JRSSEM 2022, Vol. 02, No. 6, 1187 – 1202
E-ISSN: 2807 - 6311, P-ISSN: 2807 - 6494

DELAY FACTOR ANALYSIS AND DYNAMIC SYSTEM MODELING ON THE LIQUID PETRELEUM GAS TANK EPC PROJECT IN KUPANG

Agung Fachrully Ade[1]
Sugeng Santoso[2]
[1,2]*Universitas Mercu Buana Jakarta Barat, Indonesia*
[*]*e-mail: agungfachrullyade@gmail.com, sugeng.santoso@mercubuana.ac.id*
**Correspondence: agungfachrullyade@gmail.com*

Submitted: 25th December 2022 *Revised*: 18th January 2023 *Accepted*: 29th January 2023

Abstract: Project delays are an event that often occurs in every project, especially projects with the scope of Engineering Procurement & Construction (EPC) in Indonesia. Many factors affect the slowness of the project so that the performance of a project will not run well if supervision and control are not carried out. The purpose of this study is to find out what the factors that caused delays, make modeling using dynamic systems and how to make effective managerial suggestions to accelerate project performance. This research method uses mixed methods. The results of this study there are 3 factors that cause delays in the project, starting from the largest factor based on the results of the mean rank analysis is the Construction factor, followed by Procurement, and the last is engineering. In the Construction Factor, five main indicators were taken to cause the delay in the Petreleum Gas Liquid Tank EPC project in Kupang which occurred because the material did not meet specifications, work was stopped due to design changes, delays in project manager decision making, differences of opinion between contractors and consultants, and poor construction quality. Managerial advice in this study is to improve the quality of Human Resources and improve communication networks, tighten the control function and evaluate regularly.

Kata Kunci: Project delays; EPC; Dynamic Systems.

INTRODUCTION

A project is an activity that is carried out with limited time and resources to achieve a predetermined final result. In achieving the final result, an activity on a project is limited by budget, schedule and quality (Triple Constraint) (Rani & Yuni, 2021), a project can be interpreted as a combination of various resources in a certain organizational structure that are gathered to achieve a goal. Activities or tasks carried out in a project are in the form of construction or repair of facilities such as buildings, roads, bridges, dams, and so on, or it can also be in the form of research, development activities. A project is an activity that has a temporary nature (limited time), is not repetitive, is not routine, has a start and end time, limited or certain resources and is intended to achieve a predetermined goal.

Project delays are an event that often occurs in every project, especially projects with the scope of Engineering Procurement & Construction (EPC) in Indonesia. This is very common because many factors affect the delay of the project during the EPC work process (Agung, 2020). According to (Suyatno, 2010) a project that experiences delays will have an impact on the timeframe agreed on the initial contract document and will potentially also have the cost overrun of the project.

Project Management in a job in the Service Industry is a series of activities that have complex problems so that the process of planning to project control activities during implementation is an important series of a project. One of the problems that often occurs in project activities is the risk of delays in the project. An Engineering Procurement Construction (EPC) project is a project in which the contractor works on a project with the scope of responsibility for completing the work including design studies, material procurement and construction as well as planning of the three activities (Sholeh et al., 2015). The most complex thing in an EPC project is when budgeting and project execution schedules. All activities must be created and known before the project is worked on (Ajayi & Chinda, 2022). The EPC stage starts from Engineering, Procurement, and ends with Construction (construction) (Abdullah et al., 2018).

The object of this study is a government assignment project in order to reduce fuel subsidies through the conversion of kerosene to Liquid Petreleum Gas (LPG). In addition, the project on this research object is one of the PSN (National Strategic Projects) to increase energy supply and also the reliability of national energy infrastructure. With the conversion of Fuel Oil (BBM) from kerosene to Liquid Petreleum Gas (LPG), the need for Liquid Petreleum Gas (LPG) in the future will continue to increase while the available facilities for revenue and stockpiling are still insufficient, so that there is a need to add Liquid Petreleum Gas (LPG) stockpiling facilities, in order to anticipate the increase in the need for Liquid Petreleum Gas (LPG) so that there is no crisis in the availability of Liquid Petreleum Gas (LPG) in People of East Nusa Tenggara. The project location plan for this research object is located in the fuel terminal area in East Nusa Tenggara.

The main problem that resulted in delays in the work of this project was the lack of level of readiness in the preparation of project management which took 4 (four) months from the start of the project, so that in the first 4 (four) months the progress went slow down from the plan. In the 5th (fifth) month progress began to be seen so that in the 6th (sixth) month until before the Covid-19 pandemic, progress went well according to the planned schedule. In March 2020, the out break of the Covid-19 pandemic greatly affected the overall Project Performance Productivity, both from the scope of Engineering, Procurement and Construction. This happens because of the lack of project readiness to face some unexpected risks, including:

1. Decreased Engineering performance due to the Work from Home work system which makes it difficult to interact directly with clients and vendors.
2. Increasing prices of equipment from abroad caused by fluctuations in foreign currencies against the Rupiah.
3. Policy on the Implementation of Restrictions on Community Activities which affects the performance of construction and supply chain so that there are many delays in the arrival of Materials and Main Equipment, especially those purchased from outside the island and abroad.
4. The company's financial difficulties from the beginning of the Covid-19 pandemic which resulted in disrupted project operations and cash flow.

