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ANALYSIS OF THE FACTORS CAUSING DELAYS IN CONSTRUCTION PROJECT IMPLEMENTATION, CASE STUDY: AMMONIUM NITRATE PROJECT 75000 MTPY AMMONIUM NITRATE & 60000 MTPY NITRIC ACID PLANT IN INDUSTRIAL PLANT COMPANIES IN INDONESIA

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Abstract:

The purpose of this research is to find out the factors that cause delays/delays in the Indonesian Industrial Plant Company Project and to find out the anticipatory efforts so that the same incident does not happen again in the future. The population in this study are all construction projects undertaken by EPC Service Companies. The sample in this study is the Indonesian Industrial Plant Company project. This research was conducted using quantitative methods. This method is needed to know the classification of actions that must be carried out afterwards. Data Processing with the Prospective Time Impact Analysis Method. The research results prove that the factors causing delays in the EPCC Indonesian Industrial Plant Company project are engineering low productivity. In terms of scope of work, engineering delays that occur are the result of delays in the engineering scope carried out by the ENGINEERING COMPANY, which have an impact on the procurement and construction and completion of the project. Means in this case the ENGINEERING COMPANY is the party responsible for project delays.

Keywords: Factors causing delay and Project Performance/Performance Index

PRELIMINARY

Knowledge of project management is very important in project management starting from the stages of initiating, planning, executing, monitoring & control to closing. By implementing project management, it can also make projects more effective and efficient, which will provide maximum results in accordance with project objectives, namely completing projects according to agreed standards to achieve customer satisfaction. Project management requires project managers who have three talents in three characteristics, namely technical knowledge, project management, leadership and strategic and business (Project Management Competency Development, 2017).

In general, projects have a deadline, meaning that the project must be completed before or on time. But in reality many projects are completed after the deadline. Many factors cause this to happen, and if these symptoms occur, the company must conduct an evaluation to find out which process failed.

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This research will specifically discuss the delays in the EPC Service Company project. The EPC Service Company is one of the BUMN Karya engaged in the Engineering, Procurement and Construction (EPC) sector. One of the EPC projects undertaken by the EPC Service Company is Indonesian Industrial Plant Company 75,000 MTPY & 60,000 MTPY NITRIC ACID PROJECT PLANT.

The scope of work for the Indonesian Industrial Plant Company project is EPC with a project contract value of Rp. 957,998,850,000.00. Original Contract Schedule is 30 months, commencing on (Effective Date of Contract) 18 December 2019.

Based on the March 2022 report, the Indonesian Industrial Plant Company project experienced a total delay of 4.60% which was distributed to procurement (-3.60%), construction (-0.66%), and commissioning (-0.33%) . By identifying the causes of the delay, it will become a reference for decision makers in the project, to estimate the completion and costs that will occur as well as the party who must be responsible for the costs that have been identified from this research.

Delay occurs when something happens later than expected; cause something to be done later than planned; or not acting on time (Trauner, 2009). Many factors cause delays in construction projects. Delays occur in most construction projects and the degree of delay varies greatly from one project to another.

It is very important to determine the actual factors that cause delays so that project management can minimize, reduce, and avoid them in all construction projects (Asnaashari et al., 2009).

The impact of delay on the project is the occurrence of cost overruns during delays for direct and indirect costs and the presence of late fees that will be charged to the contractor every day of delay, specifically for the Indonesian Industrial Plant Company project, late fees of 0.001% per day and according to the delay contract, a maximum of 10 percent.

The discussion in this study is focused on delay analysis only. There are two reasons, namely managerial and contractual reasons.

1. Managerial reasons: based on PMBOK 6th -2017 One of the main input costs is the Schedule baseline. One of the causes of cost overrun is the occurrence of delays. Therefore, to prevent this, we must start from anticipating delays, both delays that occur on critical paths and individual delays that are not critical paths. The critical path is the longest path of a sequence of work on a project, where if a delay occurs on the critical path, it will shift the completion of the project as a whole.
2. Contractual reasons: this project contract has been defined in detail, namely the value of fines for project delays is a maximum of 10% within 90 working days or 0.11% per day of the contract value.

Based on these two reasons, the authors conduct research that is more specific to delay, while the cost impact will naturally follow.

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Research purposes

1) To find out the factors that cause delays in the Indonesian Industrial Plant Company Project.
2) To find out the anticipatory efforts so that the same incident does not recur in the future.

LITERATURE REVIEW AND HYPOTHESIS

Critical Path Method (CPM)

The CPM method / critical path method is used to estimate the minimum project duration and determine the amount of schedule flexibility in the schedule model. This schedule network analysis technique calculates Early Start (ES), late start (LT), Early Finish (EF) and Late Finish (LF) dates for all activities regardless of any resource constraints. The analysis method can be carried out using forward and backward analysis through network planning on the schedule.

Time Impact Analysis (TIA)

Time Impact Analysis is usually associated with modelling the impact of a delay having an overall impact, the difference between the schedule without delay and the schedule that includes delays is considered as the impact of the delay.

TIA can be used more as a tool for looking ahead, so that it can be used by both employers and contractors to respond to analysis results and determine corrective steps to optimize costs and time. Nevertheless, it is an acceptable tool and can be used to determine the effects of past delays (Winter et al., 2006).

Focus Group Discussion (FGD)

Is a data collection technique with the aim of finding the meaning of a theme according to the understanding of a group. This technique is used to reveal the meaning of a group. Based on the results of discussions centred on a particular problem. FGDs are also intended to avoid a researcher's misunderstanding of the focus of the problem being researched. Inviting key informants to discuss concepts related to the data disclosed or it can also be.

Fishbone diagrams

One way or tool to improve quality is a fishbone diagram. Often referred to as a cause-and-effect diagram. Kaoru Ishikawa, a Japanese scientist who was born in Tokyo in 1915 and graduated from the University of Tokyo with a degree in chemical engineering, was the creator of the invention in the 1960s. As a result, it is often referred to as the Ishikawa Poerwanto diagram (2012).

5W+1H.

