p–ISSN: 2723 - 6609 e-ISSN: 2745-5254
Vol. 4, No. 10 October 2023 http://jist.publikasiindonesia.id/

IMPROVEMENT OF ELECTRIC MOTOR INSPECTION PROCESS IN SERVICE REPAIR WORKSHOP: WITH LEAN CONSUMPTION MAP APPROACH

Irani Harefa[1*], Edi Hamdi[2], Tantri Yanuar[3], Rina Annindita[4]
Esa Unggul University Jakarta, Indonesia
Email: irani.harefa@gmail.com, Edi.hamdi@esaunggul.ac.id

*Correspondence

Keywords: lean services; lean consumption map; workshop service repair.

ABSTRACT

The inspection process at the workshop service repair in this study is a crucial step in terms of providing speedy service to customers. The amount of waste and non-value-added activities in the inspection process is the main problem that must be corrected to increase competitive advantage. This study aims to determine the application of Lean Services in the inspection repair process at workshops service repair using the DMAIC (Define, Measure, Analyze, Improve, and Control) method and the LCM (Lean Consumption Map) tool. This study uses qualitative research methods based on direct observation of work processes and areas, interviews with several competent informants (internal and external), and analysis of forms and procedures documents. From the results of the search, it was found that research on the application of Lean Services is still limited to a few public service sectors, while similar research in the workshops service repair business is still rare and/or in its early stages. The results of this study found that the Lean Services concept with the DMAIC method and LCM tools can be applied and can improve the inspection process in workshop service repair. Then indirectly provides added value, increases trust, and increases customer satisfaction, which can be applied to other similar service workshop businesses. One of the biggest challenges in implementing Lean Services in the workshop service repair business is the non-systematic characteristics of the workshop business, the different types of work, and the varying characteristics of customer satisfaction. This research tries to contribute to and expand the evidence on the application of Lean Services to improve business repair services and encourage research on other similar businesses in the future.

Introduction

Today's industrial era 4.0 is increasingly putting strong pressure on the industrial world in terms of operational reliability. Electric motors are one of the most widely used industrial machines, where it is estimated that about 70% of the total electricity load in an industry is used by electric motors (Ahlstrom, 2004). Electric motors are equipment that converts electrical energy into mechanical energy as a drive for equipment or machinery, for example, pumping machines, compressors, belt conveyors, and so on. The vital role of electric motors in this industry on the other hand causes the need for fast and quality maintenance and repair. However, due to limited resources, the industry certainly needs third-party support from electric motor maintenance and repair service providers.

UKB Millenium service repair workshop located in the Tigaraksa area, Tangerang is one of the providers of electric motor maintenance and repair services to various small and large-scale invoice industries in Indonesia. This workshop has problems related to

the inspection process of electric motor repairs that are high compared to the KPI (Key Performance Indicator) target. Figure 1 below shows the flow diagram of the inspection process in the workshop which has not been effective and there are many wastes, such as waste of movement, place, waiting, and so on.

