

PROJECT ACCELERATION BY TIME AND COST OPTIMIZATION AT PT. DUI ESA UNGGUL WITH CPM & PERT METHOD

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ABSTRACT

Projects are activities that are temporary in nature, have deadlines, budgets, resources and have product specifications to be produced. The case study of this research is the Matarbari Throat Ring Unit-2 fabrication project carried out by PT. Dui Esa Superior . The purpose of this study is to determine the factors that cause project delays, and to find out how long the duration and the optimal cost for the project are. The methods used are FTA (Fault Tree Analysis), CPM (Critical Path Method), and PERT (Project Evaluation and Review Technique). The results of direct field observations and interviews, as well as analysis and evaluation using the FTA, CPM and PERT methods, obtained 19 basic event factors causing project delays, namely labor shortages, workers lack of understanding of drawings, bad weather / rain , and others. There are 9 basic event combinations or minimum cut sets, namely (D1*D2*D3), (D4*D5), (C3), (D6), (E1*E2), (E3*E4*E5), (F1), (F2*F3*F4), (F5*G1*G2). The optimal duration of the Matarbari Throat Ring Unit-2 project is 57 days from the normal 61 days with a 69.15% chance. The total optimal cost of the Matarbari Throat Ring Unit-2 project with the optimal duration is Rp. 127,772,400.

Keywords: CPM Critical Path Method, FTA Fault Tree Analysis, Project Acceleration, PERT Project Evaluation and Review Technique, Time and Cost Optimization.

INTRODUCTION

According to Sulistyo & Al Fikri (Sulistyo and Al Fikri 2021), Project is a set of activities with the aim of creating a product or service with existing time provisions, for the beginning and ending of a project has been planned before, the project can be said to be completed if the objectives of a project are achieved. In addition, the project is also an activity that is not routine, has a time limit, budget, and resources and has product specifications to be produced (Agustiar and Handrianto 2018). Like manufacturing, projects must also pay attention to quality, because it affects the company's strategy in competing with *competitors* (Krisnaningsih et al. 2022). In order for the project to run smoothly, it is necessary to manage the project from beginning to end, namely with project management(Sulistyo, Ilpan, and Khadijah 2021). Project Management is the entirety of planning, implementing, controlling, and coordinating a project from the beginning to the end of the project, to ensure the implementation of a project in a timely, costly, and quality manner (Fadhol Yudhagama 2020).

PT. Dui Esa Unggul is a company engaged in steel structure fabrication that runs the Matarbari Throat Ring Unit-2 project (Sulistyo, Rifki, and Gautama 2022). Proyek Matarbari ini berasal dari Bangladesh

yang sedang membangun sebuah pembangkit listrik tenaga uap (PLTU) dengan kapasitas 1.200 megawatt (Quasem and Corp 2015). While the Throat Ring is a small component of the boiler package that is shaped like cones, with stainless plate material and also carbon plate.

In the Matarbari Throat Ring Unit-2 fabrication project work, project work occurred that was not in accordance with the time that had been planned at the beginning. In the project contract, there is an implementation time to be completed in 2 months, but in the implementation of the project is completed more than 2 months, which means there is a delay in the project work process. Project delay is the process of working on a project with increasing processing time, so that the completion of the project is not in accordance with the planned time and written in the contract document (Hassan, Mangare, and Pratasia 2016).

As a first step, it is necessary to use a structured WBS (Work Breakdown Structure) and is a work element grouped in graphic form with the aim of organizing and dividing the overall scope of a work project (Arianie and Puspitasari 2017). WBS is a way used to define and group tasks so that they become small parts of a project to make them easier to organize (Rachim, Afrizal, and Zaidiah 2021). The next step was Fault Tree Analysis (FTA), first introduced at Bell Laboratories by H.A. Watson in 1962, in conjunction with the safety evaluation of intercontinental minuteman missile launch systems. Fault Tree Analysis (FTA) is an analytical method that can be used to determine the root cause of potential failures that occur in the system [4].

Then analyze the optimization of project duration by evaluating the project using the CPM (Critical Path Method) method or commonly called the critical path method and PERT (Project Evaluation and Review Technique).

The CPM method is a method that is quite widely used in managing a project and is used in planning and controlling using the principle of network formation (Abdurrasyid et al. 2019). A network is a relationship between interdependent work activities and is depicted in the form of a network diagram (Dwiretnani and Kurnia 2018). Figure 1 below is an example of a CPM arrow chart with activities (C,D) starting from event C and ending at event D.