5W+1H stands for What, Where, When, Why, Who, and How in manufacturing companies, especially in production and quality control (QC) departments. A method called 5W+1H is basically used to view and research problems that arise during the production process. Of

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course, the 5W+1H concept or method can also be used to collect data for journalism or investigation of criminal cases in addition to the production process.

Why's Analysis

The 5 Why's method was first discovered by Sakichi Toyoda and eventually applied to the Toyota Motor Corporation during the movement to improve its manufacturing. The 5 Why's method is the easiest and most simple technique in the PDCA or DMAIC methodologies. Until now the 5 Why's method has become part of the Kaizen Tools integrated into the Toyota Production System (TPS). In carrying out the 5 Why's analysis, no complicated calculations are carried out in solving a problem.

Root Cause Analysis (RCA)

Is a problem-solving method that aims to identify the root cause of a problem or event. RCA practice is based on the belief that problems are best solved by correcting or eliminating the root causes, not just by quickly addressing obvious symptoms. Identification of RCA causes the discovery of various issues that have the potential to create waste as a causative factor (Habib, 2012)

Fast tracking dan Crashing Theory

There are two methods to shorten the duration of work (compression schedule) namely Crashing and Fast-tracking schedule:

a. **Crashing Method**

   Crashing schedule is a technique used to shorten the duration of the schedule by adding resources or increasing costs.

b. **Fast tracking Method**

   The Fast tracking method is a technique used to shorten project time by changing the linkages of activities that are usually sequential to parallel, even though they are carried out in part of the activity time

Project Performance

According to Frefer, Mahmoud, Haleema, and Almamlook, there are at least two measurements of the success of a project, namely, objective factors and subjective factors. Objective measurement is a measuring tool factor consisting of project time, cost, health, and safety (health and safety), and profitability.

While subjective measurement is the measurement of tools consisting of quality, technical performance, functionality, productivity, satisfaction, and environmental resilience. This research will discuss two objective factors, which are related to time and cost performance (AA et al., 2018).

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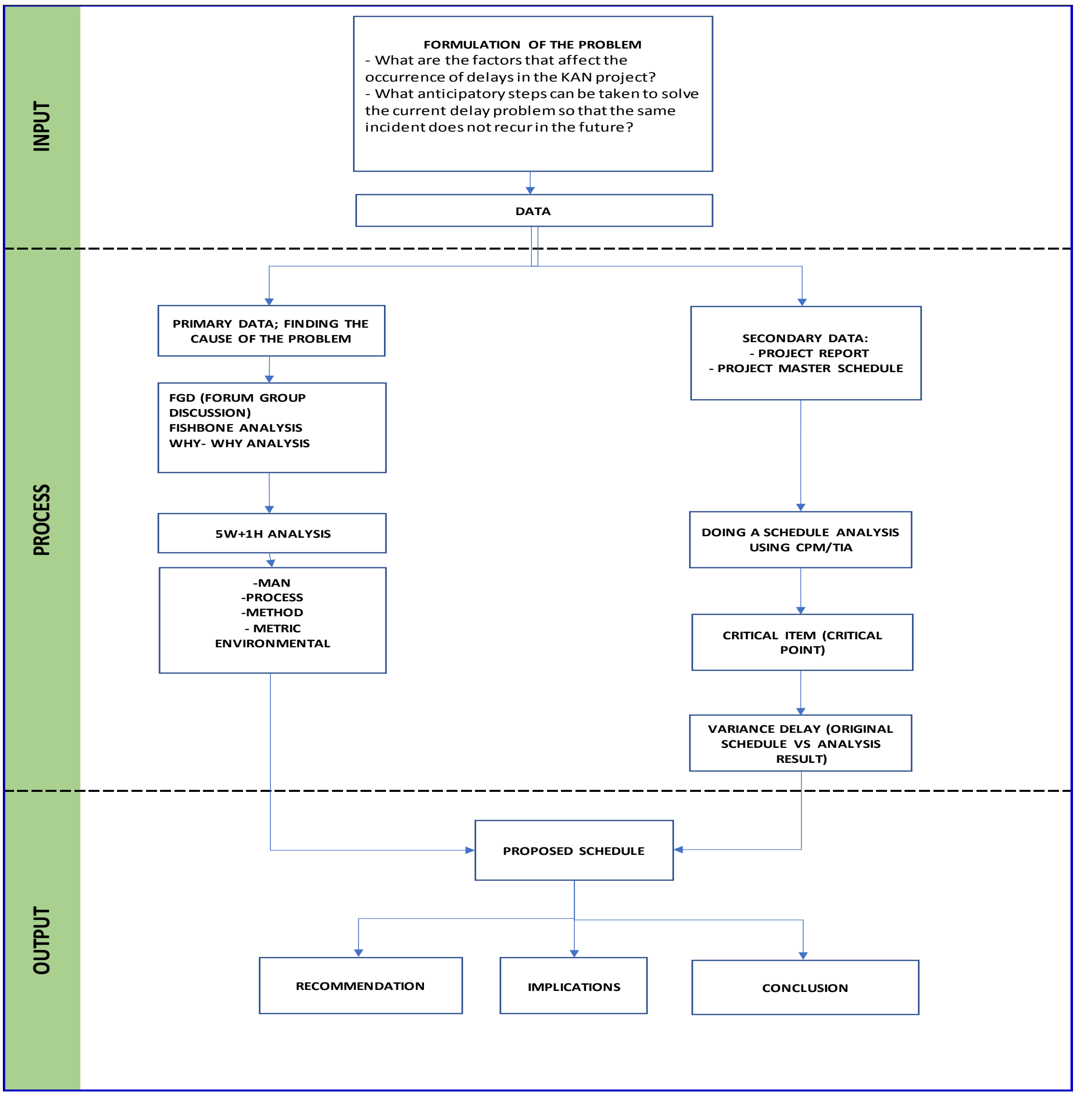
Framework

Figure 1: Research Thinking Framework



METHODOLOGY

Research design is a work plan that is structured in terms of relationships between variables in a comprehensive manner so that research results can provide answers to research questions. The plan contains things that the researcher will do, from making hypotheses and operational implications to the final analysis.

