

# Determination of Critical Pattern of 60 Meter Ship Construction Project Using Precedence Diagram Method (PDM)

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**Abstract:** PT. XYZ in Surabaya is engaged in the production of commercial ships, providing ship repair and maintenance services as well as general engineering with specifications based on orders. Along with the development of the technology industry, ship production requires every shipyard to evaluate the system used. The time delay is the problem of building a 60 meter commercial ship. The Precedence Diagram Method (PDM) is a method for scheduling project time and showing critical trajectories of project activities. The results showed that in the project scheduling, there are 13 activities that have a zero value or critical activity which are activities Hull Fabrication, Hull Sub Assembly, Hull Assembly, Hull Erection, Blasting and Painting Raw Material, Finishing Hull, Anode, Machinery Outfitting, Cabling, Computing and Information, Machinery Commissioning, Equipment Commissioning, Harbour Acceptance Test, Yard Trial, Delivery to Customer So that it needs more strict control and supervision from the contractor in carrying out the activities of the 60 meter commercial ship building project activities for each activity/activity so that it does not experience delays and the project can be completed on time.

**Keywords:** Controlling, Planning, Critical trajectories, PDM.

## I INTRODUCTION

PT. XYZ in Surabaya is engaged in the production of commercial vessels, providing ship repair and maintenance services as well as general engineering with specifications based on orders (Silvianita, 2018).

Along with the development of the technology industry, ship production

requires every shipyard to evaluate the system used. The new ship building project is required to work fast according to the schedule. Poor performance, low quality, and cost overruns often occur in a project (Arica Dwi Susanto, 2018).

The literature used in this paper were obtained to support the research. These literature includes paper titled A fuzzy pert approach to evaluate plant construction project scheduling risk under uncertain resources capacity (R.Lin, 2009). Earned Value Management Systems: Challenges and Future Direction (Wilson, 2013). CPM, PERT and Project Management With Fuzzy Logic Technique and Implementation On A Business (Mazlum, 2015). Integration of Building Information Modeling and Critical Path Method Schedules to Simulate the Impact of Temperature and Humidity at the Project Level (Shan, 2014). Comparative Study of Management Operation System Techniques (MOST) and CPM in Construction Scheduling (Shailla, 2014). Extension of Time Determination in Construction Projects in Nigeria: The Critical Path Method (Andawei, 2014). Critical path analysis for the management of fractured neck of femur (Balla, 1995). The Critical Path Method In Estimating Project Duration (Nafkha, 2016). Critical Path Analysis for New Product Planning (Wong, 1964). Measuring the Actual Energy Cost Performance of Green Buildings: A Test of the Earned Value Management Approach (Dwaikat, 2016). Cost Control and Performance Review of Software Projects by

Using the Earned Value Management (Alecú, 2014). Critical Path Method in Designing Feasible Solutions (Agarwal, 2013). Traditional Critical Path Method versus Critical Chain Project Management: A Comparative View (M, 2015). Project Planning And Control With Pert And Cpm (K.K.Khandelwal, 2002). Project Planning And Scheduling Using PERT And CPM Techniques With Linear Programming: Case Study (Agyei, 2015). Fast Missile Boat Project Planning using CPM and What If Analysis Method (Silvianita, 2018). CPM Schedule Summarizing Function of the Beeline Diagram Method (Kim, 2012). Earned value method as a tool for project control (Czarnigowska, 2008). The Factors Affecting The Methods of Construction Projects Scheduling: An State of The Art and Overview (Fateme Nouban, 2017). Contruction Project Scheduling with Time, Cost and Material Restrictions Using Fuzzy Mathematical Models and Critical Path Method (Daniel Castro-Lacouture, 2009). Planning and Monitoring of industrial punch development processes (Y. Arslan, 2017)

PDM is a network that is generally in the form of a rectangle, while the arrow is only as a guide to the relations of the activities in question. The activity relationship shows the relationship between activities with one line from the previous node to the next node.

This Paper is organized as follows. Section 2 review about the basic ship theory. Section 3 gives result and section 4 discussion of research. Finally, in section 5 present conclusion this paper.

## II MATERIALS AND METHODS

### Technical Concept

In determining the exact duration factors:

1. Volume of work
2. The condition in project fields
3. Weather conditions
4. Resources conditions (labor, materials, equipment)
5. Experiences on previous project (similar project)

### Project Time Management

There are three stages to be performed in project management:

#### 1. Planning Process

Planning process includes the setting of goals, defining projects and forming team organizations. Regarding the capability in working on several projects at once (mostly in large companies), an effective way to assign labors and physical resources is through the project organization. The project organization is led by a project manager who coordinates project activities with other departments and reports to top management.

#### 2. Scheduling

Scheduling is the link between labor, money, and materials used in a project. Project scheduling involves specifying the duration of project activities to be completed, raw materials, labor and time required for each activity. The popular approach used is the Gantt Chart or the Bar Chart Method. Other project scheduling methods are PERT (Project Evaluation and Review Technique) and CPM (Critical Path Method).