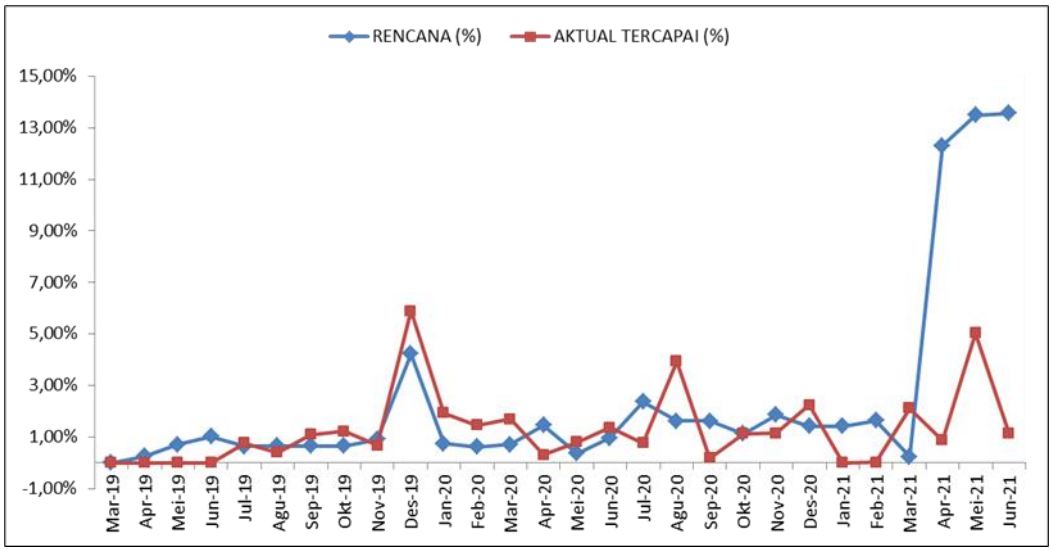

Figure 1: Project Performance Curve for the Period of March 2019 – June 2021
Source: Data Processed (2021)

The progress position achieved in June 2021 was 36.27% of the planned 69.64% so that there was a minus (Behind) deviation of -33.37%, details can be seen in Table 1.

Table 1. EPC Progress Position for June 2021 Period

NO	WORK ITEMS	WEIGHTS AGAINST CONTRACTS (%)	ACTUAL PROGRESS (%)	PLAN PROGRESS (%)	DEVIATION (%)
1	Engineering	5,3356	5,2345	5,3356	-0,1012
2	Procurement	69,4870	15,7298	46,5162	-30,7864
3	Construction	25,1774	15,3068	17,7911	-2,4843
Total		**100**	**36,2710**	**69,6430**	**-33,3719**

Source: Data processed (2021)

To complete the phenomenon in the background of this research, the first step will be to identify what factors affect the delay of the project and make a simulation concept from the results of the identification of these factors using the Dynamic Systems approach (Surya et al., 2017) (Bugaje et al., 2021).

MATERIALS AND METHODS

The framework of this study focuses on identifying the factors of delay that occur in the EPC Project of Liquid Petreleum Gas Tanks in Kupang where the framework in this study has outputs that require changing the direction of strategy or creating new work programs in order to get optimal results during the development process (Guida & Sacco, 2019).

The type of research used in this research object is Mix Methods where in research with the Mixed Methods method has a procedure to collect, analyze and mix quantitative and qualitative methods in a study to understand the problems in the study. The approach in this study uses a quantitative descriptive approach, where enrichment of explanations or variable information will be carried out through FGDs on key informants and supporting informants followed by analysis of key informants as confirmation.