According to Sugiyono (2017), research methods are scientific steps to obtain valid data so that they can be found, developed, and proven. Then the results can be used to understand, solve, and anticipate research problems.

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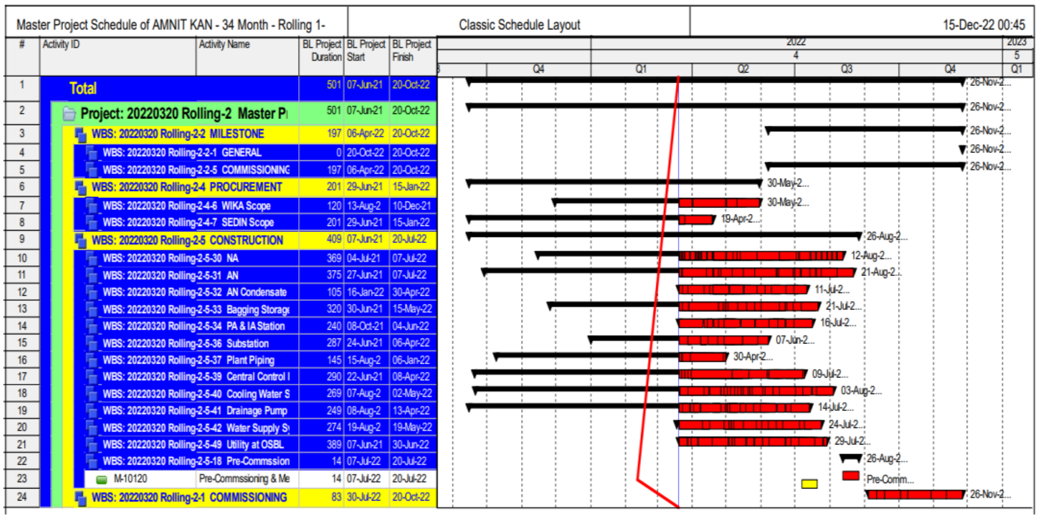
This research was conducted using quantitative methods. This method is needed to know the classification of actions that must be carried out afterwards. The population in this study are all construction projects undertaken by EPC Service Companies. The sample in this study is the Indonesian Industrial Plant Company project. Data Processing Method with Prospective Time Impact Analysis Method.

RESULTS AND DISCUSSION

Results

This study utilizes Prospective Time Impact Analysis on critical items to study the causes of delays that occur in the project:

Figure 2: CPM Analysis (Critical Path Method)



#	Activity ID	Activity Name	BL Project Duration	BL Project Start	BL Project Finish
1	Total		501	07-Jun-21	20-Oct-22
2	Project: 20220320 Rolling-2 Master P		501	07-Jun-21	20-Oct-22
3	WBS: 20220320 Rolling-2-2 MILESTONE		197	06-Apr-22	20-Oct-22
4	WBS: 20220320 Rolling-2-2-1 GENERAL		0	20-Oct-22	20-Oct-22
5	WBS: 20220320 Rolling-2-2-5 COMMISSIONING		197	06-Apr-22	20-Oct-22
6	WBS: 20220320 Rolling-2-4 PROCUREMENT		201	29-Jun-21	15-Jan-22
7	WBS: 20220320 Rolling-2-4-6 WIKA Scope		120	13-Aug-2	10-Dec-21
8	WBS: 20220320 Rolling-2-4-7 SEDIN Scope		201	29-Jun-21	15-Jan-22
9	WBS: 20220320 Rolling-2-5 CONSTRUCTION		409	07-Jun-21	20-Jul-22
10	WBS: 20220320 Rolling-2-5-30 NA		369	04-Jul-21	07-Jul-22
11	WBS: 20220320 Rolling-2-5-31 AN		375	27-Jun-21	07-Jul-22
12	WBS: 20220320 Rolling-2-5-32 AN Condensate		105	16-Jan-22	30-Apr-22
13	WBS: 20220320 Rolling-2-5-33 Bagging Storag		320	30-Jun-21	15-May-22
14	WBS: 20220320 Rolling-2-5-34 PA & IA Station		240	08-Oct-21	04-Jun-22
15	WBS: 20220320 Rolling-2-5-36 Substation		287	24-Jun-21	06-Apr-22
16	WBS: 20220320 Rolling-2-5-37 Plant Piping		145	15-Aug-2	06-Jan-22
17	WBS: 20220320 Rolling-2-5-39 Central Control I		290	22-Jun-21	08-Apr-22
18	WBS: 20220320 Rolling-2-5-40 Cooling Water S		269	07-Aug-2	02-May-22
19	WBS: 20220320 Rolling-2-5-41 Drainage Pump		249	08-Aug-2	13-Apr-22
20	WBS: 20220320 Rolling-2-5-42 Water Supply S		274	19-Aug-2	19-May-22
21	WBS: 20220320 Rolling-2-5-49 Utility at OSBL		389	07-Jun-21	30-Jun-22
22	WBS: 20220320 Rolling-2-5-18 Pre-Commssion		14	07-Jul-22	20-Jul-22
23	M-10120	Pre-Commssioning & Me	14	07-Jul-22	20-Jul-22
24	WBS: 20220320 Rolling-2-1 COMMISSIONING		83	30-Jul-22	20-Oct-22