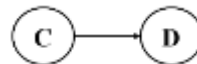


Figure 1. An example of a CPM Arrow Diagram

In CPM it is enforced dummy activity, this activity is to avoid There is 1 activity that has 2 arrows. Figure 2 below show example use of a dummy line from event b to event c to illustrate linkages activity 1 to activity 4.

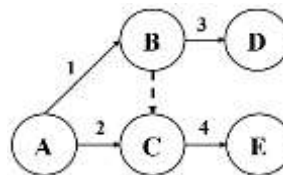


Figure 2. Example Dummy activity

According to Aremala (Armela, Amiruddin, and Hadi 2022), The PERT method is a method used for project planning using a distribution of opportunities based on three estimated times for each activity, including:

- a. ES : *Earliest Start Time*
- b. EF : *Earliest Finish Time*
- c. LS : *Late Allowable Start Time*
- d. LF : *Lates Allowable Finish Time*
- e. Slack (S) or Floa t is time free from activity , where activity can do retreat time processing without influence to retreat time project in a manner whole . Following formula calculation slack time .

$$Slack = LS - ES \text{ or } Slack = LF - EF \tag{1}$$

According to Aremala [13] , PERT method viz the method used for planning project using _ distribution opportunity based _ three estimation time for each activities , including :

- 1. Optimistic time (a)
- 2. Realistic time (m)
- 3. Pessimistic time (b)

Network steps work using _ The PERT approach is aimed at finding out How many mark probability activity project especially on the trail critical finished appropriate time according to the expected schedule . Below are : ways count period Expected time , including : _

- 1. Determine estimation time activity (Te)

$$Te = \frac{a+4m+b}{6} \tag{2}$$

- 2. Determine deviation standard from activity project (S)

$$S = \frac{1(b-a)}{6} \tag{3}$$

- 3. Determine variant activity from activity project

$$V(te) = S^2 = \left[\frac{b-a}{6} \right]^2 \tag{4}$$

- 4. Know probability achieve schedule targets . To find out probability achieve schedule targets can done by connecting between expected time (TE) with target T(d) which is expressed by the formula :

$$Z = \frac{T(d)-TE}{S} \tag{5}$$

Description :

Z = number possibility reach the target

T(d) = target timetable

TE = amount time trajectory critical

S = deviation standard activity

Z is the number number probability that percentage can be searched using _ table cumulative normal distribution z.

The aim of the research is to find out the factors that cause delays in the Matarbari *Throat Ring* Unit-2 fabrication project , find out the combination of factors that cause delays by using *the Minimum Cut Set* on the project , find out the efforts that must be made to avoid project delays and get the duration optimal and to find out the total cost of the project.

There are 2 types of costs which are included in fixed capital related to financing a construction project which can be divided into two types, namely direct costs and indirect costs (Remi 2017). Direct costs will automatically be higher if project completion is accelerated from normal times (Priyo and Risa Anggriani Paridi 2018). Below are included in direct costs: material costs, wage costs (daily wages, piece wages, productivity-based wages), equipment costs and sub-contractor costs. While indirect costs are costs incurred from beginning to end for each project activity, but are not directly related to these activities (Priyo and Risa Anggriani Paridi 2018). These indirect costs include *overhead*, unexpected costs and profits

From previous research by (Angelin and Ariyanti 2019) The project completion time acceleration was obtained by 34% of the existing project schedule using the CPM method. The decrease in project duration in paving road installation also decreased by 3 days to 11 days according to research from Eva (Yusdiana and Satyawisudarini 2018). The maximum time efficiency of up to 33 days, to 168 days was also obtained in research by Raharja using the CPM and PERT methods (Raharja 2014). From these positive references, this study also uses CPM and PERT methods.

METHOD

type of research is research descriptive approach _ quantitative that is something type research by collecting , compiling , processing and analyzing numerical data in order to be able to give description about something circumstances certain so that can taken conclusion from study that . The flowchart used _ in this research can seen in figure 3 below .