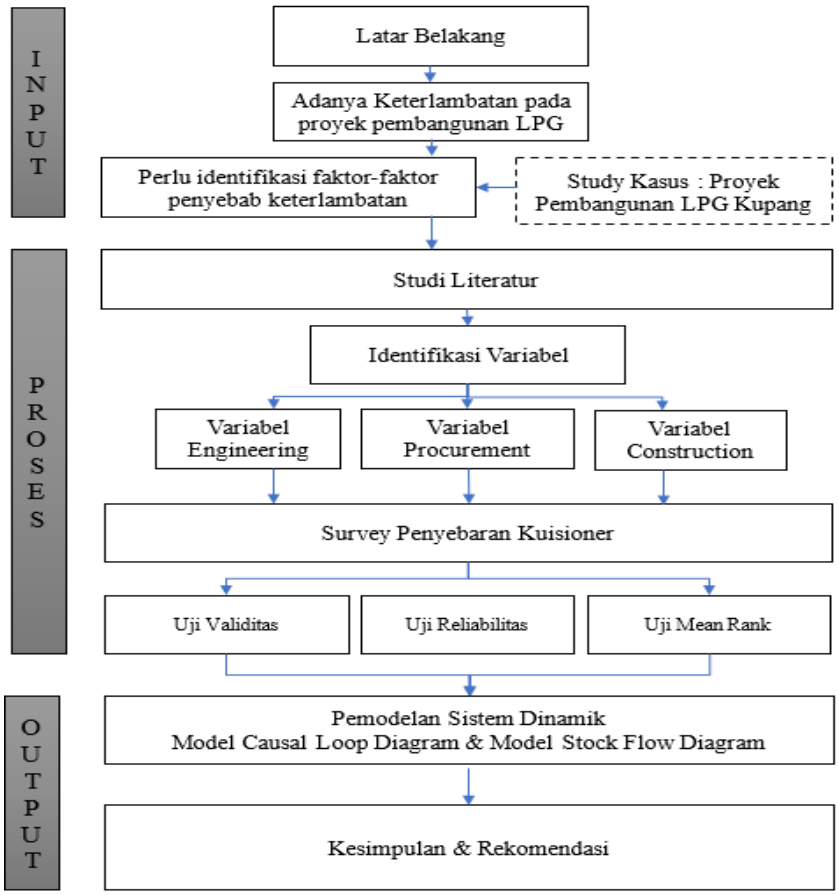

Figure 2: Fame of Mind
Source: Data processed (2021)

Research Population and Sample

A population is a collection of the whole on the measurement of objects or individuals aimed at assessing data where the population of this study consists of all staff and workers in the EPC Project of Petreleum Gas Liquid Tank in Kupang as well as all representatives of related staff at the Jakarta head office with various positions, ages and educational backgrounds (Kammouh et al., 2022). It was calculated that the population to be used in this study was approximately 25 respondents.

Data Collection Methods

This research is limited to the scope of the Petreleum Gas Liquid Tank EPC Project in Kupang which refers to the management of Project Management during the pandemic. This study used data collection methods obtained from Documentation, Observation, Interviews, Discussions, and Questionnaire Distribution.

Primary Data

Primary Data is data obtained from the original source, where in this study, the Primary Data obtained was in the form of Field Data, namely by obtaining information directly from the Project Manager and General Manager submitted by the researcher. The source of information obtained provides data directly and is original where this data is the main data for the author to obtain related

information needed according to the problems that occurred in the Project during the pandemic and before the pandemic (Egwim et al., 2021).

Secondary Data

Secondary Data in this study was carried out by collecting some information by conducting a Site Visit to the project site using the Observation, Interview, FGD (Focus Group Discussion) method and then some documentation was taken and then the distribution of questionnaires was carried out.

RESULTS AND DISCUSSION

Descriptive Analysis

Based on the results of filling out research instruments or questionnaires by the respondents, data related to project delay factors were obtained. From filling out the research instrument or questionnaire, statistical data was generated regarding the factors causing the delay in the EPC project of the Petreleum Gas Liquid Tank in Kupang.

Ranking Analysis

The sample data that appears will be in the form of frequencies in each variable used in this study is the result of filling out instruments or questionnaires. The sample data will be input analysis using descriptive analysis methods. The data will be summed in its entirety from the response answers with the use of a likert scale. Then the standard deviation of each variable used in this study will be calculated.

Standard deviation can be interpreted as a statistical value used to determine the distribution of data on the sample, as well as to determine the data point from each individual to the mean or average of the sample values. If the value of the standard deviation of a sample data is equal to zero, then it can show that all values in the instrument or questionnaire are the same. The greater the value of the standard deviation of a sample data, the more bsesar the distance value of each data point with the average value.

Mean Rank Between Variables

Mean Ranking of each factor of the cause of the delay in the EPC project of the Petreleum Gas Liquid Tank in Kupang, will be imprecipated in the figure and table below.

Table 3. Delay Factor Ranking Analysis

Factor	N	Min	Max	Std. Deviation	Ranking
Engineering (X1)	25	36	52	44.760	3
Procurement(X2)	25	44	68	58.120	2
Construction(X3)	25	46	76	61.800	1

Source: Data processed (2022)

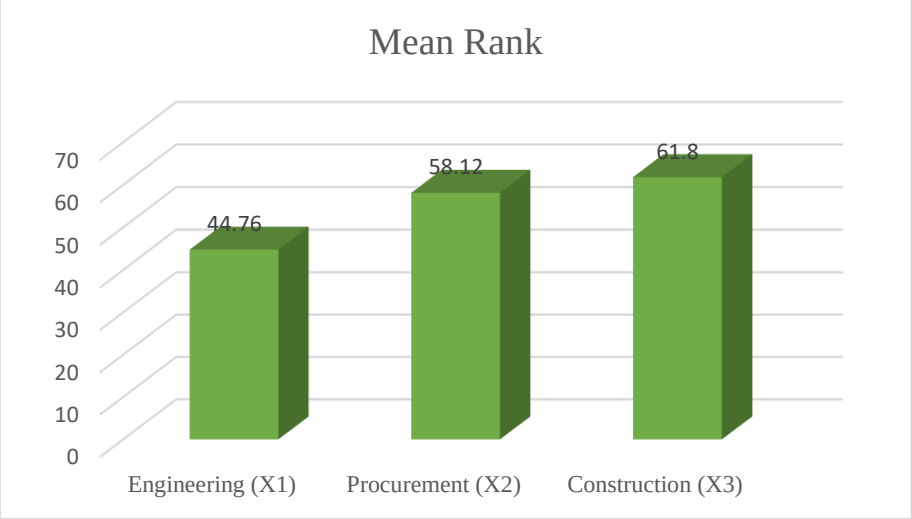

Figure 3: Delay Factor Ranking Analysis
Source: Processed Data (2022)