Figure 3: Overall Delay Project based on As Plan vs As Built Schedule

Layout: Classic Schedule Layout — Filter All: Critical

Activity ID	Activity Name	BL Project Duration	Original Duration	Activity % Complete	BL Project Start	BL Project Finish	Start	Finish	Variance - BL Project Start Date	Variance - BL Project Finish Date	Variance - BL Project Duration	Total Float
Total		501	438		07-Jun-21	20-Oct-22	15-Sep-21 A	26-Nov-22	-100	-37	64	-37
Project: 20220320 Rolling-2 Master Project Schedule		501	438		07-Jun-21	20-Oct-22	15-Sep-21 A	26-Nov-22	-100	-37	64	-37
WBS: 20220320 Rolling-2-2 MILESTONE		197	172		06-Apr-22	20-Oct-22	07-Jul-22	26-Nov-22	-62	-37	26	-37
WBS: 20220320 Rolling-2-4 PROCUREMENT		201	258		29-Jun-21	15-Jan-22	15-Sep-21 A	30-May-22	-78	-135	-57	-30
WBS: 20220320 Rolling-2-4-6 WIKA Scope		120	167		13-Aug-21	10-Dec-21	30-Nov-21 A	30-May-22	-109	-171	-62	-30
WBS: 20220320 Rolling-2-4-6-1 Procurement Material		120	167		13-Aug-2..	10-Dec-21	30-Nov-21 A	30-May-22	-109	-171	-62	-30
WBS: 20220320 Rolling-2-4-6-1-5 Civil Material		120	167		13-Aug-21	10-Dec-21	30-Nov-21 A	30-May-22	-109	-171	-62	-30
WBS: 20220320 Rolling-2-4-7 SEDIN Scope		201	217		29-Jun-21	15-Jan-22	15-Sep-21 A	19-Apr-22	-78	-94	-16	-32
WBS: 20220320 Rolling-2-5 CONSTRUCTION		409	341		07-Jun-21	20-Jul-22	15-Sep-21 A	26-Aug-22	-100	-37	64	-29
WBS: 20220320 Rolling-2-1 COMMISSIONING & START UP & PL		83	83		30-Jul-22	20-Oct-22	04-Sep-22	26-Nov-22	-37	-37	0	-37

(Source: Data processed in 2022)

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In Figure 2 (CPM) according to the baseline schedule the project must be completed on October 20, 2022, but based on the CPM analysis the project will be completed on November 26 2022 (shifted by 37 days), delays occur in Engineering, Procurement, construction and Commissioning items.

To find out the detailed items that cause delays, a detailed analysis is carried out in each area starting from engineering, procurement, construction, and commissioning.

Time Impact Analysis pada Delay Engineering

Figure 4: Time Impact Delay in Engineering

Activity ID	Activity Name	Activity % Complete	BL Project Start	BL Project Finish	Start	Finish	Variance - BL Project	Total Float
WBS: 20220320 Rolling-2-8 ENGINEERING			18-Dec-19	21-May-22	18-Dec-19 A	09-Jun-22	-18	187
WBS: 20220320 Rolling-2-8-1 WIKA Scpoe			18-Dec-19	20-Sep-21	18-Dec-19 A	09-Apr-21 A	165	
WBS: 20220320 Rolling-2-8-2 SEDIN Scope			18-Dec-19	21-May-22	02-Feb-20 A	09-Jun-22	-18	187
WBS: 20220320 Rolling-2-8-2-24 ISBL - Basic Engineering			18-Dec-19	06-Apr-21	02-Feb-20 A	20-Feb-21 A	46	
WBS: 20220320 Rolling-2-8-2-3 ISBL - Detailed Engineering			21-Feb-20	21-May-22	26-Feb-20 A	09-Jun-22	-18	187
WBS: 20220320 Rolling-2-8-2-3-20 Process Safety			10-Nov-20	15-May-21	20-Jan-21 A	23-Jun-21 A	-38	
WBS: 20220320 Rolling-2-8-2-3-2 NA			29-Aug-20	21-May-22	20-May-20 A	03-Apr-22	48	200
WBS: 20220320 Rolling-2-8-2-3-5 AN			18-Oct-20	03-Jan-22	08-Dec-20 A	03-Apr-22	-90	200
WBS: 20220320 Rolling-2-8-2-3-3 AN Condensate Purification			02-May-20	22-Nov-21	03-Feb-21 A	09-Jun-22 A	-198	
WBS: 20220320 Rolling-2-8-2-3-7 Bagging Storage AN			02-May-21	17-Jan-22	30-Oct-20 A	30-Nov-21 A	49	
WBS: 20220320 Rolling-2-8-2-3-4 AN Warehouse			02-May-21	04-Feb-22	30-Oct-20 A	03-Apr-22	-58	200
WBS: 20220320 Rolling-2-8-2-3-6 PA and IA station			02-May-21	07-Dec-21	30-Nov-20 A	03-Apr-22	-117	200
WBS: 20220320 Rolling-2-8-2-3-1 Substation			02-May-21	20-May-22	04-Feb-21 A	02-Apr-22	48	201
WBS: 20220320 Rolling-2-8-2-3-8 Central control building			02-May-21	11-Dec-21	20-Nov-20 A	02-Apr-22	-112	201
WBS: 20220320 Rolling-2-8-2-3-10 Cooling Water system			29-Apr-21	10-Dec-21	04-Mar-21 A	02-Apr-22	-113	201
WBS: 20220320 Rolling-2-8-2-3-11 Water supply system			29-Apr-21	01-Nov-21	29-Jan-21 A	02-Apr-22	-152	201
WBS: 20220320 Rolling-2-8-2-3-12 Drainge pump station and emergency pool			29-Apr-21	25-Sep-21	28-Jan-21 A	02-Apr-22	-189	201
WBS: 20220320 Rolling-2-8-2-3-13 Maintenace center			09-May-21	12-Mar-22	20-Dec-20 A	02-Apr-22	-21	201
WBS: 20220320 Rolling-2-8-2-3-9 General Plot Plan			21-Feb-20	10-Aug-21	26-Feb-20 A	16-Apr-22	-249	187
WBS: 20220320 Rolling-2-8-2-3-14 staff gate			02-May-21	26-Dec-21	29-Jan-21 A	02-Apr-22	-97	201
WBS: 20220320 Rolling-2-8-2-3-23 Logistics gate			30-May-21	25-Dec-21	01-Nov-20 A	02-Apr-22	-98	201
WBS: 20220320 Rolling-2-8-2-3-21 Hazardous waste Warehouse			30-May-21	09-Mar-22	23-Feb-21 A	02-Apr-22	-24	201
WBS: 20220320 Rolling-2-8-2-3-15 Power Supply of Plant			14-Jun-21	28-Jul-21	15-Jul-21 A	02-Apr-22	-248	201
WBS: 20220320 Rolling-2-8-2-3-16 Telecommunication			30-May-21	17-Aug-21	07-Jun-21 A	11-Jun-21 A	68	
WBS: 20220320 Rolling-2-8-2-3-17 Plant water supply and drainage			30-May-21	28-Jul-21	05-Mar-21 A	20-Nov-21 A	-115	
WBS: 20220320 Rolling-2-8-2-3-18 Plant piping			02-May-21	05-May-22	04-Mar-21 A	02-Apr-22	33	201
WBS: 20220320 Rolling-2-8-2-3-19 FIRE FIGHTING			22-Apr-22	21-May-22	14-Feb-21 A	20-Mar-22	63	215

Source: Data processed in 2022

Variance baseline schedule in Engineering occurs for 18 (eighteen days) which contributes to delays in the process and the next stages, namely procurement and construction and commissioning.

