Lean Construction Analysis of the Interior Project

Dinda Ayu Nawangsasi,
Master Degree Student, Departement of Industrial Engineering
Universitas Mercu Buana
DKI Jakarta, Indonesia
dindaanaw@gmail.com

Zulfa Fitri Ikatrinasari
Senior Lecturer, Departement of Industrial Engineering
Universitas Mercu Buana
DKI Jakarta, Indonesia
zulfa.fitri@mercubuana.ac.id

Abstract

The implementation of the interior project development delays so that the total duration of the development a setback, the occurrence of the delay was due to waste in project activities. Based on this, this study aims to analyze the types of waste and their causes and make an improvement that can result in timely scheduling for the next SOHO (Small Office Home Office) project. The approach used is the Project Management and Lean Construction. Project management approach by monitoring the s curve and identify the critical path using the critical path method (CPM), this approach is used to see differences in weekly progress and the critical path in interior work. The lean construction approach uses value stream mapping to identify waste in current state mapping, fishbone diagrams to describe the causes of waste, and future state mapping to describe improvements that will be made in order to produce timely project scheduling. The result of this research, there is waste in the critical work of this project, it is a waste of defects, inventory, and waiting. The cause of waste that occurs in the implementation of interior projects is waste waiting because the material is stored in a warehouse located far from the workshop, so it takes a long time. Waste defects by checking material samples and waste inventory by submission of materials with the same specifications. So from the proposed improvement, the duration of the interior project is 15 days faster from 85 days to 70 days.

Keywords
Project Management, Lean Construction, Waste, Value Stream Mapping, Critical Path Method, Fishbone Diagram

1. Introduction
Construction is the arrangement of the elements of a building, where the position of each part is in accordance with its function. In construction, there are also 4 (four) types of construction, namely residential construction, building construction, heavy engineering construction, and industrial construction.

According to data from the BCI Indonesia Construction Market Outlook 2021 report entitled “Preparing for Tomorrow – Indonesia's 2021 Construction Market Recovery Outlook”, residential projects are estimated to increase by 48.71% in 2021. So, residential development will continue to experience rapid growth (Antaranews 2020). This is supported by increasing demand for property. According to PPKOM (2020), Property demand in the fourth quarter of 2020 grew by 0.03% (QoQ). The apartment category grew by 3.01% (QoQ) in the fourth quarter of 2020 after experiencing a decline of -13.26% (QoQ) in the previous quarter. This increase in demand was driven by an increase in the trend of staycation and work from home (WFH) (PPKOM, 2020).

In the implementation of construction development, there are problems that can hinder the course of construction and result in delays in project completion time. In Indonesia, the number of delays in completing construction projects is 55%, which is still relatively small compared to India’s 57%, Saudi Arabia’s 59% and Pakistan’s more than 90% (Roslan 2015).

The case study in this research is the construction of an interior project. At the time of the implementation of development, there was a delay which resulted in the total duration of development experiencing a setback. According to the schedule plan, the work will last for 15 weeks, but in its implementation, it will last for 18 weeks, the data is shown in the s curve.

The delay was caused by waste in project activities. Based on data from the Lean Construction Institute Indonesia in 2019, several construction research experts in America found that every construction project has 40% value-added activity and 60% nonvalue added activity (LCII 2019).

Lean Construction has a focus on eliminating activities that do not have added value, waste, or loss. The goal is to maximize the value that the end-user wants to achieve, but with a process that results in minimal waste.

1.1 Objectives

This study aims to approach the identification of waste and its causal factors in the implementation of interior projects with lean construction so as to produce timely project scheduling.

2. Literature Review

Lean Construction is defined as a way of designing a production system to minimize waste of material, time, and energy to produce the maximum possible value. The design of this production system is to achieve the stated final goal through the collaboration of all project participants, namely owners, contractors, to end-users (Koskela, et al. 2007).

Based on data submitted by the lean construction institute, waste in construction is 57%, while activities that have added value are 10%. This is inversely proportional to the manufacturing industry, where waste in manufacturing is 26%, while activities that have added value are 62% (Abduh 2007).

The types of waste that always exist in business and industry, namely Environmental, Health and Safety (EHS), Defects, Overproduction, Waiting, not utilizing employee's knowledge, skills, and abilities, Transportation, Inventories, Motion, Excess Processing (Gasperz 2016).