Based on the results of the ranking analysis imprecipated in Table 8 and Figure 4, it is known that the sequence of factors causing the delay in the Liquid Petreleum Gas Tank EPC Project in Kupang, namely:

1. Construction Factor

One of the most supportive factors in the creation of a good project development is the contrsuktion factor. In this study, the construction factor was the biggest factor that made the delay in the EPC Project of Liquid Petreleum Gas Tank in Kupang.

In this study, there are various construction factors that can be indicators of obstacles in the Liquid Petreleum Gas Tank EPC Project in Kupang, for example site conditions that are much different from design, unexpected weather conditions, poor construction quality, to delays in cash flow in the Petreleum Gas Tank EPC Project in Kupang.

Based on previous research, project delays caused by construction factors are usually due to construction delays followed by administrative delays and also consultant delays as well as due to unpredictable weather. This is likely to happen, because when you want to do construction, it turns out that the state of the site has changed from before or there is a delay in determining decisions in the field by the project manager.

2. Procurement Factor

In addition to construction factors, procurement factors are also one of the determining factors in project development. Delays in procurement such as the provision of materials needed can occur due to difficulties in obtaining them or due to bid prices that are too high than predetermined estimates.

Based on previous research, project delays caused by procurement factors are usually because the materials used are not produced alone or there is a conflict of interest and also the policies that apply in the surrounding community are not synchronized.

3. Engineering Factors

The last factor that can affect the slowness in project implementation is the factor of experts or manpower. Errors in this technician factor, usually regarding the incorrect calculation of the number of workers so that the work carried out does not run effectively. In addition, mistakes that often occur are changes in specifications that eventually make design changes and also changes in budget plans.

The amount of manpower required at each stage of project implementation will vary. This depends on the type of work and job responsibilities. Planning that does not match the needs contained in the field will cause problems (Kammouh et al., 2022). The reason is, labor is one of the resources that is difficult to get and also the price is quite soaring.

Lack of skills and expertise and communication from workers can also result in less productive work done. Because the time it takes to complete a project will become longer.

Based on the previous research, with the title Modeling of Delay Factors for the Ambon Lantamal Pier Arrangement Project with a Dynamic System, Project delays caused by labor or technician factors are usually due to difficulties in obtaining human resources in accordance with qualifications and changes in specifications during project work(Buyang & Buyang, 2020). So because of these changes, it causes design changes in the project and also changes in budget and additions or reductions of the materials to be used.

Mean Ranking per item variable

Table 4. Ranking Analysis of Engineering Variables

Variabel	N	Min	Max	Mean	Std. Deviation	Ranking
VAR00001	25	3.00	4.00	3.6400	.48990	3
VAR00002	25	3.00	4.00	3.6000	.50000	4
VAR00003	25	2.00	4.00	3.6430	.56862	2
VAR00004	25	2.00	4.00	3.1600	.74610	13
VAR00005	25	3.00	4.00	3.6440	.48990	1
VAR00006	25	3.00	4.00	3.5600	.50662	6
VAR00007	25	2.00	4.00	3.1610	.74610	12
VAR00008	25	3.00	4.00	3.5600	.50662	7
VAR00009	25	3.00	4.00	3.5610	.50662	5
VAR00010	25	2.00	4.00	3.1620	.74610	11
VAR00011	25	2.00	4.00	3.3630	.70000	10
VAR00012	25	2.00	4.00	3.3650	.70000	8
VAR00013	25	2.00	4.00	3.3640	.70000	9

Source: Data processed (2022)

Table 5. Procurement Variable Ranking Analysis

Variabel	N	Min	Max	Mean	Std. Deviation	Ranking
VAR00001	25	2.00	4.00	3.6210	.57735	3
VAR00002	25	2.00	4.00	3.6500	.57735	2
VAR00003	25	2.00	4.00	3.4800	.58595	8
VAR00004	25	2.00	4.00	3.4200	.57735	10
VAR00005	25	2.00	4.00	3.4100	.57735	11
VAR00006	25	3.00	4.00	3.7600	.43589	1
VAR00007	25	3.00	4.00	3.4800	.50990	9
VAR00008	25	3.00	4.00	3.4830	.50990	7
VAR00009	25	2.00	4.00	3.0800	.75939	17
VAR00010	25	2.00	4.00	3.0820	.75939	15
VAR00011	25	2.00	4.00	3.0810	.75939	16
VAR00012	25	2.00	4.00	3.0840	.75939	14
VAR00013	25	2.00	4.00	3.6100	.57735	5
VAR00014	25	2.00	4.00	3.4010	.70711	13
VAR00015	25	2.00	4.00	3.6010	.57735	6
VAR00016	25	2.00	4.00	3.6200	.57735	4
VAR00017	25	2.00	4.00	3.4100	.70711	12