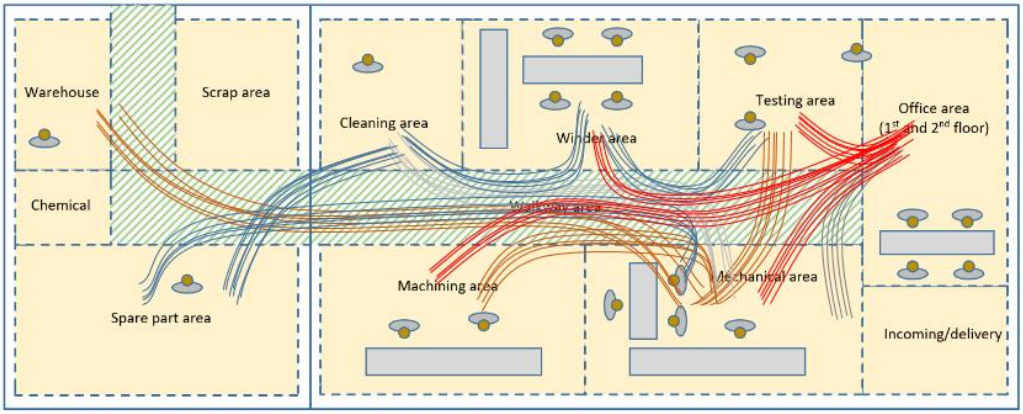

Figure 1. Flow chart on the inspection process

Figure 2. LCM before *Lean Consumption*

Figure 2 above shows the LCM condition before Lean Consumption, then in Table 1 below shows that for the inspection process, the customer as a service user takes a total of 2,735 minutes, with a total value added of 285 minutes (10.4%) and a total of non-value added of 2,450 minutes (89.6%). While the workshop as a service provider takes a total of 3,045 minutes, with a total value added of 850 minutes (27.9%) and a total of non-value added of 2,195 minutes (72.1%).

Table 1
Data LCM Before (Value Added Assessment)

Information	***Customer (Consumption Time)***	**Provider *(Provision Time)***

Total Time	(a)	**2735**	**3045**
Value Added	(b)	**285**	**850**
Non value Added	(c)	**2450**	**2195**
% VA	= (b) / (a) * 100%	**10.4%**	**27.9%**
% NVA	= (c) / (a) * 100%	**89.6%**	**72.1%**
Value to Waste Ratio	= (b) / (c) * 100%	**12%**	**39%**

This delay in the inspection process provides major losses for the workshop as a provider, including reducing customer competitiveness and trust, while for customers it will reduce trust and disrupt the production or operational process. Because of the criticality of this problem, improvements need to be made to identify and reduce waste and non-value-added activities.

Based on The study of Womack and Jones (2005) on the same process as in this study states that Lean Services with Lean Consumption tools can provide satisfaction to customers by solving customer problems well, effective process time, and not making it difficult for customers not to spend time with customers.

The application of Lean Six Sigma in the service sector can increase profits and customer satisfaction (Vignesh, Suresh, &; Aramvalarthan, 2016), improve services to the community (Antony et al. 2017), and improve company performance by reducing all forms of non-value-added activities (Ferdousi & Ahmed, 2009). Several previous studies have found that *Lean Six Sigma* has proven to be successfully applied in the service sector (Appendix Table 5), including hospital services (Bhat, Gijo, & Jnanesh, 2014)(Bhat et al., 2014; Susanti et al., 2020), government public administration (Fletcher, 2018; Sunaryanto & Shah, 2018; Shah et al., 2019), logistics (Lee, Olson, Lee, Hwang, &; Shin, 2008), office (Silva, 2015), education (LeMahieu, Nordstrum, & Greco, 2017), banking (Sunder, Ganesh, &; Marathe, 2019), financial sector services organizations (LeMahieu, Nordstrum, & Greco, 2017)and information technology services (Sunder, Ganesh, & Marathe, 2019)(Delgado, Ferreira, & Branco, 2010)(Gijo, Antony, & Sunder M, 2018).

However, the application of Lean service as in the studies above is still limited to a few service sectors so it requires further research in other service business sectors that are more detailed, where Lean Service has been (or can) be applied (Leite &; Vieira, 2015)(Leite & Vieira, 2015). Such continued research should focus more on providing empirical evidence on the impact of Lean systems on performance in the context of services (Hadid & Mansouri, 2014). Moreover, research by (Arlinghaus & Knizkov, 2020) concluded that the status quo of Lean implementation in the repair workshop business is still at an early stage and is still not developed.

Researchers have also never found a thesis or similar research that reviews the application of Lean Six Sigma in the service repair workshop business using the Lean Consumption Map (LCM) tool. In fact, according to Womack and Jones (Womack & Jones, 2005), this LCM tool is very suitable for describing current state and future state conditions for services in the service company sector, especially the service repair workshop business model like this study.

Based on these considerations, researchers want to research the application of Lean Services in a service repair workshop company using LCM and DMAIC tools. The choice of LCM tools is because other tools tend to be commonly applied in manufacturing companies and some companies in the suit (service) sector. This study aims to determine the application of Lean Service in the inspection process, reduce non-value-added activities, add research in the same field, and increase the knowledge of researchers and academics. In the future, it is hoped that this research can be a reference for other researchers.