The steps taken in the lean construction analysis by Barathwaj et al. (2017) are to identify all waste and the root of the problem, then proceed with providing corrective solutions to the waste that occurs. This step can be done using Value Stream Mapping (VSM), VSM is used to process lean implementation by helping identify activities that provide value (value-added) in the process flow (value stream) and eliminate non-value-added activities or waste (Barathwaj, 2017).

There are seven waste activities that often occur by Sugiantari et al. (2015) are namely field inspections, purchasing one type of goods from different suppliers, waiting for work instructions from the owner, delays in material delivery, the need for additional approvals or signatures, the need to clarify actions and wait for work instructions from superiors.

Failure Mode and Effects Analysis (FMEA) a structured procedure to identify and prevent as many failure modes as possible. FMEA is used to identify the sources and root cause of a quality problem (Chrysler 1995).

3. Methods

Step 1: Project Management Approach

1) Monitoring schedule with the S curve. The S curve shows a graph of the relationship between the project implementation time and the accumulated progress of the implementation from the beginning to the end of the project. The S curve is used in planning and monitoring schedules.
2) Identify the critical path with the Critical Path Method (CPM). The CPM is a method for identifying critical work paths. The CPM contains jobs that are on the critical path that the project team must maintain.

Step 2: Lean Construction Approach

1) Making current state mapping. Current State Mapping is made to explain the overall picture of critical work that has been obtained from the CPM method and is used to analyze the waste that occurs.

2) Analysis of the type of activity. The analysis was carried out to see the types of activities contained in the current state mapping depiction. There are three types of activities in an activity process according to Hines, P & Taylor, (2007), namely:
   a. Value-Adding Activity is a type of activity that is able to provide added value to a product/service so that consumers are willing to pay for the added value of the activity.
   b. Non-Value Adding Activity is an activity that does not add value to the product/service. This is a waste that must be eliminated immediately.
   c. Necessary Non-Value Adding Activity is an activity that does not add value to the product/service but is needed in the existing process. This activity can be eliminated in a short period of time but can be made more efficient.
3) Fishbone Diagrams. The use of fishbone diagrams to describe waste and the factors that cause waste that occurs in a process from the results of waste analysis and interviews.
4) Using FMEA to get critical waste which are risks that will be analyzed further. The critical risk is obtained after calculating the RPN for each identified waste.
5) Making future state mapping. The improvement process is carried out by making Future state mapping. In the Future state mapping, the flow is described according to the proposed conditions to eliminate the waste found in the current state mapping.

4. Data Collection

Researcher have conducted a review of related literature, direct observations, focus group discussions to obtain the right project improvement proposals. The data collected comes from company data such as schedules, project activities as well as weekly progress weights and direct observations for the types, amounts and causes of waste.

5. Results and Discussion

5.1 Monitoring S Curve

Kode	Item Works	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
A	Prepatory Works																		
B	Structure Works																		
C	Wall, Door & Window Partition Works																		
D	Ceiling Works																		
E	Floor Works																		
F	Furniture Works																		
G	Additional Item																		
	Plan	0.20%	0.20%	2.98%	2.98%	2.98%	7.78%	7.78%	15.78%	16.38%	12.38%	14.38%	1.85%	7.85%	1.25%	5.25%			
	Acumulative Plan	0.20%	0.40%	3.38%	6.36%	9.33%	17.11%	24.89%	40.67%	57.04%	69.42%	83.80%	85.65%	93.50%	94.75%	100.00%			
	Actual	0.20%	0.20%	2.50%	2.78%	3.25%	5.35%	7.75%	9.29%	5.40%	6.04%	9.75%	3.50%	8.20%	6.85%	8.94%	8.44%	6.80%	4.76%
	Acumulative Actual	0.20%	0.40%	2.90%	5.68%	8.93%	14.28%	22.03%	31.32%	36.72%	42.76%	52.51%	56.01%	64.21%	71.06%	80.00%	88.44%	95.24%	100.00%
	Deviasi	0.00%	0.00%	-0.48%	-0.68%	-0.40%	-2.83%	-2.86%	-9.35%	-20.32%	-26.66%	-31.29%	-29.64%	-29.29%	-23.69%	-20.00%	88.44%	95.24%	100.00%

Figure 1. S Curve the Interior Project

In figure 1, it is known that the interior project has 7 activities, namely preparatory, structure, doors, windows and walls, ceilings, floors, furniture, and additional items. After the project was running, it turned out that the project had been delayed for 3 weeks.

