article booked in post office or booking office passes through different processing centers before it reaches to its destination. The different stages in Speed post article flow is shown in Figure 1.

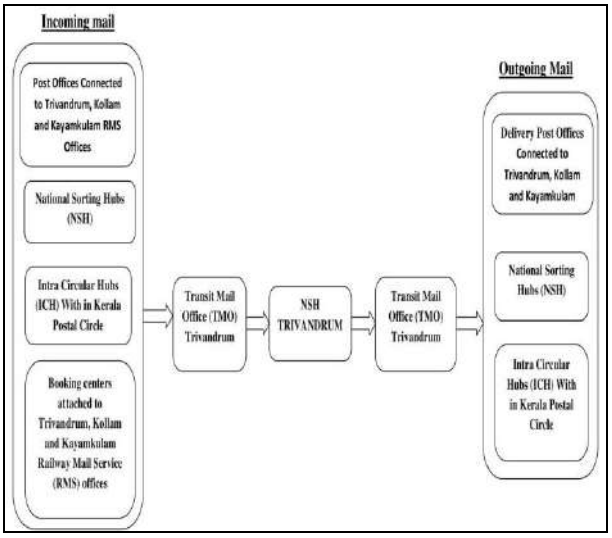

Fig 1: Process flow diagram for speed post articles

Every speed articles passes through six processing stages as shown in Figure 2. The stages are

- Bag receiving from Transit Mail Office Trivandrum
- Bag opening
- Receiving articles inside the bag
- Destination wise sorting.
- Bag closing to destination post offices.
- Bag dispatching to Transit Mail Office.

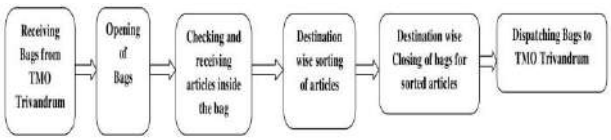

Fig 2: Different stages of mail processing

5. Data collection and statistical analysis

After the detailed analysis of the current mail processing system relevant data for conducting a simulation study is collected. The collected data includes mail arrival rate and number of speed articles processed per 15 minutes interval of time. The data collected is recorded inside an excel sheet. The data collection was done in the Night Set (shift) for a period of 15 days. The Night Set starts at 5.00 PM and ends at 5.00 AM. The mail arrival rate is highest during night set mails from post offices also arrive during this time, so night shift was chosen for data collection. For conducting the simulation study the collected data is statistically analysed and processing time distributions are determined the distributions obtained after applying Chi Square and K S tests are shown in Figure 3. Figure 4 shows the simulation model.

Sl No.	Process Name	Processing Time Distribution
1	Receiving Bag	Gamma(5.61,0.0046)
2	Opening Bag	Gamma(1.81,0.019)
3	Receiving Articles	Log norm(0.096,0.075)
4	Sorting	Log norm(0.054,0.025)
5	Bag Closing	Gamma(5.901,0.0171)
6	Bag Dispatching	Log norm(0.033,0.032)

Fig 3: Processing time distributions

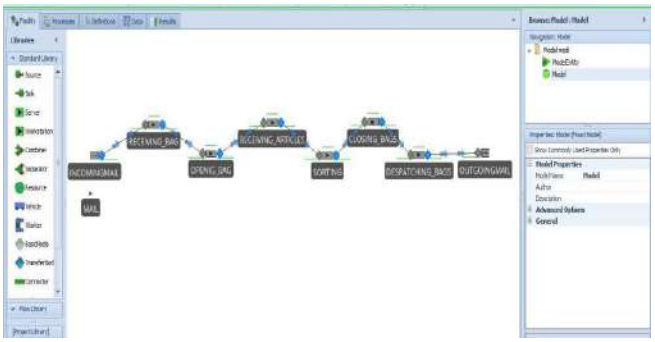

Fig 4: The simulation model of existing system

6. Simulation results

Simulation is study is done to find out the process which causing delay in the present mail processing system. Here simulation process is done using 'SIMIO 9'.The simulation length is 12 hours and number of replications done is 1000. The result of the simulation study is shown in Table I.