Source: Data processed (2022)

Table 6. Construction Variable Ranking Analysis

Variabel	N	Min	Max	Mean	Std. Deviation	Ranking
VAR00001	25	2.00	4.00	3.0100	.76376	17
VAR00002	25	2.00	4.00	3.0300	.76376	16
VAR00003	25	2.00	4.00	3.2800	.61373	8
VAR00004	25	2.00	4.00	3.2400	.72342	12
VAR00005	25	2.00	4.00	3.5600	.65064	2
VAR00006	25	3.00	4.00	3.6800	.47610	1
VAR00007	25	3.00	4.00	3.5200	.50990	3
VAR00008	25	1.00	4.00	3.4000	.86603	7
VAR00009	25	2.00	4.00	3.0400	.67577	14
VAR00010	25	2.00	4.00	3.0000	.76376	18
VAR00011	25	2.00	4.00	3.4100	.57735	6
VAR00012	25	1.00	4.00	2.9600	.84063	19
VAR00013	25	2.00	4.00	3.2000	.76376	13
VAR00014	25	2.00	4.00	3.4300	.64550	4
VAR00015	25	2.00	4.00	3.4200	.64550	5
VAR00016	25	2.00	4.00	3.0400	.81650	15
VAR00017	25	2.00	4.00	3.2440	.66332	9
VAR00018	25	2.00	4.00	3.2430	.66332	10
VAR00019	25	2.00	4.00	3.2410	.66332	11

Source: Data processed (2022)

Mean Ranking per Item Variabel

Based on the results of the Mean Ranking Test of each item on each variable, it was decided to take five indicators for each delay factor or each variable. The collection of the five indicators is based on the greatest mean value of each delay factor or variable to become a dynamic system modeling. Modeling for this dynamic system will use the help of Ventana Simulation (Vensim) Software, the goal is to make the delivery of information easier and more effective. Here are the items or indicators of each delay factor that will be the input for dynamic system modeling:

Table 7. Mean Rank Variabel Engineering

Variabel	Keterangan	Mean	Ranking
Engineering	Rencana anggaran proyek	3.6440	1
	Jaringan Komunikasi engineering dengan procurement	3.6430	2
	Tingkat keakuratan Scope Of Work	3.6400	3
	Kualifikasi engineer	3.6000	4
	Tingkat keakuratan desain	3.5610	5
Procurement	Keterlambatan kedatangan material dan alat	3.7600	1
	Meningkatnya harga equipment akibat fluktuasi mata uang asing	3.6500	2
	Harga penawaran vendor yang lebih tinggi dari estimasi	3.6210	3
	Proses klarifikasi teknis yang kurang akurat	3.6200	4
	Kualifikasi pegawai	3.6100	5
Construction	Material tidak sesuai spesifikasi	3.6800	1
	Pekerjaan terhenti akibat perubahan desain	3.5600	2
	Keterlambatan pengambilan keputusan project manager	3.5200	3
	Perbedaan pendapat antara kontraktor dan konsultan	3.4300	4
	Kualitas kontruksi yang jelek	3.4200	5

Source: Data processed (2022)

In the dynamic system model used in this study, Level is interpreted as every factor of slowness, Rate is interpreted as all interpretations of delay in each indicator, Source is interpreted as the prefix of each delay factor, and Auxalary is interpreted as the purpose of conducting this study, which

is the factor causing the delay in the project.

In Rate Engineering, after analysis using the Mean Ranking method, levels were obtained in the top five rankings, namely project budget plan, engineering Communication Network with procurement, Scope of Work accuracy level, engineer qualification, and design accuracy level.

In Rate Procurement, after analysis using the Mean Ranking method, levels were obtained in the top five rankings, namely delays in the arrival of materials and tools, increasing equipment prices due to foreign currency fluctuations, vendor offer prices that are higher than estimated, technical clarification processes that are not accurate, and employee qualifications.

In Rate Construction after analysis using the Mean Ranking method levels were obtained in the top five rankings, namely materials not according to specifications, work stopped due to design changes, delays in project manager decision making, differences of opinion between contractors and consultants, and poor construction quality (Santoso et al., 2022).