5.2 Critical Path Method (CPM)

Table 1. Critical Path

Kode	Predecessor	Duration	ES	EF	LS	LF	Slack	Desc
A	-	22	0	22	0	22	0	Critical
B	A	15	23	37	26	40	3	Non-Critical
C	B	25	33	57	36	60	3	Non-Critical
D	B	25	38	62	41	65	3	Non-Critical
E	C, D	15	48	62	51	66	3	Non-Critical

Table 1. Critical Path

Kode	Predecessor	Duration	ES	EF	LS	LF	Slack	Desc
F	A	60	11	70	11	70	0	Critical
G	E, F	5	66	70	66	70	0	Critical

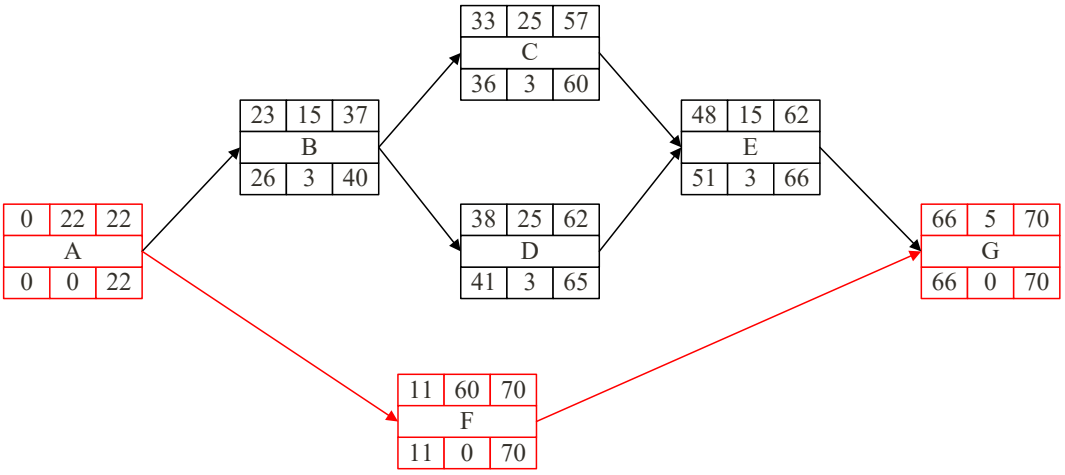

Figure 2. Critical Path

From Table 1 and Figure 2, it was found that the critical path for work with codes A, F, and G is preparation work, furniture, and additional items.

5.3 Current State Mapping

The following is an identification of value-added, nonvalue added, and necessary nonvalue added activities. Value added is an activity that is able to provide added value or is an important component in the production process, nonvalue added is an activity that does not produce added value and necessary nonvalue added is an activity that is not value-added but is needed. The results of the identification of activity values in interior projects can be seen in figure 3.