Table 1: Simulation Results

Results Process	Server Utilization	Average waiting time In the queue(Mints)	Average Number Of Speed Articles In Queue(Units)
Bag Receiving	69%	19.9	531
Bag Opening	70.%	6.72	148
Article Receiving	68%	3.14	711
Sorting Of Articles	94%	116.1	3428
Bag Closing	70%	30.94	27
Bag Dispatching	51%	42.3	398

Analyzing the results of the simulation shows that 'Sorting process' is the bottleneck process with highest waiting time and number is station. In order to remove the current bottlenecks the six sigma concepts are applied. Here the DMAIC methodology of Six Sigma is used to improve the current process which is explained in detail in the next section.

7. Application of dmaic methodology

In this section the application of Six Sigma methodology for improving the identified bottleneck process during the simulation study is presented. Six Sigma is a process improvement technique which focuses on reducing variability in a process. For implementing Six Sigma DMAIC (Define-Measure-Analyze-Implement-Control) methodology is used as the main frame work. The activities carried out in each phase are reported in the following five subsections.

A. Define phase

In the Define phase the process that is to be investigated and the customer's requirements on the output of the process are identified. Project charter and SIPOC (Supplier-Input-Process -Output-Customer) are the tools used in this phase.

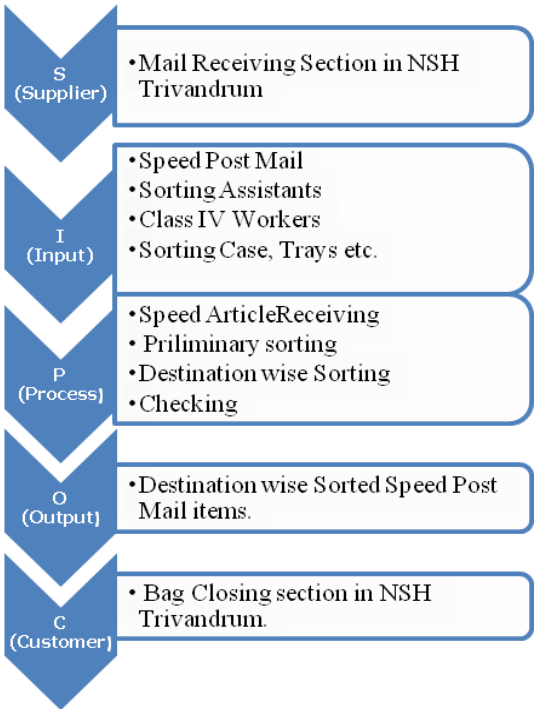

Fig 4: SIPOC Diagram

B. Measure Phase

In the Measure phase the parameters to be measured are determined after preparing a detailed process map of the sorting process. Figure 5 shows the current process map. Process map gives a clear vision of the current state of the Sorting processing. It also shows the different processing steps, inputs and outputs.

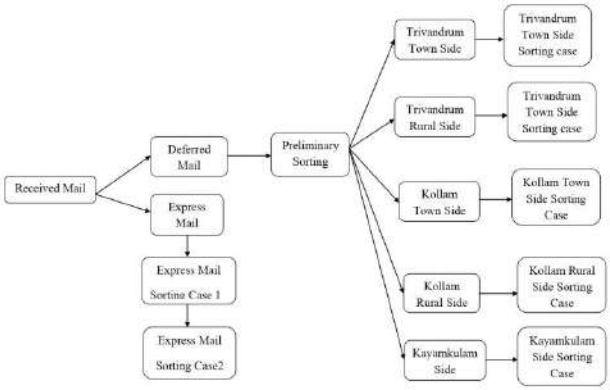

Fig 5: Process map for sorting process

The time consumed by each activity in the Sorting process is determined using a time study method. Here the measurement is taken by direct observation and through video recording. The measures that were taken are Cycle time, Value added time, and non-value added times, Necessary non value added time and work in Process (WIP). Data is collected from NSH Trivandrum during the Night SET (Shift). The Night SET was chosen for data collection because highest volume of mail is processed during this period. There are four Sorting Assistants (workers) working in this SET and a total working hour available is 12 hrs.
Table III shows the process lead time for different sub process in sorting. Table IV shows the data collected regarding the number of speed articles processed and unprocessed in each SET. The average speed mail processed is found to be 17186