Lean Consumption Map (LCM)

According to Womack and Jones ((Womack & Jones, 2005), the concept of the Lean Consumption Map (LCM) is a tool that is very suitable for service industries, such as workshops. LCM is one of the tools for organizations to see more deeply the needs of their customers to provide value to customers (Gülyaz, van der Veen, Venugopal, & Solaimani, 2019). (Leite & Vieira, 2015) concluded that Lean Service does not have a single tool model or practice and standard only.

Metode Penelitian

Researchers use qualitative research methods, where data is obtained based on process observations, interviews, photo documentation of processes and work areas in the workshop, document analysis, procedures, and inspection reports. Researchers conducted this research at the UKB Millennium workshop in the Tigaraksa area, Tangerang Regency, for approximately three months starting from April to June 2021.

Results and Discussion

As a first step, researchers use the Time Series Plot tool to determine the target measure of success if the data trend used is random or random. The results in Figure 3 below show that the inspection process of the electric motor has a random trend.

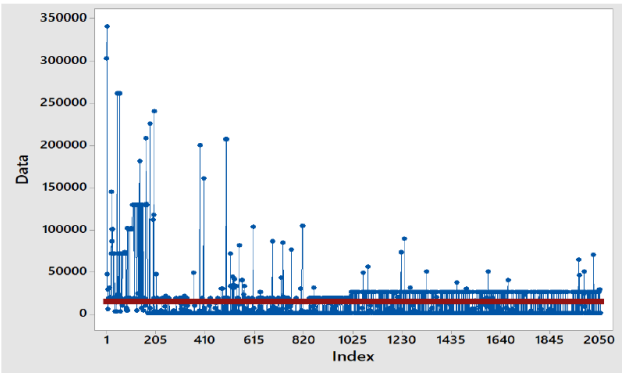

Figure 3. *Time Plot Series Before Lean Consumption*

Thus the data can be used to determine the target measure of success of improvement efforts also called improvement projects as shown in Figure 4 below. Determining the goal statement of success measures is very necessary for every *Lean Service* project because it is closely related to guiding all parties involved in the process

and other teams in the process, where in the future there will be the opportunity to continue other improvement proposals after the project is handed over to the process owner. There is also ease of communication to all teams involved in providing an overview of the efforts that must be made to make the project a success.

Perhitungan Sasaran Ukuran Keberhasilan

Diketahui:
1. Nilai rata-rata = 7 hari
2. Nilai performa terbaik = 4 hari
3. Persentase perbaikan = 43%

Langkah 1. Menentukan selisih

Nilai selisih = nilai rata-rata - nilai performa terbaik
= 7 hari - 4 hari = 3 hari

Langkah 2. Menentukan nilai perbaikan

Nilai perbaikan = persentase perbaikan * selisih
= 43% * 3 hari = 1.29 hari

Langkah 3. Menentukan sasaran

Sasaran perbaikan = nilai rata-rata - nilai selisih
= 7 hari - 3 hari = 4 hari

Langkah 4. Menentukan persentase penurunan

Persentase penurunan = (nilai rata-rata - sasaran perbaikan / nilai rata-rata) * 100%
= ((7 hari - 4 hari)/7 hari)*100% = 42.8 %

Langkah 5. Menentukan pernyataan sasaran ukuran keberhasilan

Mengurangi waktu penyelesaian proses inspeksi motor listrik di workshop sebesar 42.8% dari rata-rata 7 hari menjadi 4 hari pada semester I 2022

Figure 4. Goal Calculation Measures of Success

After determining the goal measure of success, determine the scope of the project using the SIPOC diagram (Figure 5) which can illustrate the scope of the project, because all supporting elements namely *suppliers, inputs, processes, outputs,* and *customers* are considered and included in the SIPOC diagram.