Delay analysis on Procurement

Figure 5: Time Impact Delay on Procurement

Activity ID	Activity Name	Activity % Complete	BL Project Start	BL Project Finish	Start	Finish	Variance - BL Project	Total Float
WBS: 20220320 Rolling-2-4 PROCUREMENT			18-Dec-19	26-Jan-22	18-Dec-19 A	23-Jul-22	-178	89
WBS: 20220320 Rolling-2-4-6 WIKA Scope			18-Dec-19	10-Dec-21	18-Dec-19 A	30-May-22	-171	143
WBS: 20220320 Rolling-2-4-7 SEDIN Scope			04-Apr-21	26-Jan-22	06-Feb-20 A	23-Jul-22	-178	89
WBS: 20220320 Rolling-2-4-7-1 Equipment			04-Apr-21	26-Jan-22	06-Feb-20 A	23-Jul-22	-178	89
WBS: 20220320 Rolling-2-4-7-2 Meterial			30-May-21	15-Jan-22	30-May-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-4 Telecom			17-Jul-21	15-Jan-22	05-Jun-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-3 Electric			30-May-21	15-Jan-22	14-May-21 A	18-Apr-22	-93	-9
WBS: 20220320 Rolling-2-4-7-5 Instrument			02-May-21	15-Jan-22	15-Mar-21 A	19-Apr-22	-94	-36
WBS: 20220320 Rolling-2-4-7-5-3 Votex Flow Meter			02-May-21	15-Jan-22	15-Mar-21 A	24-Mar-22	-68	-5
WBS: 20220320 Rolling-2-4-7-5-1 Electric-magnetic Flow Meter			02-May-21	15-Jan-22	15-Mar-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-5-2 Mass Flow Meter			02-May-21	15-Jan-22	15-Mar-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-5-5 standard orifice plate& long diameter nozzle			30-May-21	15-Jan-22	15-Mar-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-5-4 Rotor Flow Meter			02-May-21	15-Jan-22	15-Mar-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-5-7 Radar Level Meter			02-May-21	15-Jan-22	15-Mar-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-5-8 Magnetic Tilting Level Meter			02-May-21	15-Jan-22	15-Mar-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-5-9 Pressure Transmitter			02-May-21	15-Jan-22	16-Mar-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-5-10 Bimetal Pressure Meter			02-May-21	15-Jan-22	15-Mar-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-5-11 Temperature Transmitter			02-May-21	15-Jan-22	15-Mar-21 A	20-Mar-22	-63	-5
WBS: 20220320 Rolling-2-4-7-5-21 Integrated Built-in Orifice Flowmeter			02-May-21	15-Jan-22	15-Mar-21 A	20-Mar-22	-63	-5
WBS: 20220320 Rolling-2-4-7-5-14 Analyzer			02-May-21	15-Jan-22	15-Mar-21 A	20-Mar-22	-63	-5
WBS: 20220320 Rolling-2-4-7-5-19 Tube Valve & Heat Insulated Box			30-May-21	15-Jan-22	07-Jun-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-5-20 Intrument Repair			30-May-21	15-Jan-22	07-Jun-21 A	28-Feb-22 A	-43	
WBS: 20220320 Rolling-2-4-7-5-12 Regulator			02-May-21	15-Jan-22	15-Mar-21 A	20-Mar-22	-63	-5
WBS: 20220320 Rolling-2-4-7-5-13 Ball Valve			02-May-21	15-Jan-22	15-Mar-21 A	20-Mar-22	-63	-5
WBS: 20220320 Rolling-2-4-7-5-15 DCS/SIS			14-Jun-21	06-Jan-22	01-May-21 A	19-Apr-22	-103	-36
WBS: 20220320 Rolling-2-4-7-5-16 PIM			14-Jun-21	06-Jan-22	07-Jun-21 A	19-Apr-22	-102	-35

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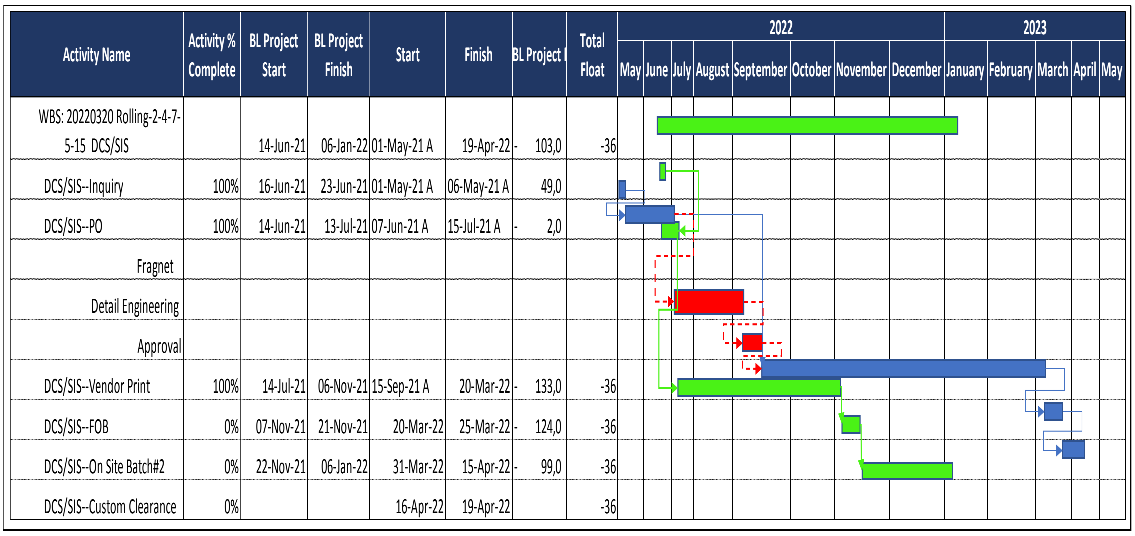
Based on the CPM (Critical Path Method) analysis, the total delay in procurement was 178 (one hundred and seventy-eight) days, but the impact on the project was 36 (thirty-six) days. This delay was caused by the late start of procurement for 103 days and had an impact on the overall schedule for 36 days, on WBS items; 20220220 Rolling 2-4-7-5-15; DCS/SIS. This item is the longest delay which is the delay driver for the project.