Table 2: Process lead time for different activities in sorting

Process	value added time (Minutes)	Non Value added Time(Minutes)	Necessary non value added time (Minutes)	Total process Lead time (minutes)
Collection of mail from Article Receiving section	41	16	8	65
Sorting of Express Mail in Sorting case 1	188	84	71	343
Sorting of Express Mail in Sorting case 2	50	120	15	185
Preliminary Sorting of Deferred Mail	65	115	325	505
Sorting of Trivandrum Town Side Deferred Mail	300	240	20	560
Sorting of Trivandrum Rural Side Deferred Mail	230	270	25	525
Sorting of Kollam Town Side Deferred Mail	300	160	40	500
Sorting of Kollam Rural Side Deferred Mail	215	145	20	380
Sorting of Kayamkulam Side Deferred Mail	175	110	15	300

Table 3: No. of speed articles processed and in deposit

Days	No. of Speed articles Processed Day wise.	No of Speed articles in Deposit Day wise
Day 1	17246	2426
Day 2	15849	3289
Day 3	18120	2676
Day 4	16731	3641
Day 5	17241	3887
Day 6	18214	2646
Day 7	17665	3544
Day 8	15994	2087
Day 9	17899	2994
Day 10	18243	3315

A process capability analysis is done to find out the present process capability or performance of sorting process. This statistical technique checks whether the process under study meets certain standards or not.

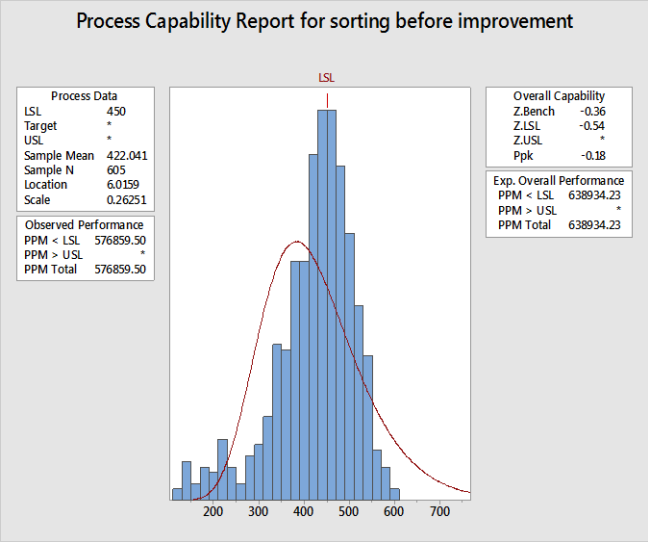

Fig 6: Process capability report

C. Analyze phase

In the Analyze phase the collected data is analyzed and the current performance is determined. After the analysis the potential root causes of variation and bottlenecks in the process are identified. The possible reasons for variation and bottlenecks are found out and finally improvement opportunities are prioritized.

The Sorting process is studied and collecting the needful measures are taken. The next step is to analyze the collected data to find out the root causes of the problems in sorting process. Each sub process involved in sorting process is studied and observations are noted. The possible reasons behind high mail deposit are found out. A cause and effect diagram is prepared to summarize the findings made in the analyze phase which is shown in figure 7.