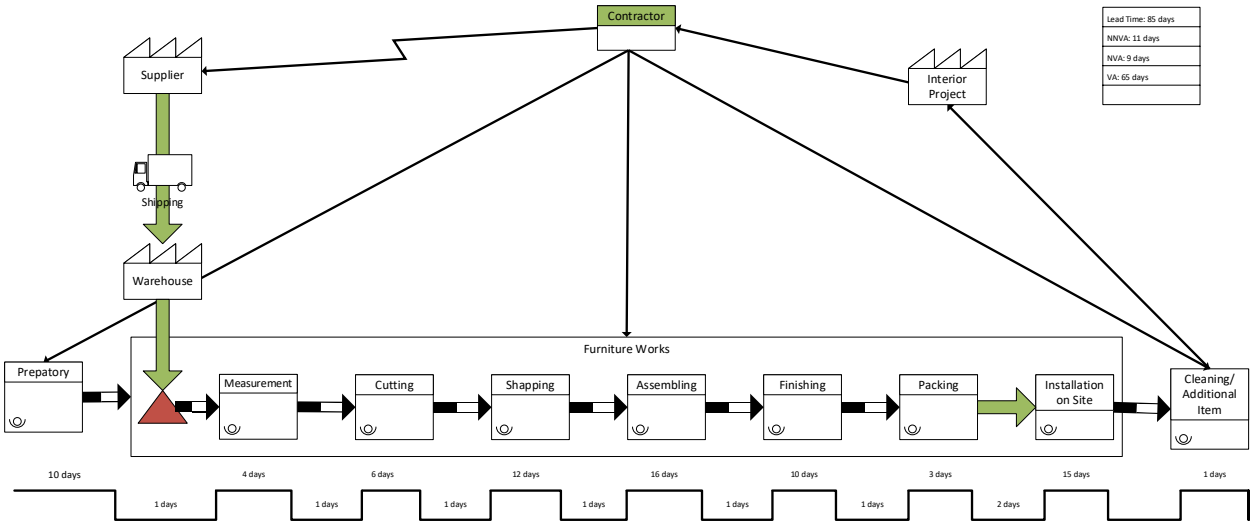

Figure 3. Current State Mapping

Table 2. Identification Activity

No	Activity	Duration (days)	Percentage	VA/NVA/NNVA
1	Preparatory	10	11.76%	NNVA
2	Material Delivery from Warehouse	1	1.18%	NNVA
3	Material Measurement	4	4.71%	NVA
4	Material Transfer	1	1.18%	NVA
5	Cutting	6	7.06%	VA
6	Material Transfer	1	1.18%	NVA
7	Shaping	12	14.12%	VA
8	Material Transfer	1	1.18%	NVA
9	Assembling	16	18.82%	VA
10	Material Transfer	1	1.18%	NVA
11	Finishing	10	11.76%	VA
12	Material Transfer	1	1.18%	NVA
13	Packing	3	3.53%	VA
14	Shipping	2	2.35%	VA
15	Installation On Site	15	17.65%	VA
16	Cleaning/Additional Item	1	1.18%	VA
Total Lead Time		85	100.00%	

The total duration in table 2 is 85 days for the implementation of interior projects, this is still considered less effective and efficient because there are still some activities that are non-value added.

From the results of grouping processes based on the above activities, it can be seen in table 3.

Table 3. Activity Grouping

Activity	Amount	Duration	Percentage
VA	8	65	76.47%
NVA	5	9	10.59%
NNVA	2	11	12.94%
Total	15	85	100.00%

Based on the identification of activities and employment conditions that occur in the implementation of interior projects, the following wastes are generated in the processes that occur:

1. Waiting

Waste of waiting time due to unbalanced processes so that some workers and machines have to wait to do other work. The waiting time that occurs in the implementation of interior projects is the process of sending raw materials from the warehouse to the workshop, transferring materials from one process to the next. To be more effective, the raw materials used should be sent from the supplier directly to the workshop and the material transfer is carried out immediately after the production process is completed on the same day.

2. Defect

Waste on defect in the resulting production process. The defects that occur are measurement errors and raw material cutting, which are still done manually by the operator. Preferably, the cutting of raw materials is done by machine.

3. Inventory

Waste on inventory is very influential because if there are no raw materials, the implementation of interior projects will stop. Based on the results of the discussions carried out, the cause of the delay in the supply of raw materials is due to raw materials from empty suppliers, this vacancy occurs because of the large number of requests from suppliers, but factory production is not fulfilled.

5.4 Fishbone Diagram

Based on the description of the current state mapping, the waste that occurs in the interior project is identified as in the fishbone diagram in figure 4, figure 5, and figure 6.