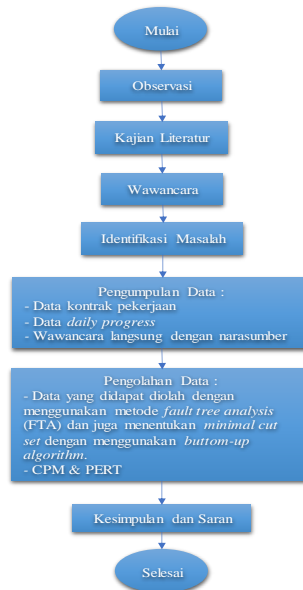


Figure 3. Framework Study

RESULTS AND DISCUSSION

Research data obtained from the results of observations directly and the interview process with sources ie *superintendent, engineering, and foreman* PT. Dui Esa Unggul , these data between other :

1. Work Breakdown Structure (WBS)

Overview of the WBS on the project fabrication *Matarbari Throat Ring Unit- 2* can seen in figure 4. Meanwhile nfor connection dependency between work can seen in table 1 below .

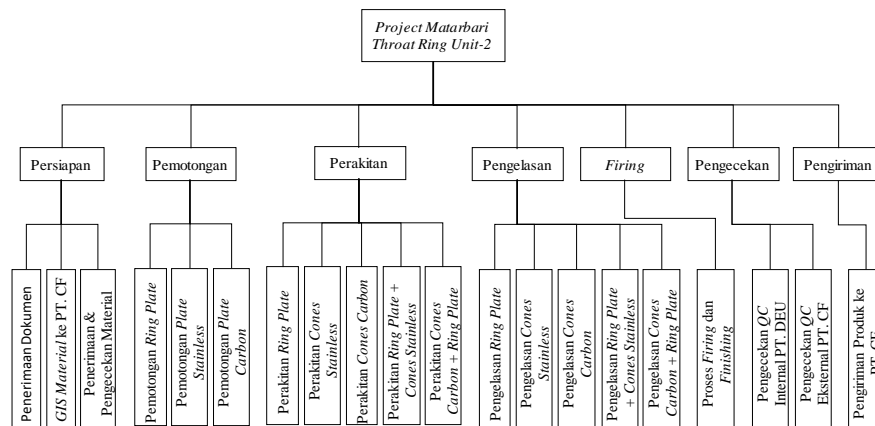


Figure 4. Work Breakdown Structure

Table 1. Sequence Activity Project

	Work item	Duration (Day)	Activity Before	Activity After
Stage Preparation				
A	Reception Document	1	-	B
B	GIS Material to PT CF	1	A	C
C	Receiving and Checking Materials	2	B	D
Stage Cutting				
D	Ring Plate Cutting	3	C	E, G
E	Stainless Plate Cutting	4	D	F,H
F	Carbon Plate Cutting	5	E	I

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Stage Assembly				
G	Ring plate assembly	4	D	L
H	Stainless Cones Assembly	6	E	m
I	Carbon Cones Assembly	5	F	N
J	Ring Plate + Stainless Cones Assembly	6	L, M	O
K	Carbon Cones + Ring Plate Assembly	5	N,O	P
Stage Welding				
L	Ring Plate Welding	5	G	J
m	Welding Stainless Cones	7	H	J
N	Welding Carbon Cones	6	I	K
O	Welding Ring Plate + Stainless Cones	7	J	K
P	Welding Carbon Cones + Ring Plate	6	K	Q
Firing Stage				
Q	Firing & Finishing Process	4	P	R
Stage Checking				
R	PT DEU Internal QC Check	3	Q	S
S	PT CF External QC Check	4	R	Q
Stage Delivery				
Q	Delivery to PT CF	2	S	-

2. Cost Project

To find out the total cost project *Matarbari Throat Ring Unit-2* , namely by count wages workers involved _ plus the duration duration job . Furthermore that is add to the total cost wages to total costs *consumable* so obtained a total of Rp. 127,023,400. Next , data processing begins from FTA analysis , manufacture network CPM work , and also do PERT calculations .

1. FTA Analysis (*Fault Tree Analysis*)

From the identification results problem done by the way interview together source person namely with *the superintendent* and also *the foreman*, so obtained some of the work processes that become reason happen delays on projects fabrication *Matarbari Throat Ring Unit-2* namely , the assembly process , the welding process , and the checking process . Construction chart *fault tree* can seen in the picture under This :