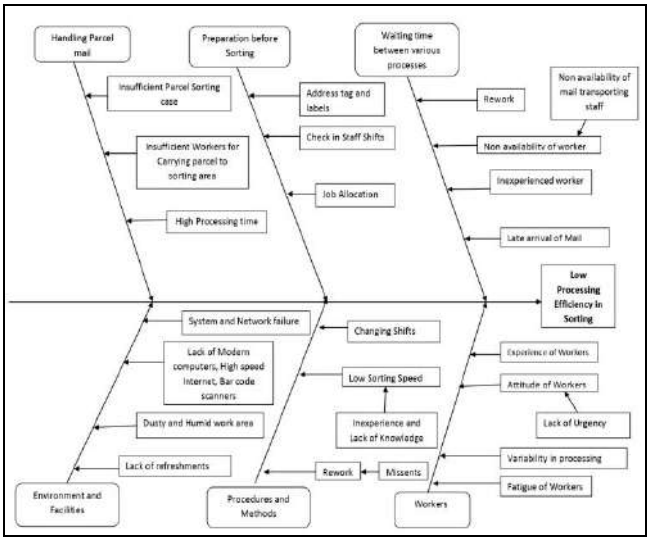

Fig 7: Cause and Effective diagram

D. Improve phase

During this phase the current process map is analyzed in depth, using the cause and effective analysis and brainstorming session's possible improvement solutions are developed. During the analyze phase several activities are identified which are contributing to delay in sorting process. These activities includes waiting between various processes during sorting, Delay in handling parcel mail, Preparation before sorting process, Worker related problem. In addition to that working environment, Facilities available and procedures and methods followed are important factors which contribute to excess processing time in sorting process.

The expected reductions in waiting time of various process after improvement is shown in Figure 8. These results are used to apply in the simulation model already prepared for studying the performance variations.

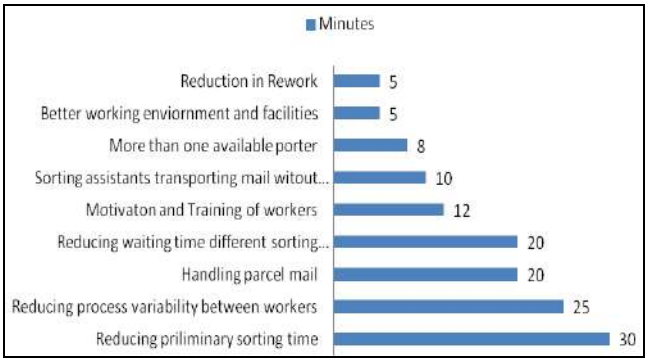

Fig 8: Reduction in time per activity

The simulation model is tested by applying the improvements made and the results are shown in Table V. The result shows that the utilization is increased from 93.7% to 99.4%, the waiting time is also reduced from 114.4

minutes to 12.4 minutes. The number of articles in use is also reduced from 3261 to 156. All these results show that there is a definite improvement in the process. Process capability test of the improved process is shown in Figure 9.

Table 5: Simulation results after improvement

Results Process	Server Utilization	Average waiting time in the queue (Min)	Average number of speed articles in Queue (Units)
Sorting (Before Improvement)	93.7%	114.2	3261
Sorting (After Improvement)	99.4%	12.4	156

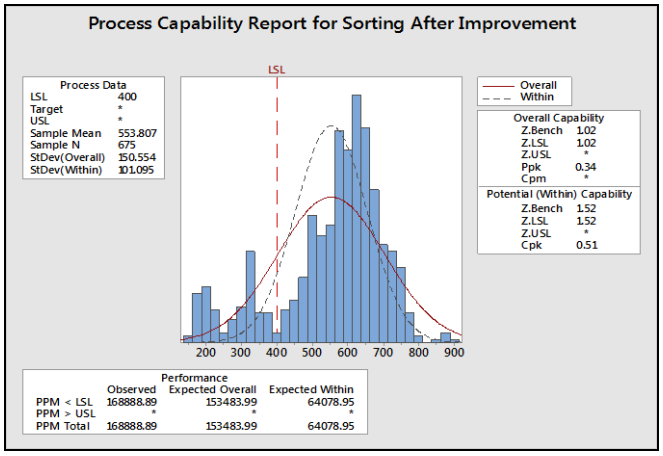

Fig 9: Process capability report after improvement

E. Control phase

Control phase is the final phase in the DMAIC methodology. During this phase a control plan was implemented to ensure that the improvements made are continued for a long period and variations in process outputs are reduced. The performance level in sorting process is expected to increase through these control policies. Resistance to change is common in every organization, so successful implementation of the control plan is only possible through the coordination of top management and workers.

In NSH Trivandrum, the most important resources are Sorting Assistants; they should never feel comfortable adopting an improvement process or standardization technique unless there is a proof of its effect on process efficiency improvement. Sorting Assistants are involved in the analysis, improvement and control phases through participation in the improvement phase as well as through meetings and discussing process improvement issues. The other stakeholders like class IV workers, Supervisors, Mail transporting staff etc should cooperate in the suggested methods to stabilize and standardize the improvements.