Time Impact Analysis

Time Impact Analysis is performed on Critical Items, WBS; 20220220 Rolling 2-4-7-5-15; DCS/SIS, by entering delay items in the DCS activity.

Figure 6: Time Impact Analysis



Activity Name	Activity % Complete	BL Project Start	BL Project Finish	Start	Finish	BL Project	Total Float
WBS: 20220320 Rolling-2-4-7-5-15 DCS/SIS		14-Jun-21	06-Jan-22	01-May-21 A	19-Apr-22	- 103,0	-36
DCS/SIS--Inquiry	100%	16-Jun-21	23-Jun-21	01-May-21 A	06-May-21 A	49,0	
DCS/SIS--PO	100%	14-Jun-21	13-Jul-21	07-Jun-21 A	15-Jul-21 A	- 2,0	
Fragnet							
Detail Engineering							
Approval							
DCS/SIS--Vendor Print	100%	14-Jul-21	06-Nov-21	15-Sep-21 A	20-Mar-22	- 133,0	-36
DCS/SIS--FOB	0%	07-Nov-21	21-Nov-21	20-Mar-22	25-Mar-22	- 124,0	-36
DCS/SIS--On Site Batch#2	0%	22-Nov-21	06-Jan-22	31-Mar-22	15-Apr-22	- 99,0	-36
DCS/SIS--Custom Clearance	0%			16-Apr-22	19-Apr-22		-36

Based on the discussion that was carried out, the delay in procurement was caused by delays in the start of procurement caused by delays in Detail Engineering Design (DED), where if based on the plan, the procurement process must start immediately after the Purchase Order is issued, so that no delays occur. The delay in the procurement item will shift the next critical item activities, namely Construction and Commissioning.

Time Impact Analysis on Construction & Commissioning

Based on the time impact analysis on Engineering & Procurement, the total float on Procurement is -36 (minus thirty six) days while for Construction and Commissioning it is also the same as the total float is -37 (minus thirty seven) days, there is an additional total float of -1 (minus one) day which is not significant, so it can be concluded that delays in Construction and Commissioning are a domino effect of delays in previous activities (Engineering & Procurement).

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Figure 7: Total Float in the construction area

Activity ID	Activity Name	Activity % Complete	BL Project Start	BL Project Finish	Start	Finish	Variance - BL Project	Total Float
WBS: 20220320 Rolling-2-5 CONSTRUCTION			15-Jan-20	20-Jul-22	15-Jan-20 A	31-Aug-22	-42	50
WBS: 20220320 Rolling-2-5-26 Soil Investigation Work			15-Jan-20	29-Apr-20	15-Jan-20 A	29-Apr-20 A	1	
WBS: 20220320 Rolling-2-5-27 Site Preparation			20-Mar-20	01-Jun-20	20-Mar-20 A	01-Jun-20 A	1	
WBS: 20220320 Rolling-2-5-28 Temporary Facility			25-Mar-20	21-Oct-20	25-Mar-20 A	18-May-22	-574	49
WBS: 20220320 Rolling-2-5-29 Static Loading Test			20-Mar-20	23-Jun-20	20-Mar-20 A	23-Jun-20 A	1	
WBS: 20220320 Rolling-2-5-30 NA			15-Mar-21	07-Jul-22	16-Mar-21 A	12-Aug-22	-36	69
WBS: 20220320 Rolling-2-5-31 AN			08-Mar-21	07-Jul-22	20-Mar-21 A	21-Aug-22	-45	60
WBS: 20220320 Rolling-2-5-32 AN Condensate Purification			22-Feb-21	30-Apr-22	16-Mar-21 A	11-Jul-22	-72	101
WBS: 20220320 Rolling-2-5-33 Bagging Storage AN			25-Feb-21	15-May-22	24-Jan-21 A	21-Jul-22	-67	91
WBS: 20220320 Rolling-2-5-34 PA & IA Station			24-May-21	04-Jun-22	01-Apr-21 A	16-Jul-22	-42	96
WBS: 20220320 Rolling-2-5-35 AN Warehouse			12-Apr-21	20-Feb-22	05-Dec-20 A	19-Jun-22	-119	124
WBS: 20220320 Rolling-2-5-36 Substation			29-Mar-21	06-Apr-22	06-Mar-21 A	07-Jun-22	-62	135
WBS: 20220320 Rolling-2-5-37 Plant Piping			03-May-21	06-Jun-22	23-Apr-21 A	04-Jul-22	-27	109
WBS: 20220320 Rolling-2-5-38 Maintenance Center			01-Mar-21	15-Feb-22	10-Feb-21 A	14-Jun-22	-119	22
WBS: 20220320 Rolling-2-5-39 Central Control Building			10-May-21	08-Apr-22	08-Jan-21 A	24-Jul-22	-106	89
WBS: 20220320 Rolling-2-5-40 Cooling Water System			03-May-21	02-May-22	18-Apr-21 A	03-Aug-22	-93	78
WBS: 20220320 Rolling-2-5-41 Drainage Pump & Emergency Pool			05-Jul-21	13-Apr-22	15-Apr-21 A	14-Jul-22	-92	98
WBS: 20220320 Rolling-2-5-42 Water Supply System			17-Jul-21	19-May-22	27-Mar-21 A	24-Jul-22	-66	-18
WBS: 20220320 Rolling-2-5-43 Water Supply and Drainage			17-Oct-21	15-Mar-22	20-Mar-22	02-Jun-22	-79	34
WBS: 20220320 Rolling-2-5-44 Staff Gate			15-Sep-21	28-Dec-21	03-Sep-21 A	04-Jul-22	-187	3
WBS: 20220320 Rolling-2-5-45 Logistic Gate			22-Aug-21	16-Nov-21	09-Oct-21 A	19-May-22	-184	48
WBS: 20220320 Rolling-2-5-46 Hazardous Waste Warehouse			13-Aug-21	17-Feb-22	29-Sep-21 A	12-Jun-22	-115	24
WBS: 20220320 Rolling-2-5-48 Permanent Road			30-Nov-20	18-Aug-21	20-Nov-20 A	08-May-22	-263	59
WBS: 20220320 Rolling-2-5-1 Drainage					20-Mar-22	03-May-22		64
WBS: 20220320 Rolling-2-5-49 Utility at OSBL			30-May-21	30-Jun-22	20-Mar-22	31-Aug-22	-62	50
WBS: 20220320 Rolling-2-5-18 Pre-Commssioning & Mechnical Acceptance			07-Jul-22	20-Jul-22	12-Aug-22	26-Aug-22	-37	-37