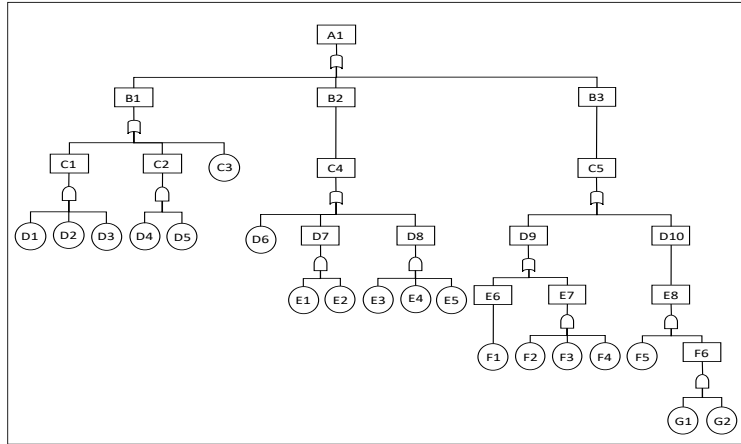


Figure 5. Delay FTA chart Project *Matarbari Throat Ring Unit-2*

From the FTA chart above , you can is known that there were 19 incidents basic / *basic events* that can be done cause happen delays in projects fabrication *Matarbari Throat Ring Unit-2*. For information from FTA chart can seen in table 2 below .

Table 2. Description of the FTA chart

Events	Information
A1	Lateness Project <i>Matarbari Throat Ring Unit-2</i>
B1	Assembly Process
B2	Welding Process
B3	Checking Process
C1	assembly <i>Cones Stainless</i>
C2	Machine Dead <i>Gantry Crane</i>
C3	Labor Shortage
C4	Welding <i>Cones Stainless</i>
C5	PT External QC Check . CF
D1	Workers don't understand pictures
D2	Inexperienced _
D3	Inappropriate Bending Material Size
D4	Burnt <i>Coils</i>
D5	Less Maintenance
D6	Weather / Rain
D7	Welding Method
D8	Damage Welding Machine
D9	Check NDE PT (<i>penetrant test</i>)
D10	FDT check (<i>final dimensional test</i>)
E1	<i>Gouging</i> Process in every Welding
E2	<i>Welding Size</i> Must Be Appropriate
E3	<i>Gun/ handlebar</i> Jammed Weld
E4	Fan Cooling Engine Off

Table 2. Continued

Events	Information
E5	Lack of Maintenance
E6	QC is coming Late

E7	<i>Repair Porosity</i>
E8	<i>Dimensional Repair</i>
F1	There are checks at other places / shops
F2	Unclean Welding Area _
F3	Arrangement <i>Ampere</i> Inappropriate _
F4	Lots of Wind in Open Work Areas
F5	Incorrect Size _ Consequence Deformation Welding
F6	Improper <i>Firing</i> Process _
G1	Workers Lack of Understanding of <i>Firing</i> Techniques
G2	Internal QC is less thorough when checking

next step is determination Minimum cut set, as follows steps determination *Minimum cut set*:

$$\begin{aligned}
 \text{Top level} &= A1 \\
 \text{Level 5} &= B1 + B2 + B3 \\
 \text{Level 4} &= (C1 + C2 + C3) + C4 + C5 \\
 \text{Level 3} &= [(D1 * D2 * D3) + (D4 * D5) + (C3)] + (D6 + D7 + D8) + (D9 + D10) \\
 \text{Level 2} &= [(D1 * D2 * D3) + (D4 * D5) + (C3)] + [(D6) + (E1 * E2) + (E3 * E4 * E5)] + [(E6 + E7) + (E8)] \\
 \text{Level 1} &= [(D1 * D2 * D3) + (D4 * D5) + (C3)] + [(D6) + (E1 * E2) + (E3 * E4 * E5)] + [(F1) + (F2 * F3 * F4) + (F5 * F6)] \\
 \text{Level 0} &= [(D1 * D2 * D3) + (D4 * D5) + (C3)] + [(D6) + (E1 * E2) + (E3 * E4 * E5)] + [(F1) + (F2 * F3 * F4) + (F5 * G1 * G2)]
 \end{aligned}$$

The following is the result determination *The minimum cut set* is 9 combinations *basic events* are , (D1 * D2 * D3), (D4 * D5), (C3), (D6), (E1 * E2), (E3 * E4 * E5), (F1), (F2 * F3 * F4), (F5 * G1 * G2).

2. Critical Path Method (CPM)

Next activity _ that is creating network diagrams work . Below is a network diagram Work project fabrication *Matarbari Throat Ring Unit-2*. Result of calculation progress and calculations back off , then obtained track critical marked by the child arrow thick namely ABCDEHJMJKPQRST with the longest time solution project namely 61 days . The following is a network diagram of the calculation results progress and calculations back off .