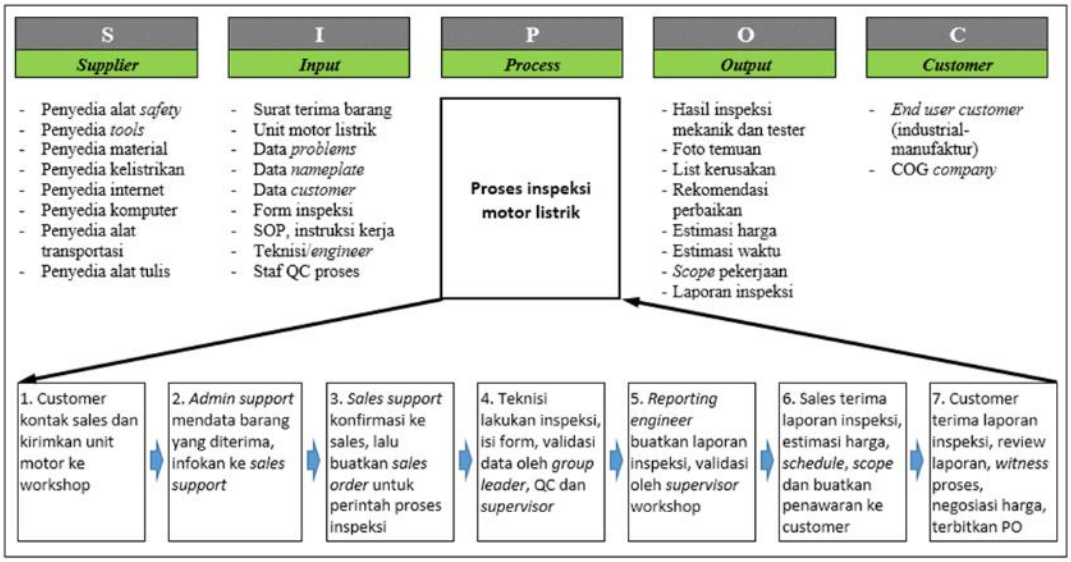

Figure 5. SIPOC diagram of the inspection process

The two tools above provide a very good understanding to researchers and all parties involved, namely being able to understand the current state, the target to be targeted, and who will be involved in the project.

Measure

In this Measure stage, researchers use Process Map tools, Cross-Functional Flowcharts, Flow Charts, Lean Consumption Maps (LCM), and finally Value-Added Assessment. From the Process Map in Figure 6 below, researchers increasingly understand how the inspection process carried out at the UKB Millennium workshop starts from the initial process to the final process. Broadly speaking, there are four parties involved directly and interrelated, namely customers, sales teams, workshop teams, and supplier teams. Furthermore, it also shows that there are five validation processes, where each validation point is based on the results of interviews and observations of researchers in the field, there is a high chance of experiencing delays due to the process of waiting for data or confirmation from other parties before deciding to the next stage of the process.

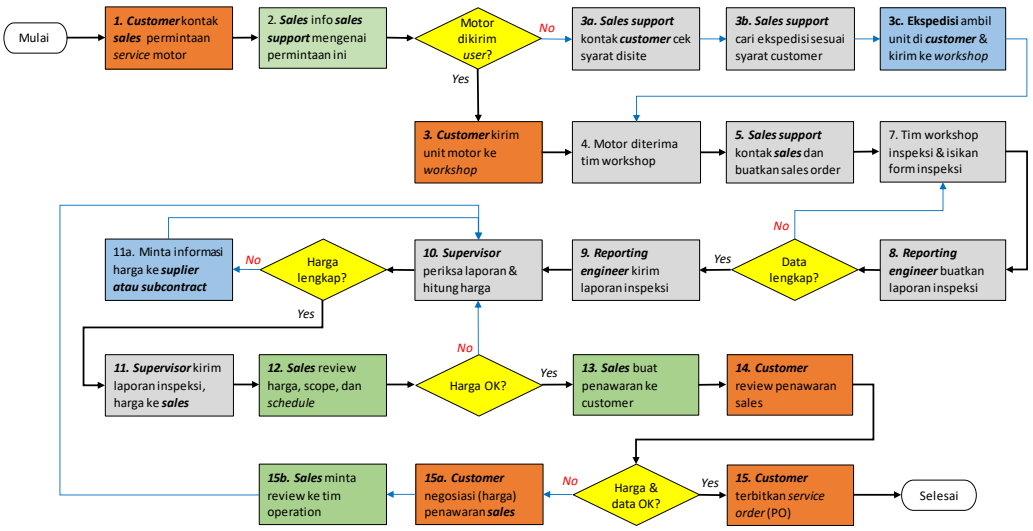

Figure 6. *Process Map* on the motorcycle inspection process in the *workshop*

Then the initial findings information on the *Process Map* above is used by researchers to explore data in the next stage, namely by making a *Functional Flowchart* according to Figure 6 below, which clearly shows the process flow to identify or reconfirm potential *delays*, rework, excessive inspection and validation and stages that have the potential to cause system failure. The results of the data from the two tools above confirm each other and strengthen the confidence of researchers that the motor inspection process in the *workshop* has great potential to be used as an area of improvement in the next stage.