Figure 8: Total Float in the Commissioning Area

Total			18-Dec-19	20-Oct-22	18-Dec-19 A	26-Nov-22	-37	-37
Project: 20220320 Rolling-2 Master Project Schedule of AMNIT KAN -			18-Dec-19	20-Oct-22	18-Dec-19 A	26-Nov-22	-37	-37
WBS: 20220320 Rolling-2-2 MILESTONE			04-Apr-21	20-Oct-22	18-Dec-19 A	26-Nov-22	-37	-37
WBS: 20220320 Rolling-2-8 ENGINEERING			18-Dec-19	21-May-22	18-Dec-19 A	09-Jun-22	-18	187
WBS: 20220320 Rolling-2-4 PROCUREMENT			18-Dec-19	26-Jan-22	18-Dec-19 A	23-Jul-22	-178	89
WBS: 20220320 Rolling-2-5 CONSTRUCTION			15-Jan-20	20-Jul-22	15-Jan-20 A	31-Aug-22	-42	50
WBS: 20220320 Rolling-2-1 COMMISSIONING & START UP & PLANT ACCEPTANCE			22-May-22	20-Oct-22	12-Jul-22	26-Nov-22	-37	-37
C2-1000	Training Services	0%	22-May-22	20-Jun-22	12-Jul-22	27-Jul-22	-37	3
C2-1020	Start Up	0%	30-Jul-22	05-Aug-22	04-Sep-22	11-Sep-22	-37	-37
C2-1030	Test Run	0%	06-Aug-22	12-Aug-22	11-Sep-22	18-Sep-22	-37	-37
C2-1040	Shut Down for rectifing	0%	13-Aug-22	26-Aug-22	18-Sep-22	02-Oct-22	-37	-37
C2-1041	Start Up again	0%	27-Aug-22	02-Sep-22	02-Oct-22	09-Oct-22	-37	-37
C2-1042	Demonstration	0%	03-Sep-22	22-Sep-22	09-Oct-22	29-Oct-22	-37	-37
C2-1050	Performance Test	0%	23-Sep-22	06-Oct-22	29-Oct-22	12-Nov-22	-37	-37
C2-1060	Plant Acceptance	0%	07-Oct-22	20-Oct-22	12-Nov-22	26-Nov-22	-37	-37

Project Delay Summary

Table 1: Project Delay Summary

Delay Factor	Start Plan	Completed Plan	Realization Start	Realization Completed	Individual Delay (Days)
Engineering Delay	18 Dec 19	21 May 22	18 Dec 19	09 Jun 22	18
Procurement delays	18 Dec 19	26 Jan 22	06 Feb 20	23 Jul 22	178
Construction Delays	15 Jan 20	20 Jul 22	15 Jan 20	31 Aug 22	43
Commissioning Delays	22 May 22	20 Oct 22	12 Jul 22	26 Nov 22	37
Total Delay Impact					37

Fishbone Diagram Analysis Results

Based on the time impact analysis, it appears that project completion is driven by the Engineering process, so further analysis is carried out through Fishbone analysis to determine the factors causing delays in engineering.

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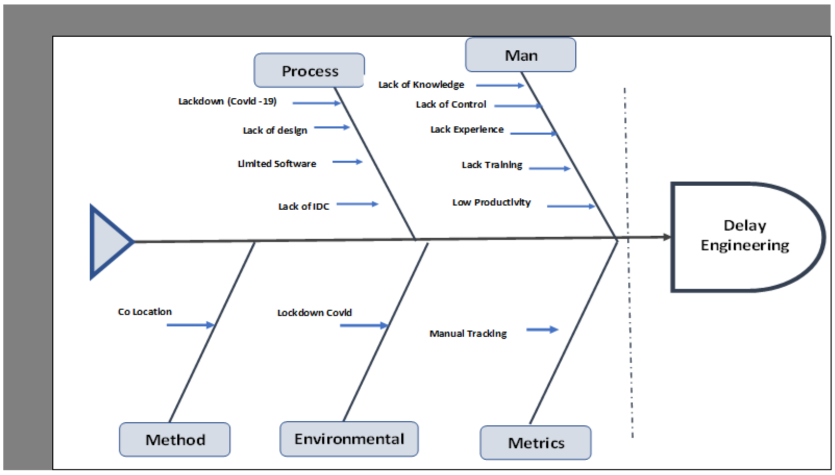
Figure: 9 Fishbone Analysis



(Source: Data processed in 2022)

From the results of the fishbone diagram, what influences delay engineering is the aspect of process, man, method, environmental and metrics. Furthermore, these significant sub-causes are analyzed further to find the root causes of the problem by asking 5 times a technique called Five Whys or 5 Whys to find out the main causes.