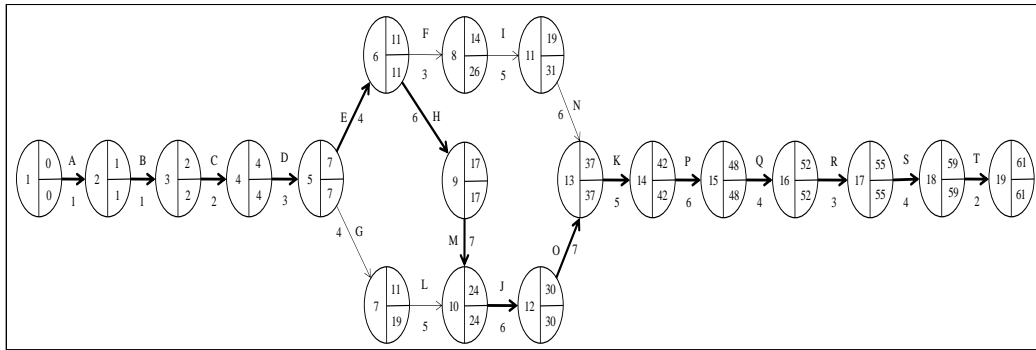


Figure 6. Network Diagram of Forward and Backward Calculation Results

3. Counting Cost Project

On the job project This *Matarbari Throat Ring Unit-2*, will There is a number of activity timed work _shortened , like work assembly *stainless cones*, work assembly *ring plate + stainless cones*, work assembly *carbon cones + ring plate*, work welding *stainless cones*, work welding *ring plate + stainless cones*, work welding *carbon cones + ring plate*, work *firing*, and work PT external QC checking . CF. For the cost slope of each activity can calculated in the table below . The following are formula to calculate cost slope :

$$Slope = \frac{Biaya\ dipercepat - Biaya\ Normal}{Durasi\ Normal - Durasi\ Dipercepat}$$

Table 3. Time and Cost Accelerated

Activity	Duration (Days)		Cost (Rp)		Cost Slope (Rp)
	Normal	Accelerated	Normal	Accelerated	
A	1	1	792,000	-	-
B	1	1	268,000	-	-
C	2	2	836,000	-	-
D	3	3	2,202,000	-	-
E	4	4	4,136,000	-	-
F	3	3	2,202,000	-	-
G	4	4	4,336,000	-	-
H	6	4	7,656,000	8,606,000	475,000
I	5	5	5,420,000	-	-
J	6	4	8,856,000	9,172,000	158,000
K	5	4	6,630,000	6,946,000	316,000

L	5	5	5,660,000	-	-
m	7	3	8,974,000	10,742,000	374,500
N	6	6	7,692,000	-	-
O	7	5	8,974,000	9,306,000	166,000
P	6	4	7,692,000	8,024,000	166,000
Q	4	3	3,544,000	3,694,000	150,000
R	3	3	1,578,000	-	-
S	4	3	3,704,000	4,278,000	574,000
Q	2	2	2,184,000	-	-
Cost Consumables			33,687,400	33,687,400	-
Total Cost			127,023,400	94,185,400	

Addition cost the happen Because exists addition workers and also turnover tools broken machine , to speed things up duration from every activity the job to be done acceleration .

Acceleration Analysis Activity Project

From results analysis previously with using method CPM, can known that duration solution project *Matarbari Throat Ring Unit-2* , namely 61 days with a total cost of Rp. 127,023,400,- . Furthermore that is do calculation for each activities carried out acceleration and also included into the track critical . Activities the accelerated started from activities most end i.e activities S, Q, P, O, M, K, J, H. Below are example calculation on activity M accelerated by 4 days

Completion time project namely :

$$\begin{aligned} \text{Time} &= A - B - C - D - E - H - M - J - O - K - P - Q - R - S - T \\ &= 1 + 1 + 2 + 3 + 4 + 6 + 3 + 6 + 7 + 5 + 6 + 4 + 3 + 4 + 2 = 57 \text{ days} \end{aligned}$$

Accelerated total cost :

$$\begin{aligned} \text{Cost} &= \text{total normal cost} + (2 \times \text{activity slope M}) \\ &= 127,023,400 + (2 \times 374,500) \\ &= 127,023,400 + 749,000 \\ &= \text{Rp. } 127,772,400 \end{aligned}$$

Analysis results acceleration activities S, Q, P, O, M, K, J, H can be seen in table 4 below .