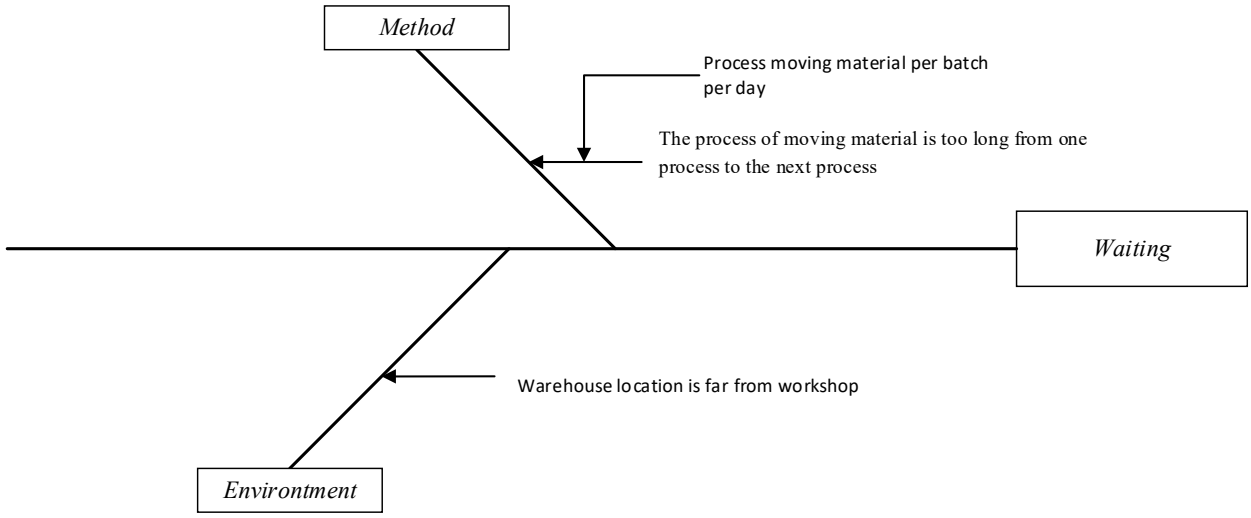

Figure 4. Waste Waiting

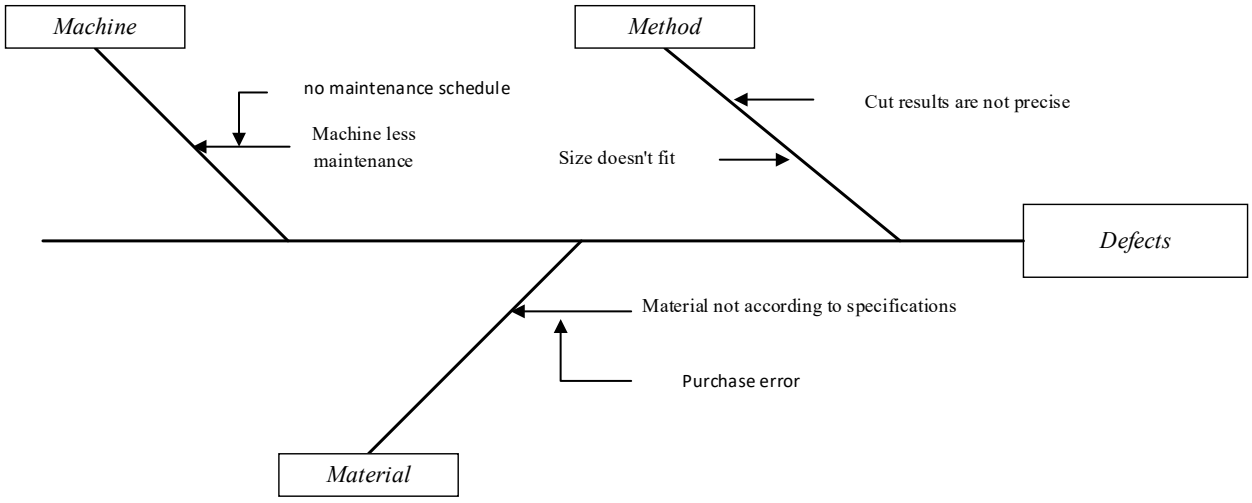

Figure 5. Waste Defect

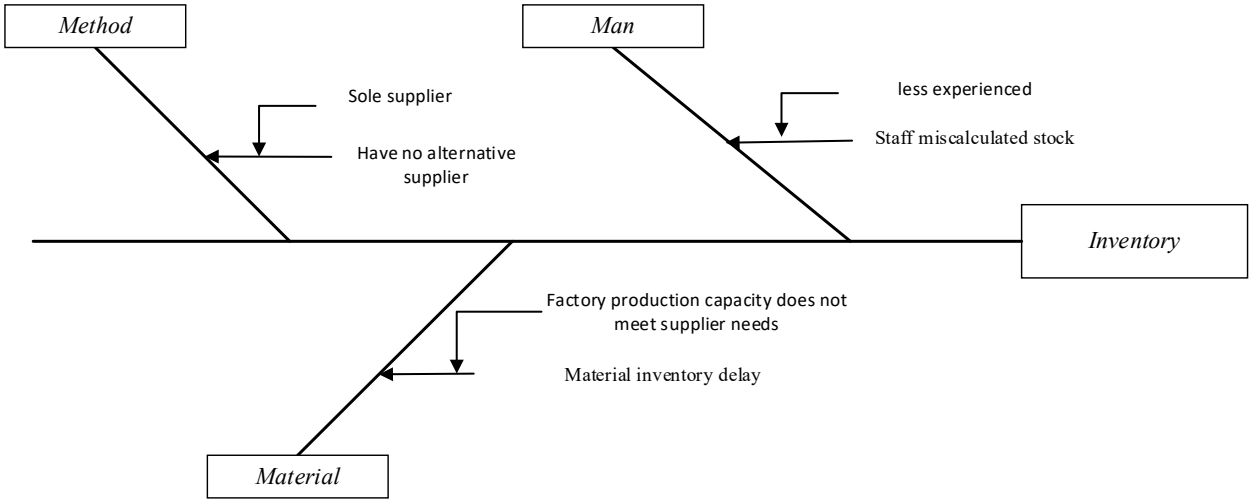

Figure 6. Waste Inventory

5.5 Failure Mode and Effects Analysis

Table 4. Failure Mode and Effects Analysis

Mode of Failure	*Effects Of Failure*	S	O	D	RPN
Waiting	Warehouse location is far from workshop	4	5	2	40
	The process of moving material is too long from one process to the next process	6	5	3	90
Defects	Size doesn't fit	5	3	2	30
	Cut results are not precise	6	2	2	24
	Material not according to specification	7	5	2	70
	Machine less maintenance	6	5	1	30
Inventory	Staff miscalculated stock	5	5	1	25
	Material inventory delay	6	4	1	24
	Have no alternative supplier	7	5	3	105

In Table 4 -6, the results of the RPN value with the highest ranking of 4 are obtained, namely a value of 105 for not having alternative suppliers, a value of 70 for materials that do not meet specifications, a value of 90 on the process of moving materials too long and a value of 40 for a warehouse location far from the workshop. From this ranking, appropriate improvement proposals will be made.

5.6 Improvement

After analyzing the causes of waste in critical project activities, improvements are proposed so that the causes of the waste can be reduced. The proposed improvements are as follows:

1. Submission of materials with the same specifications

There are some materials that can only be supplied by certain vendors and these materials are not ready stock, so the company does not have alternative vendors and has to wait several months for these materials. Then a proposal is given so that the company can submit material with the same specifications as the previous material to the owner so that the replacement of the material can be approved.

2. Process adjustment
The transfer of material from one process to the next requires a long waiting time of 1 (one) day, so it is suggested to make adjustments to the measurement, cutting and shaping processes so that each finished material can be directly processed to the next stage without waiting. This is also done in the finishing and packing processes to shorten processing time and avoid unwanted events after the finishing process such as damage to finished materials, loss, and others.

3. Material sample checking
For every material that will be purchased, the purchasing staff must request a sample of the material to the supplier to be submitted to the owner. This can avoid the mistake of purchasing materials that are not according to specifications.
4. Material Delivery from Supplier to Workshop.

In the furniture production process, the materials needed have to wait for delivery from the warehouse, which is located 32KM from the workshop. This requires a very long waiting time, not to mention if there is a delay in the delivery of materials from the supplier to the warehouse. Therefore, it is proposed that each ordered material will be sent directly from the supplier to the workshop to shorten the time and distance.

5.7 Future State Mapping

After describing the current state mapping and identifying waste, it can be seen the parts that need to be improved. The proposed improvements can be seen in the future state mapping in figure 7.