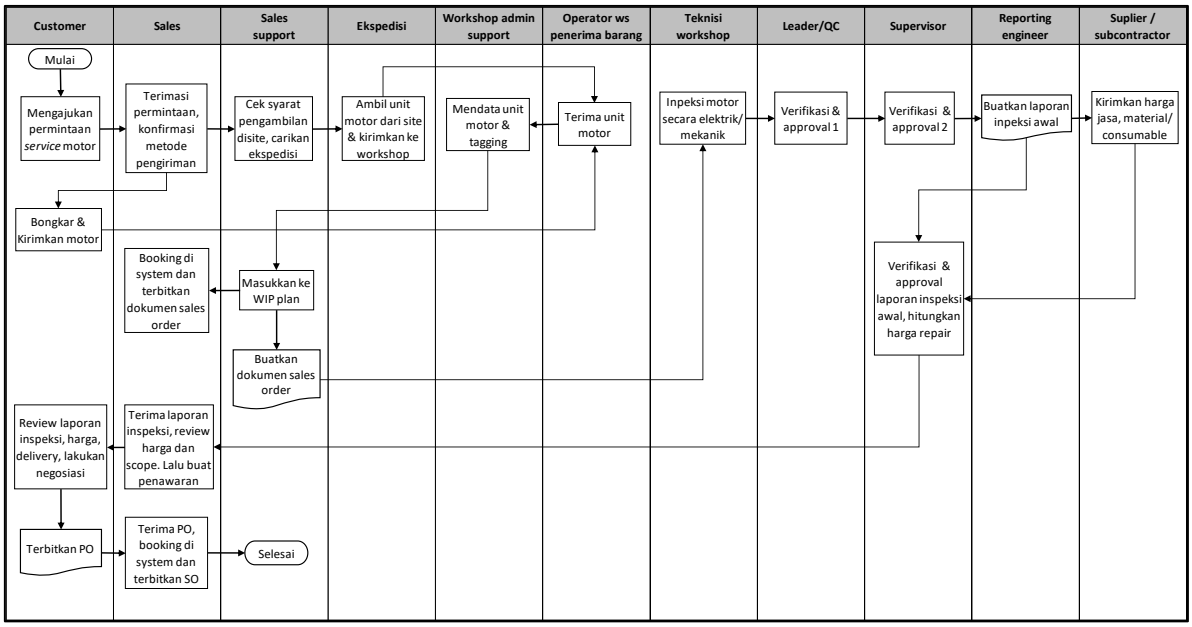

Figure 7. *Cross-functional flowchart* motor inspection process in the workshop

Furthermore, the researcher entered the stage of describing the Lean Consumption Map according to Figure 2 in the previous section, the results of which made the researcher know the total time needed by customers was 2,735 minutes, with value-added 285 minutes (or 10.4%) and non-value added 2450 minutes (or 89.6%). In contrast, the provider's total time required was 3045 minutes, with value-added 850 minutes (or 27.9%) and non-value-added 2195 minutes (or 72.1%).

Through the data presented by the Lean Consumption Map, important information is obtained that many activities have a longer processing time, thus affecting other processes (bottlenecks). For example, from the provider or workshop side, the sub-process starting from receiving the motorbike in the workshop to waiting for the customer's witness certainty takes as much as 790 minutes, the next in the sub-process when the reporting engineer starts making the initial inspection report until finally the sales send the inspection report to the customer, It took 1120 minutes. On the other hand, on the customer side, in the sub-process when witnessing in the workshop, it takes 480 minutes.

To further complete this Measure stage, researchers made a Flow Chart according to Figure 1 in the previous introduction, to better understand the layout and distance, as well as the process flow when workers work in the workshop room, including carrying out verification and validation activities for inspection documents. This is very helpful in the Analyze stage later, which is when determining what potential failures or wastes may arise due to the layout or due to the many flows of movements of workers in the workshop that are not effective and efficiently carried out.