Table 4. Acceleration Activity

Activities that planned accelerated	Duration Project (Day)	Cost Project (Rp)
Normal	61	127,023,400
H accelerated by 2 days	59	127,973,400
J accelerated 2 days		127,339,400
J line 1	59	
J line 2	51	
K sped up 1 day		127,655,400
K line 1	48	
K line 2	60	
K line 3	52	
M accelerated 4 days	57	127,772,400
O speed up 2 days		127,355,400
O line 1	59	
O line 2	51	
P accelerated by 2 days		127,355,400
P line 1	47	
P line 2	59	
P line 3	51	
Q accelerated by 1 day		127,323,400
Q line 1	48	
Q line 2	60	
Q line 3	52	
S accelerated by 1 day		127,171,400
S line 1	48	
S line 2	60	
S line 3	52	

Result of table the obtained that time speed up solution project with optimal cost ie for 57 days contained in activity M by accelerating duration is 4 days and is also accompanied by additions cost amounting to Rp. 127,772,400. Activity M is selected as optimal duration because own least duration _ among all the activities included into the trajectory critical .

For calculations PERT method will using 3 estimates time , that is the most optimistic time (a), the most pessimistic time (b), and the most likely time (m). The following is the result of the interview estimation time according to available sources _ seen in table 5 below .

Table 5. Estimated Activity Time Project

Activity	Time	Time	Time	Time	Deviation	
	Optimistic	Realistic	Pessimistic	activity	Standard	Variance
	(Day)	(Day)	(Day)	$T_e = (a+4m+b)/6$	$S=1(ba)/6$	$V=S^2$
	(a)	(m)	(b)			
A	1	1	2	1.17	0.17	0.028
B	1	1	2	1.17	0.17	0.028
C	1	2	3	2.00	0.33	0.111
D	3	3	4	3.17	0.17	0.028
E	3	4	6	4.17	0.50	0.250
F	3	3	4	3.17	0.17	0.028
G	3	4	5	4.00	0.33	0.111
H	4	6	8	6.00	0.67	0.444
I	4	5	6	5.00	0.33	0.111
J	4	6	8	6.00	0.67	0.444
K	4	5	7	5.17	0.50	0.250
L	5	5	7	5.33	0.33	0.111
m	3	7	9	6.67	1.00	1,000
N	5	6	8	6.17	0.50	0.250
O	5	7	9	7.00	0.67	0.444
P	4	6	8	6.00	0.67	0.444
Q	3	4	5	4.00	0.33	0.111
R	3	3	4	3.17	0.17	0.028
S	3	4	5	4.00	0.33	0.111
Q	1	2	3	2.00	0.33	0.111
Total	63	84	113	85	8	4

Based on table on can calculated total time implementation project so that obtained variant and standard deviation project . Then can determined probability time planning the as in calculations below .

1. Variants and standards deviation project , standard obtained deviation _ from calculations on the table on that is of 8 days . And this results in total variance project that is of 4 days .
2. Probability hit the target schedule , to find out probability can done using _ formula as following :

$$Z = \frac{T(d) - TE}{S}$$
$$Z = \frac{61 - 57}{8} = 0.5$$

From the calculation results previous Z value obtained mark of 0.5, and then can be seen in table Z namely obtained value 0.6915. the tilapia obtained through the x axis is 0.5 and the y axis = 0. Then it is obtained opportunity of 0.6915 or 69.15% to complete project the in period time 57 days .

CONCLUSION

Causal factors lateness project Matarbari Throat Ring Unit-2 has 19 basic events or occurrences basic, namely : lack of energy work , workers do not understand drawings , inexperienced , bending material is not suitable size . burnt coil , lack of maintenance , weather bad / rainy , gouging process at each welding , welding size must be appropriate , gun/ welding handlebar jammed , fan cooler machine dead , lack of maintenance , yes checking in other places /shops, the welding area is not clean , the amperage settings are not appropriate , many wind in area Work Open , size doesn't fit consequence deformation welding workers don't understand firing technique , internal QC was less thorough when checking2. After done calculation qualitatively , there are 9 combinations of basic events or minimal cut sets, namely (D1*D2*D3), (D4*D5), (C3), (D6), (E1*E2), (E3*E4*E5), (F1), (F2*F3*F4), (F5*G1*G2). Then one _ the effort made is doing acceleration on one activities included _ in track critical , so obtained optimal duration of the project from normal time 61 days to 57 days . As well as having opportunity of 69.15% to complete project with a duration of 57 days . Optimal total cost on the job project Matarbari Throat Ring Unit-2 based optimal duration ie amounting to Rp. 127,772,400.

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