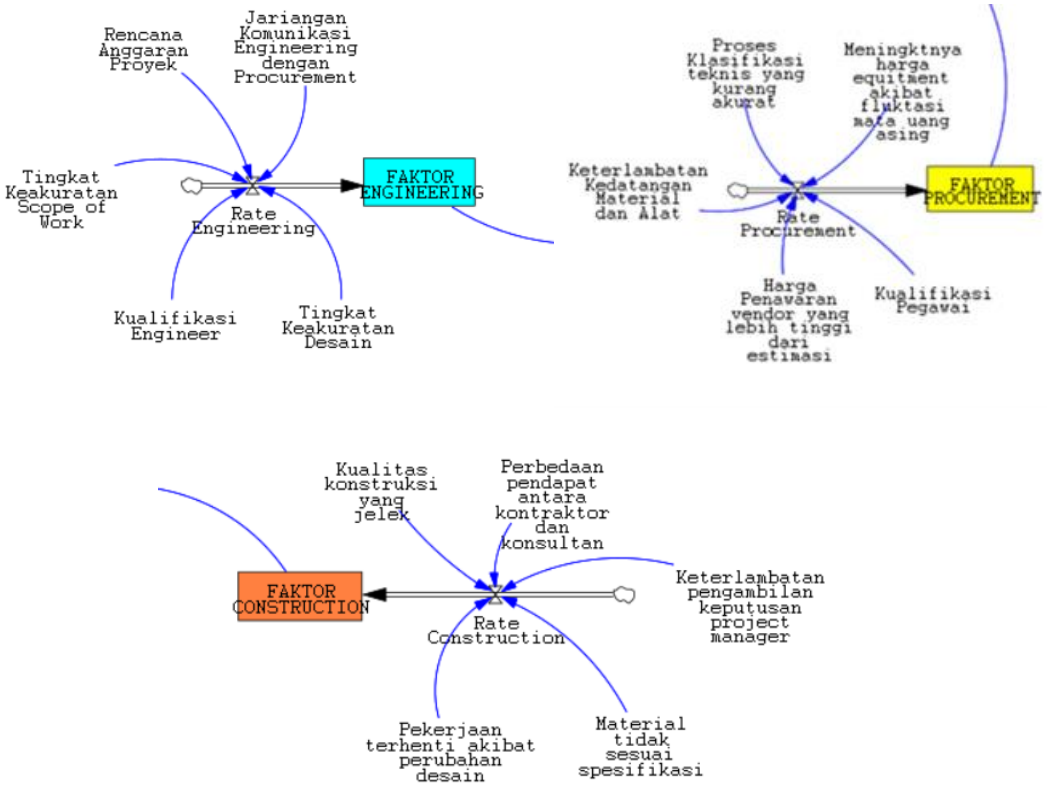

Figure 4: Level, Rate, Auxalary, Source Factors of Project Delay
Source: Data Processed (2022)

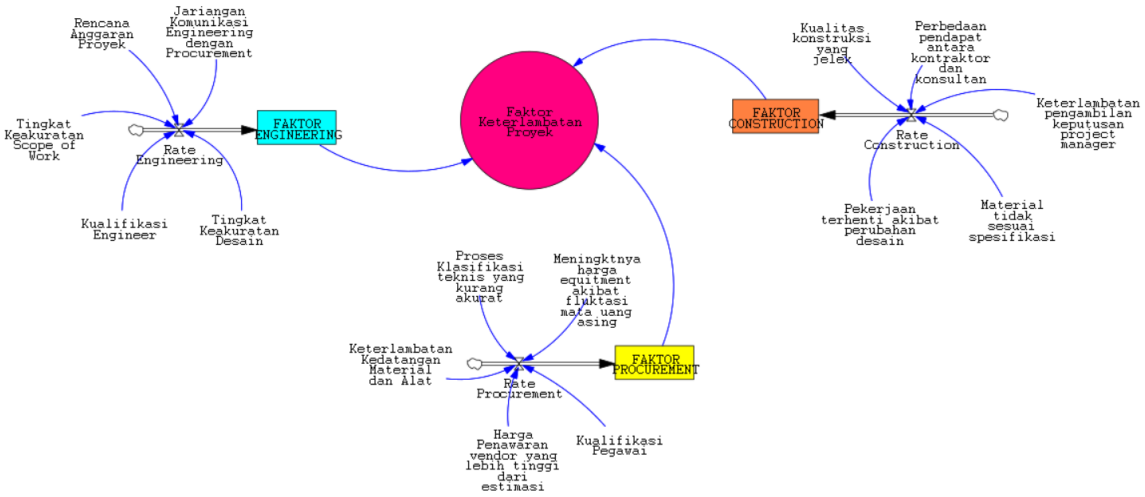

Figure 5: Dynamic System Modeling of Delay Factors in the Project
Source: Data Processed (2022)

Thus, after knowing the Level at each rate, for dynamic system modeling for Project slowness factors can be depicted throughout as shown in figure 6 (Megawati, 2021; Riyanto & Santoso, 2022). Based on the dynamic system modeling for the delay factors that occur, it can be written Strategic steps to be able to be a solution, namely as follows:

1. Engineering
   a. The Project Budget Plan is the main factor in delays in engineering work, from all engineering indicators it can be interpreted that the project budget plan can affect spec changes caused by the lack of thoroughness of material calculations. This can also affect the communication network between engineering and procurement hampered related to administration. On the other hand, to get approval from the Client will also be too late. Managerial advice for this point is to make some alternative project budget plan from the beginning of the project even before the project starts and make alternative technical specifications if you feel that the material is difficult to obtain or special order by considering the remaining duration of work, price, quality.
   b. Engineering Communication Network with Procurement is the 2nd (two) factor in delays in engineering work, at this point the communication network between engineering and procurement usually also affects the Communication Network with Vendors and Clients. This will also cause delays in approval from the job owner. Managerial advice for this point is that the use of technology is very necessary in this case to speed up the technical clarification process related to Design Engineering Details.