To maintain the quality level after the process improvement the control policies for each counter measures are proposed. The variations in each process are expected to reduce through these control policies. Table VI shows the control policy of sorting process.

The performances of key variables are analysed using control charts. Figure 10 and Figure 11 shows the control charts before and after improvement. Analysing the chart it was found that the mean number of speed articles in deposit is reduced by 76%, from 2547 to 330, also reduction in the upper and lower control limits which shows that the process is under control.

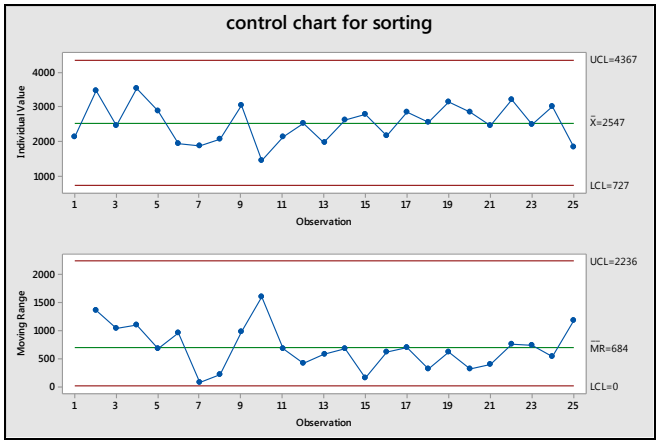

Fig 10: Control before improvement.

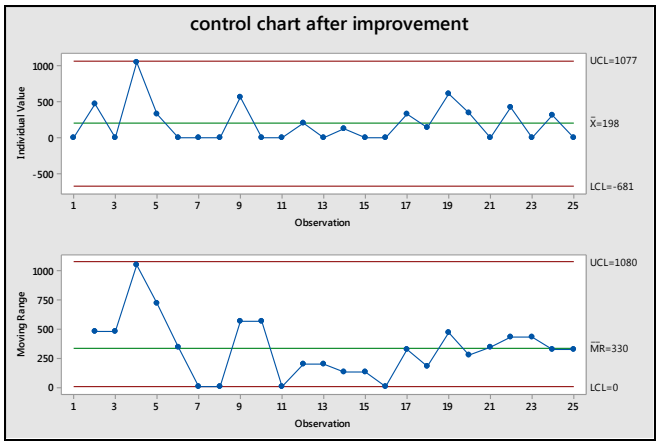

Fig 11: IMR Control after improvement

Measure of Improvement	Responsible Unit	Control
Rework of miss directed mail	Sorting	Proper inspection and training of Sorting Assistants
Reducing process variability between workers.	Top Management	Training and motivation of workers
Reducing waiting time in mail arrival at different processing points	Sorting, Transportation	Reducing preliminary mail sorting time , Reducing mail transportation time between different processing centers
Reducing preliminary sorting time	Sorting, Top management	Post offices and booking centers closing separate bags for Trivandrum,kollam and kayamkulam side
Better working environment and facilities	Top management	Clean and tidy working environment, modern computers and fast internet service, refreshment to the workers,
Handling Parcel mail	Sorting, Mail Receiving unit	Shifting parcel mail to Parcel Sorting Hub

Fig 12: Control policy of the sorting process

8. Conclusion

In this study the present mail processing system in NSH Trivandrum is improved by applying Simulation techniques and Lean Six Sigma Methodology. Simulation is used to find out the factors affecting the performance of current system. The DMAIC methodology is applied to the identified bottleneck process (Sorting) and the process is improved by reducing the waiting time in sorting process. The approximate reduction in waiting time is 100 minutes. The process capability analysis done also sigma value is also improved from the current value of 1.05 to 3.04 indicating a clear improvement in performance of sorting process.

From the study conducted in NSH Trivandrum it can be concluded that Lean Six Sigma methodologies can be successfully applied in service sector like postal service and there service quality can be improved by reducing the waiting time. This study also shows that simulation can be used as an effective tool to find out the bottleneck or variation in a process.

The future scope of this study includes the further improvement of the process efficiency and Sigma value, achieved after implementing Lean Six Sigma's DMAIC methodology. The present study can also be applied in other units of India post like parcel sorting Hub, Registration Hub, Post office counters etc.

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