Analyze

In this analysis stage, researchers will conduct a problem-identification study and determine the root cause of the problem and future improvement steps with FMEA (Failure Mode and Effect Analysis) tools. The first step that must be done in this FMEA is brainstorming related to the potential failures in each sub-process, then assessing Severity (severity in the event of failure), determining the potential cause of failure, assessing Occurrence (how often the failure occurs), determining the method and value of Detection (how much the failure can be detected), make recommendations for corrective actions, and finally predict the value of the Risk Priority Number (RPN) before and after the improvement recommendations are made. By general standards, when an RPN value above 100 is found, the value is considered high and needs to be improved. The full FMEA data can be seen in the appendix to Table 12).

Based on the data presented in the FMEA, plus consideration of the data presented in the previous Measure stage, namely Flow Chart data, Process Map, Functional Flowchart, and LCM, in the end, the researcher decided 4 proposed improvements would focus on being followed up in the next stage of the process, according to Table 2 below.

Table 1. List of proposed improvements and repair codes

No	Proposed improvements	Code

1	Create a WA group with customers for job updates, schedules, *daily reports*, and inspection videos	S1
2	Inform as soon as possible when finding abnormal damage, changes in scope, duration, and price	S2
3	Marking motor components and storing all spare parts	S3
4	Ask for a pricelist of materials from vendors, make service contracts	S4

At this stage, researchers will use several tools, namely the Impact and Effort Matrix, Lean Consumption Map (After Lean Service), and Value Added Assessment. All improvement proposals in Table 2 above will then be selected using the Impact and Effort Matrix method. From the Impact and Effort Matrix (annex Figure 12), it was found that all improvement proposals were in Zone I and Zone II, which means that this fully confirms that the proposed improvements can be implemented in the UKB Millennium Tangerang workshop with not-so-much effort but has a big impact on the side of process improvement. The next step is to make an estimate that describes the conditions of change that will occur, namely the estimated value of Value Added Assessment after improvement with the help of the Lean Consumption Map after Lean Service tool according to Figure 8 below.

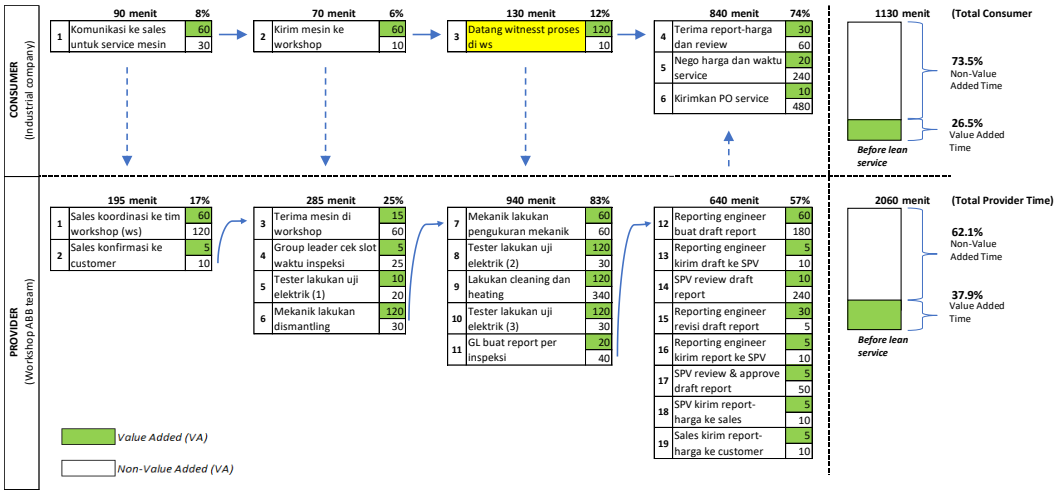

Figure 8. LCM Simulation after Lean Consumption

Figure 8 above shows a simulation of Lean Consumption after Lean Consumption, where researchers found significant changes both on the customer side and on the provider side, namely improvements in the value-added activities process. Table 3 below shows that the total time required by customers to complete this inspection process was reduced to 1,130 minutes (from 2,735 minutes previously), with a total value-added time of 300 minutes (or 26.5%) and a total non-value-added time of 830 minutes (or 73.5%). On the other hand, on the provider side, namely the workshop itself, the total time needed was also reduced to 2060 minutes (from the previous 3045 minutes), with a total value-

added time of 780 minutes (or 37.9%) and a total of non-value added time of 1280 minutes (or 62.1%).