Table 2: 5 Whys

Aspect	Why-1	Why-2	Why-3	Why-4	Why-5
Man					
	Low Productivity	Lack of Experience	Lack of knowledge (Software Mastery)	Lack of Engineering Control	Lack of Engineers Training
Process					
	Design Error	Weak design integration	Lack of communication between Engineers in each discipline	Lack of Interdisciplinary Check (IDC) Process	*Lockdown due to the Covid -19 Pandemic in China & Indonesia*
Method					
	Co-location				
Metric					
	Manual *Tracking* document	Lack of Detail Schedule Engineering			
Environmental					
	Lockdown in China early 2020				

1. Man

In the aspect of man (labor), there are 5 things that influence, namely Low productivity, why? Due to lack of experience to work on projects with complexity, why? Lack of engineering

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knowledge where knowledge can make up for a lack of experience, why? Lack of engineering control caused by lack of adequate training.

2. Process

The delay factor in the engineering process is caused by design errors, why? The design process is not well integrated, so the design process is not optimal, why? Limited communication between discipline engineers, why? There is Work from Home (WFH), why? There are government regulations in each country for lockdown, why? Due to covid-19.

DISCUSSION

This study aims to analyze the causes of delays in the EPCC Indonesian Industrial Plant Company project. Based on the analysis of the Critical Path Method (CPM) and Time Impact Analysis (TIA) and followed by root cause analysis. In the technical analysis, the delays that occur can be divided into 4, namely delays in engineering, procurement and construction and commissioning. However, delays in construction and commissioning are the impact of delays in engineering and procurement. Based on detailed time impact analysis, it was found that the delay in procurement was also caused by delays in Design Engineering Design (DED).

Engineering delays are also in line with Bajjou and Chafi's research (2018) which revealed that significant obstacles were lack of knowledge about construction concepts, unskilled resources, and insufficient financial resources.

The discussion on delay Engineering is continued with the root cause analysis method in the Engineering area and the recovery process is carried out using the 5W+1H method.

Based on the fishbone analysis, it was found that the factors causing the delay are as follows:

- Man
- Process
- Method
- Metric
- Environmental

Root Cause analysis results

Table 3: Root Cause analysis

Factor	Root Cause
Man	Lack of Training
Proses	Lock Down due to the Covid 19 Pandemic

Sounce : Data processing results of interviews (2022)

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Table 4: 5W + 1H Method

Aspect	Why	Where	When	Who	How
Man					
	Lack of Training	Engineering EPC SERVICE COMPANY and ENGINEERING COMPANY	Before and during the project	Project Manager, Engineering Manager, Senior Engineer for each discipline to engineering	a) Provide training to Engineers b) Selection of Partners Engineering companies have experience in similar projects. c) Do professional Hired d) Using experts or Subject Matter Experts (SME)
Process					
	Lock Down due to the Covid 19 Pandemic	In China and Indonesia	2019-2022	All Engineering team and Project management Team	Conduct a Workshop with all related Engineering teams to review cross Discipline designs. Exploring Lesson Learn from similar projects that have been completed or are currently underway. Inviting experts to get Expert Judgment

Delays in procurement also contribute to delays. However, these delays are more due to delays in engineering. The biggest delay occurred in procurement at WBS: 20220320 Rolling-2-4-7-5-15 DCS/SIS. On WBS: 20220320 there is a delay in starting procurement for 137 (one hundred thirty-seven) days on individual activities with a total float of -36 (minus thirty-six) days. The WBS procurement has contributed to an overall delay of 36 (thirty-six) days out of 37 (thirty-seven) days of project delay.

Although this delay occurred in the WBS procurement group, it occurred due to the DED (Detail Engineering Design) process which had to be carried out after the PO (Purchase Order) was given to the Vendor (DCS) as shown in Figure 4.7. The impact of delays in the DED process at the procurement stage will shift the details of manufacturing, pre-fabrication, shipment, and other activities. Research Ji et al. (2018) shows that the most significant and easily influencing factor for construction delays is inefficient structural joints for prefabricated components.

We can see that the delays in the construction phase in this study are the result or domino effect of delays in the procurement process driven by engineering factors. In construction, it still contributes to overall delay of 18 (eighteen) days. This does not mean that there are no individual delays in construction, but the delays that occur in the construction area are smaller when compared to delays caused by procurement and do not have a significant effect on the overall delay.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

1. Factors causing delays in the EPCC Indonesian Industrial Plant Company project are engineering low productivity, due to lack of experience, inadequate training, lack of interdisciplinary checks, and software limitations so that the resulting design is less effective and efficient, so changes and improvements need to be made in the field. Another

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factor that also affected engineering delays was the Covid-19 outbreak at the start of the project, which limited internal engineering coordination.

2. 2. In terms of scope of work, the engineering delays that occur are the result of delays in the engineering scope carried out by the ENGINEERING COMPANY, which have an impact on the procurement and construction and completion of the project. Means in this case the ENGINEERING COMPANY is the party responsible for project delays.

Recommendations

The research conducted by the author is still far from being perfect, there are still many shortcomings and weaknesses in it. Based on the results of the conclusions in this study the authors provide the following suggestions:

1. To anticipate engineering delays in EPCC projects, it is necessary to make a more accurate engineering plan by considering the scope of works, responsibilities matrix, acceptance criteria design and project exclusion, so that the design process can run better because it has more limitations and references clear.
2. For the perfection of the quality of the Project Master Schedule which is a reference in the implementation of the Project, it is recommended that a Project Master Schedule workshop be held which is attended by all functions in the project, so that all teams in the project have the same understanding of project targets, especially critical items that become the basis for the movement of the project schedule both delay and ahead.
3. For future research, it is recommended to use methods other than this research so that the causes of project delays can be studied more deeply. For example, the EPCC project research by incorporating Global Supply Chain factors.

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