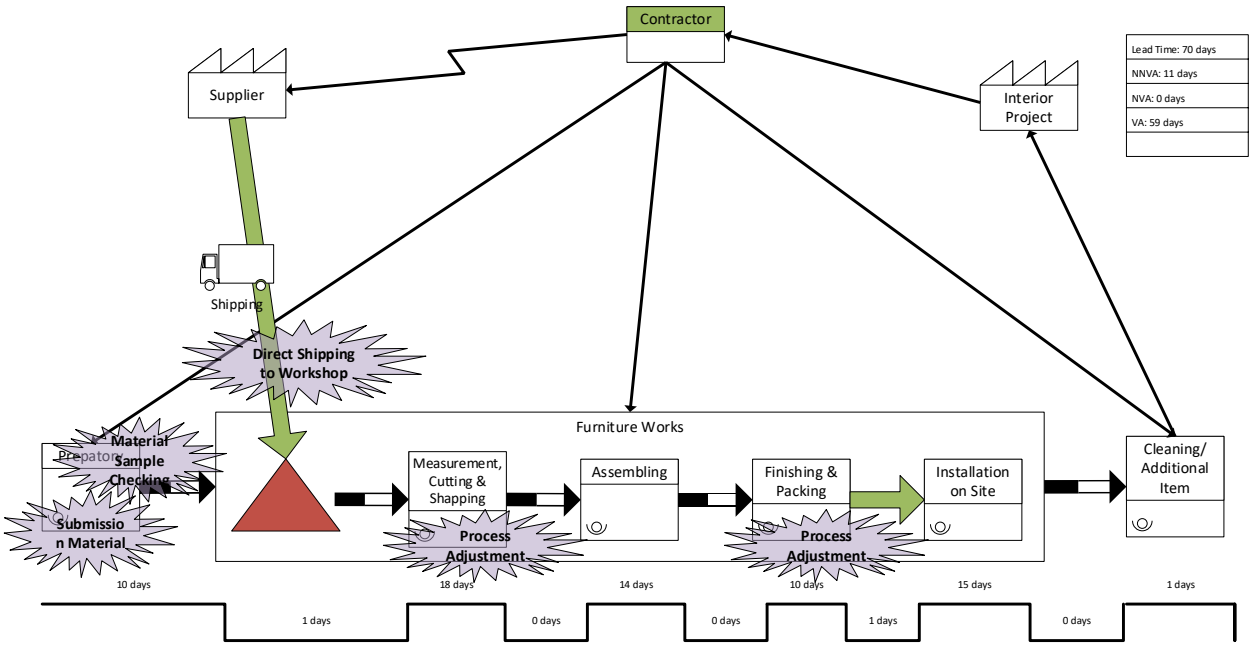

Figure 7. Future State Mapping

Based on the future state mapping above, the proposed time has been adjusted according to various calculations. The activity mapping in table 5 and table 6.

Table 5. Identification Activity After Improvement

No	Activity	Duration (days)	Percentage	VA/NVA/NNVA
1	Preparatory	10	14.29%	NNVA
2	Material Delivery from Warehouse	1	1.43%	NNVA
3	Measurement, Cutting & Shaping	18	25.71%	VA

4	Assembling	14	20.00%	VA
5	Finishing & Packing	10	14.29%	VA
6	Shipping	1	1.43%	VA
7	Installation on Site	15	21.43%	VA
8	Cleaning/Additional Item	1	1.43%	VA
	Total Lead Time	70	100.00%	

Table 6. Activity Grouping After Improvement

Activity	Amount	Duration	Percentage
VA	6	59	84.29%
NVA	0	0	0.00%
NNVA	2	11	15.71%
Total	8	70	100.00%

From the future state mapping, it can be seen that there is a difference in the resulting duration. The implementation of interior projects is 17.65% faster than the current state, reducing the duration from 85 days to 70 days.

6. Conclusion

From the results of the study, it can be concluded that:

1. Waste that occurs in interior projects is waste waiting, defects, and inventory. The cause of waste that occurs in the implementation of interior projects is waste waiting because the material is stored in a warehouse located far from the workshop, so it takes a long time, so operators have to wait to carry out the production process. The cause of the waste defect is due to measurement and cutting errors by unskilled operators, materials that do not meet specifications. The cause of inventory waste is because the material stock from the supplier is empty, material planning errors, and the absence of alternative suppliers.
2. The proposed activity improvement in order to reduce the waste is waste waiting by delivery of materials from suppliers directly to the workshop, merging processes. Waste defects by checking material samples and waste inventory by submission of materials with the same specifications.
   So from the proposed improvement, the duration of the interior project is 15 days faster from 85 days to 70 days.

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BiographyFF

Dinda Ayu Nawangsasi is a master degree student of Industrial Engineering at Universitas Mercu Buana Jakarta. She graduated in Industrial Engineering from Universitas Muhammadiyah Tangerang in 2019. Her research interest includes Project Management, Lean Construction, etc. during her studies in the master degree in Industrial Engineering, she has always been interested in conducting research in the construction industry.

Zulfa Fitri Ikatrinasari is a senior lecturer in Productivity and Performance Management System at Universitas Mercu Buana Jakarta. Her research interest includes Decision Support System, Performance Management System, Lean & Green Manufacturing, etc. She graduated in Agroindustrial Engineering from Institut Pertanian Bogor in 1995, Master in Management & Industrial Engineering from Institut Teknologi Bandung in 1998, and obtained a Ph.D in 2010 from Institut Pertanian Bogor.