Table 2. Value-Added Assessment Simulation after Lean Consumption

Information		Customer (Consumption Time)	Provider (Provision Time)
Total Time	(a)	**1130**	**2060**
Value Added	(b)	**300**	**780**
Non value Added	(c)	**830**	**1280**
% VA	= (b) / (a) * 100%	**26.5%**	**37.9%**
% NVA	= (c) / (a) * 100%	**73.5%**	**62.1%**
Value to Waste Ratio	= (b) / (c) * 100%	**36%**	**61%**

Therefore, the implementation of these improvement proposals is very important to be carried out immediately to ensure the achievement of the objectives of the Lean Service project at the UKB Millennium Tangerang workshop.

In lean service programs, the use of DMAIC and LCM is a complementary combination of each other. Both are excellent at contributing highly to the understanding of process improvement, as well as providing objective accuracy. The Measure and Improve stages of LCM can present an overview before and after process improvement in the workshop to the Lean Service project team. Moreover, the LCM can produce Value to Waste Ratio data as shown in Table 4 below. This data makes it easier for the project team to determine the Lean level of a process in the workshop work.

To run, manage, and maintain the continuity of the Lean Consumption program at the UKB Millennium workshop, namely in the inspection process, three steps are needed, the first is to start gradually so that all teams involved have the opportunity to fully understand and accept Lean Consumption as a new culture at work. The second step is managing the Lean Consumption program using program planning, program implementation, and program follow-up. The third step is to maintain the continuity of Lean Consumption in the organization after a department has completed a Lean Consumption project. It is important to think strategically about how to sustain improvements and when necessary, spread the spirit of Lean Consumption throughout the organization.

Table 3. Value to Waste Ratio of electric motor inspection process in workshop

LCM before Lean Service Value Added Assessment		Customer (Consumption Time)	Provider (Provision Time)
Total Time	(a)	**2735**	**3045**
Value Added	(b)	**285**	**850**
Non value Added	(c)	**2450**	**2195**
% VA	= (b) / (a) * 100%	**10.4%**	**27.9%**
% NVA	= (c) / (a) * 100%	**89.6%**	**72.1%**

Value to Waste Ratio	= (b) / (c) * 100%	**12%**	**39%**

LCM after Lean Service Value Added Assessment		**Customer (Consumption Time)**	**Provider (Provision Time)**
Total Time	(a)	**1130**	**2060**
Value Added	(b)	**300**	**780**
Non value Added	(c)	**830**	**1280**
% VA	= (b) / (a) * 100%	**26.5%**	**37.9%**
% NVA	= (c) / (a) * 100%	**73.5%**	**62.1%**
Value to Waste Ratio	= (b) / (c) * 100%	**36%**	**61%**

Conclusion

Based on previous analysis, researchers concluded that the Lean Service concept using the DMAIC method and the Lean Consumption Map approach can be applied to the electric motor inspection process at the UKB Millennium Tangerang workshop. The concept of Lean Service through LCM simulation after Lean Consumption is applied can improve the inspection process, which previously the average completion of the inspection process was 7 days reduced to 4 days according to the KPI target. Then the value added each increased, on the customer side from 10.4% to 26.5%, and on the provider side from 27.9% to 37.9%. It also reduced the total time of both parties, namely on the customer side from 2735 minutes to 1130 minutes, and on the provider side from 3045 minutes to 2060 minutes. This will also provide added value and increase competitive advantage.

Thus, researchers are also confident that the application of the Lean Service concept in this service repair workshop can also be applied to other workshop business fields that have similar processes and organizational characteristics.