c. The level of accuracy of the Scope of Work is the 3rd (three) factor in delays in engineering work, this is influenced by the qualifications of engineers and the lack of thoroughness of engineering in terms of technical analysis. Managerial advice for this point is to increase the number of senior engineers on the project and tighten the qualifications of engineers both in terms of education, work experience of prospective employees in the recruitment process, as well as regular training for engineers, especially if there are technological updates, technical related issues and so on.
d. Engineer qualifications are the 4th (four) factor in delays in engineering work, Managerial advice for this point is to increase the number of senior engineers on the project and tighten the qualifications of engineers both in terms of education, work experience of prospective employees in the recruitment process, as well as routine training for Engineers, especially if there are technological updates, technical related issues and so on.
e. The level of design accuracy is the 5th (five) factor in delays in engineering work, the level of design accuracy is influenced by communication networks and affects design engineering details. Managerial advice for this point is that the use of technology is very necessary in this case to speed up the technical clarification process related to Design Engineering Details.

2. Procurement
   a. Delays in the arrival of materials and tools are the main factors for delays in procurement work, delays in the arrival of materials and tools caused by the late po issuance process, inaccurate technical clarification processes and policies for imposing restrictions on community activities. In the implementation of the project, the procurement of materials will take a relatively long time in its delivery. Therefore, speeding up the process of transporting critical materials will be of great help in accelerating the duration of project implementation. Anticipatory steps to minimize this are improvements from the engineering side related to a more mature technical administration preparation process and building systematic communication between engineering and procurement. Managerial advice for this point is to speed up the technical clarification process but with accurate results and accelerate the selection of vendors and the selection of ready stock or special order materials with the criteria of price, quality, accuracy and speed of delivery. This can certainly absorb costs higher than the planned cost budget, but to fix the project ciptra that is too late, the project manager must be brave to take this risk. In

addition, the level of smooth cash flow is also an important point in the smooth running of work where in the implementation of the project adequate funding is needed, so that all activities in the project run smoothly. Therefore, in the implementation of projects in actions related to funding, there is no hesitation in decision making including intense control and supervision functions.

b. The increase in equipment prices due to fluctuations in foreign currencies is the 2nd (two) factor in delays in procurement work, the Covid-19 pandemic outbreak is very impactful on fluctuations in the foreign currency exchange rate against the Rupiah. Managerial advice for this point is to mediate with vendors to change the payment system or find alternatives so that equipment fabrication is carried out in Indonesia because it requires an administrative process and also delivery to the project location. Therefore, the solution to use materials and tools from within the country will be able to shorten the duration of time.
c. The vendor's offer price that is higher than estimated is the 3rd (three) factor in delays in procurement work, this is due to limited material availability and results in the po issuance process being late. Managerial advice for this point is to coordinate with the Client to find other alternatives in terms of material spec changes, look for alternative vendors with the same specs but not on the brand list approval, etc. In this case, the Engineering and Procurement team must be active to convince the client to run smoothly.
d. The inaccurate technical clarification process is the 4th (fourth) factor in delays in procurement work, this is due to the qualifications of employees or the number of project human resources that are still lacking and this results in the issuance of late POs. Managerial advice for this point is to increase the number of senior staff on the project and tighten staff qualifications both in terms of education, work experience of prospective employees in the recruitment process, as well as regular training for staff, especially if there are technological updates, technical related issues and so on.
e. Employee qualifications are the 5th (five) factor in delays in procurement work, this is due to the lack of project human resources and this results in late issuance of PO. Managerial advice for this point is to increase the number of senior staff on the project and tighten staff qualifications both in terms of education, work experience of prospective employees in the recruitment process

3. Construction
   a. Material not meeting specifications is the main factor in delays in construction work, this is due to employee qualifications and

employee limitations on the project and results in the material being rejected at onsite. Managerial advice for this point is to increase the number of quality control staff on the project and tighten staff qualifications both in terms of education, work experience of prospective employees in the recruitment process. The controlling role of Quality Control is very important in this case where double inspection must be carried out before the material is sent and when the material has arrived in the field.

b. Work stopped due to design changes is the 2nd (two) factor in delays in construction work, caused by site conditions that are different from the planning design so that the design cannot be applied optimally in the field. Managerial advice for this point is to carry out intense coordination between the project team and the division team, take initiative steps by the project team to make designs according to the actual conditions of the field with coordination between the project team and the project consultant to request design approval and parallelly start work in accordance with the actual design with the approval of the project consultant while waiting for the actual design to be approved by the center.
c. The delay in making project manager decisions is the 3rd (three) factor in delays in construction work, this is caused by differences of opinion between contractors and consultants and results in delayed licensing regulations so that work is stopped. Managerial advice for this point is to conduct coordination meetings to evaluate the work thoroughly either on a weekly basis or at any time if needed.
d. Differences of opinion between contractors and consultants are the 4th (four) factor in delays in construction work, this is related to the previous point (3.c) where the role of the project manager is very important in terms of coordinating thoroughly.
e. The poor quality of construction is the 5th (five) factor in delays in construction work, this is related to the previous point (3.c) where the role of the project manager is very important in terms of coordinating thoroughly.