Bibliography

Ahlstrom, Par. (2004). Lean service operations: translating lean production principles to service operations. *International Journal of Services Technology and Management*, *5*(5–6), 545–564. https://doi.org/10.1504/IJSTM.2004.006284

Arlinghaus, Julia C., & Knizkov, Stephanie. (2020). Lean Maintenance and Repair Implementation - a Cross-Case Study of Seven Automotive Service Suppliers. *Procedia CIRP*, *93*, 955–964. https://doi.org/10.1016/j.procir.2020.03.144

Bhat, Shreeranga, Gijo, E. V., & Jnanesh, N. A. (2014). Application of Lean Six Sigma Methodology in the Registration Process of a Hospital. *International Journal of Productivity and Performance Management*, *63*(5), 613–643.

Delgado, Catarina, Ferreira, Marlene, & Branco, Manuel Castelo. (2010). The Implementation of Lean Six Sigma in Financial Services Organizations. *Journal of Manufacturing Technology Management*, *21*(4), 512–523.

Ferdousi, Farhana, & Ahmed, Amir. (2009). an Investigation of Manufacturing Performance Improvement through Lean Production: A Study on Bangladeshi Garment Firms. *International Journal of Business and Management*, *4*(9), 106–116.

Fletcher, Jeffrey. (2018). Opportunities for Lean Six Sigma in Public Sector Municipalities. *International Journal of Lean Six Sigma*, *9*(2), 256–267.

Gijo, E. V., Antony, Jiju, & Sunder M, Vijaya. (2018). Application of Lean Six Sigma in IT Support Services – a Case Study. *TQM Journal*, *31*(3), 417–435.

Gülyaz, Erdoğan, van der Veen, Jack A. A., Venugopal, Venu, & Solaimani, Sam. (2019). Towards a holistic view of customer value creation in Lean: A design science approach. *Cogent Business and Management*, *6*(1).

Hadid, Wael, & Mansouri, S. Afshin. (2014). The lean-performance relationship in services: A theoretical model. *International Journal of Operations and Production Management*, *34*(6), 750–785.

Lee, Sang M., Olson, David L., Lee, Sang Heui, Hwang, Taewon, & Shin, Matt S. (2008). Entrepreneurial Applications of the Lean Approach to Service Industries. *Service Industries Journal*, *28*(7), 973–987.

Leite, Higor dos Reis, & Vieira, Guilherme Ernani. (2015). Lean philosophy and its applications in the service industry: A review of the current knowledge. *Producao*, *25*(3), 529–541.

LeMahieu, Paul G., Nordstrum, Lee E., & Greco, Patricia. (2017). Lean for Education. *Quality Assurance in Education*, *25*(1), 74–90.

Radnor, Zoe. (2010). Transferring Lean Into Government. *Journal of Manufacturing Technology Management*, *21*(3), 411–428.

Silva, Iris Bento da. (2015). Lean Office in Health Organization in the Brazilian Army. *International Journal of Lean Six Sigma*, *6*(1), 2–16.

Sunaryanto, Ketut, & T.Y.R., Syah. (2019). Application of Lean Thinking Development : Case Study over Badan Pendapatan Daerah (BAPENDA), South Tangerang Based on Lean Government. *Journal of Multidisciplinary Academic*, *1*(1), 20–26.

Sunder, Vijaya, Ganesh, L. S., & Marathe, Rahul R. (2019). Lean Six Sigma in Consumer Banking – an Empirical Inquiry. *International Journal of Quality and Reliability Management*, *36*(8), 1345–1369. https://doi.org/10.1108/IJQRM-01-2019-0012

Susanti, Barlian, Syah, Tantri Yanuar Rahmat, & Sunaryanto, Ketut. (2020). Lean consumption implementation for acceleration improvement in executive outpatient wait time over Hermina hospital Bekasi. *Journal of Multidisciplinary Academic*, *4*(1), 42–46.

Syah, T. Y. R., Nurohim, A., & Hadi, D. S. (2019). Lean Six Sigma Concept in The Health Service Process in The Universal Health Coverage of BPJS Healthcare (Healthcare and Social Security Agency). *Proceeding of The 3rd International Conference on Accounting, Business & Economics*, 71–88.

Vignesh, V., Suresh, M., & Aramvalarthan, S. (2016). Lean in Service Industries: a Literature Review. *IOP Conference Series: Materials Science and Engineering*, *149*(1).

Womack, James P., & Jones, Daniel T. (2005). Lean Consumption. *Lean Enterprise Institute, Harvard Business Review*.