CONCLUSIONS

Based on the data, analysis, and discussion of the research conducted, it was concluded that: 1) The identification of delay factors in this study resulted in three factors, namely Engineering, Procurement and Construction where in each. 2) Based on the results of the Mean Ranking Test of each item on each variable, it was decided to take five indicators for each delay factor or each variable. The collection of the five indicators is based on the greatest mean value of each delay factor or variable to become a dynamic system modeling. Modeling for this dynamic system will use the help of Ventana Simulation (Vensim)

Software, the goal is to make the delivery of information easier and more effective. The following are the items or indicators of each delay factor that will be the input for dynamic system modeling. 3) Based on the results of the analysis, Managerial Advice was obtained in this study which has been listed in the discussion chapter.

REFERENCES

Abdullah, M. S., Alaloul, W. S., Liew, M. S., & Mohammed, B. S. (2018). Delays and cost overruns causes during construction of palm oil refinery projects. *MATEC Web of Conferences*, *203*, 2004.

Agung, G. (2020). *Pemodelan Sistem Dinamis Produksi Tempe "Sumber Mas" Di Kabupaten Jember*. Politeknik Negeri Jember.

Ajayi, B. O., & Chinda, T. (2022). Impact of construction delay-controlling parameters on project schedule: DEMATEL-system dynamics modeling approach. *Frontiers in Built Environment*, *8*, 9.

Bugaje, B., Rutherford, P., & Clifford, M. (2021). A systems dynamics approach to the bottom-up simulation of residential appliance load. *Energy and Buildings*, *247*, 111164.

Buyang, C. G., & Buyang, J. (2020). Pemodelan Faktor Keterlambatan Proyek Penataan Dermaga Lantamal Ambon Dengan Sistem Dinamik. *Jurnal Simetrik*, *10*(2), 355–361.

Egwim, C. N., Alaka, H., Toriola-Coker, L. O., Balogun, H., & Sunmola, F. (2021). Applied artificial intelligence for predicting construction projects delay. *Machine Learning with Applications*, *6*, 100166.

Guida, P. L., & Sacco, G. (2019). A method for project schedule delay analysis. *Computers & Industrial Engineering*, *128*, 346–357.

Kammouh, O., Kok, M. W. A. M., Nogal, M., Binnekamp, R., & Wolfert, A. R. M. R. (2022). MitC: Open-source software for construction project control and delay mitigation. *SoftwareX*, *18*, 101023.

Megawati, L. I. A. A. (2021). Analisis faktor keterlambatan proyek konstruksi bangunan gedung. *Jurnal Teknik| Majalah Ilmiah Fakultas Teknik UNPAK*, *21*(2).

Rani, N. M. S., & Yuni, N. K. S. E. (2021). Analisis Faktor Risiko Terhadap Keterlambatan Proyek Konstruksi the Himana Condotel. *Paduraksa: Jurnal Teknik Sipil Universitas Warmadewa*, *10*(1), 41–55.

Riyanto, A., & Santoso, S. (2022). Interior Design Production Plan Simulation Modeling with Dynamics System: A Case Study of PT. Panutan Sejati. *Journal of Humanities and Social Sciences Studies*, *4*(1), 77–88.

Santoso, S., Widyanty, W., Nurhidajat, R., Marfatah, M. R., Mahmud, G., Fahlevi, M., Aljuaid, M., Zhghenti, T., & Shahid, D. (2022). System dynamics modeling for developing an agrotourism-creative economy in the framework of the village innovation system. *Frontiers in Environmental Science*, 1497.

Sholeh, M. N., Fauziyah, S., Wibowo, M. A., & Kistiani, F. (2015). Analisis Proses Pengadaan Material Proyek

Konvensional Dan Proyek Engineering Procurement Construction (Epc)(Studi Kasus: Proyek Pembangunan Gunawangsa Merr Apartement Surabaya Dan Proyek Epc 1 Banyu Urip Cepu). *Jurnal Karya Teknik Sipil*, *3*(4), 1149–1160.

Surya, A. B., Wiguna, I. P. A., & Suryani, E. (2017). Pengembangan Model Penyebab Rework Pada Pekerjaan Konstruksi Infrastruktur Jalan Dengan Pendekatan Sistem Dinamik. *Jurnal Aplikasi Teknik Sipil*, *15*(2), 45–52.

Suyatno, A. (2010). Pengaruh Pemanasan Bahan Bakar Dengan Radiator Sebagai Upaya Meningkatkan Kinerja Mesin Bensin. *Proton*, *2*(2).