#### 3. Controlling

Project controls include control over resources, cost, quality and budget. Project control is also used to revise the project plan and allow to change/shift resources to a needed places (rearranging) so that the time and cost can be appropriate. Project control involves strict supervision of resources, cost, quality and budget. Control also means the use of feedback loops to revise the project plan and resource arrangements where needed.

### Network Component

There are two approaches to describe the project network: activity on node - AON and activity on arrow (AOA). At the AON convention, the point indicates the activity, whereas at the AOA, the arrow indicates the activity.

### Precedence Diagram Method (PDM)

Precedence Diagram Method is a networking method that is included in the classification of AON (Activity On Node). In this method, the activity is written in a node that is generally rectangular, while the arrows

as a pointer relationship between the activities concerned. Thus the dummy which is an important sign to indicate the dependence relationship, is not required in PDM.

The precedence method diagram can be described as four relations of activity/logic, Each node has two ends, namely the beginning or beginning = (S) and the end or end = (F) that is (Tan, 1998):

In the precedence diagram method, the existence of four relations of activity/logic can

be described. Each node has two ends namely the beginning/starting tip = (S) and end/finish tip = (F) (Tan, 1998):

1. Activity relation of *Start-to-start* (SS): When A starts, B can be started.
2. Activity Relation of *Start-to-finish* (SF): When A starts, B can be finished.
3. Activity Relation *Finish-to-Start* (FS): When A finish, B can be started.
4. Activity Relation *Finish-to-finish* (FF): When A finish, B can be finished.

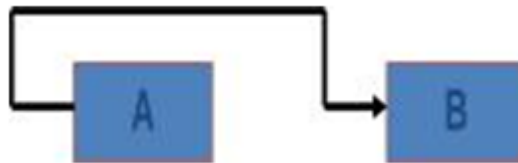


Fig. 1 Activity Relation of *Start-to-Start* (SS)



Fig. 2 Activity Relation of *Start-to-Finish* (SF)



Fig. 3 Activity Relation of *Finish-to-Start* (FS)



Fig. 4 Activity Relation of *Finish-to-Finish* (FF)

### Method of Research.

Analysis of this research data are as follows:

Calculations was performed using excel software whose results can handle planning an activity, organizing and controlling time and costs that convert input data into an output data according to purpose, then the overall time of building a 60 meter commercial ship can be known.

### III. RESULTS

In this part, the authors would like to discuss about critical path with PDM, so that the expected time can be in accordance with the planning of the 60 meters commercial ship construction

The time and cost plan data of a 60 meter commercial ship construction project was for 314 days. The data on the schedule and duration of the 60 meter commercial ship building planning project along with the time duration are presented in table 1 and the cost budget design data are listed in table 2.

**Table. 1** Schedule and Duration of the 60 Meter Commercial Ship Construction Project

No	Activity	Duration (Day)	Start	Finish
	Hull Construction		10/10/2016	06/06/2017
1	Hull Fabrication	70	10/10/2016	15/01/2017
2	Hull Sub Assembly	104	18/10/2016	11/03/2017
3	Hull Assembly	137	26/10/2016	06/05/2017
4	Hull Erection	137	25/11/2016	06/06/2017
	Painting anode Catodic Protection		01/10/2016	22/05/2017
5	Blasting and Painting Raw Material	48	10/10/2016	15/12/2016
6	Block Blasting and Painting	137	15/11/2016	31/05/2017
7	Finishing Hull	27	06/06/2017	12/07/2017
8	Painting Outfitting	79	06/06/2017	22/09/2017
9	Anode	19	14/03/2017	07/04/2017
	Hull Outfitting		10/10/2016	05/10/2017
10	Seat and Foundation	86	10/10/2016	07/02/2017
11	Deck Machinery and Equipment	86	07/02/2017	07/06/2017
12	Interior	171	07/02/2017	05/10/2017
	Machinery Outfitting		10/10/2016	05/10/2017
13	Piping System Including Ducting	181	10/10/2016	20/06/2017
14	Shafting	51	20/06/2017	30/08/2017
15	Machinery Outfitting	25	31/08/2017	05/10/2017
	Electric, Electronic Outfitting		10/10/2016	05/10/2017
16	Cabling	172	10/10/2016	07/06/2017
17	Power Supply	172	02/11/2016	01/07/2017
18	Illuminiation	172	26/11/2016	26/07/2017
19	Communication and Instrumentation	178	21/12/2016	18/08/2017
20	Computing and Information	172	13/01/2017	12/09/2017
21	Nautical and Radio	172	07/02/2017	05/10/2017
	Function and Commisioning		05/10/2017	30/10/2017
22	Machinery Commisioning	9	05/10/2017	18/10/2017
23	Equipment Commisioning	8	10/10/2017	21/10/2017
24	Lighting Commisioning	4	18/10/2017	24/10/2017
25	System Control Commisioning	4	24/10/2017	30/10/2017
	HAT and SAT		02/11/2017	18/12/2017
26	Harbour Acceptance Test	31	02/11/2017	16/12/2017
27	Yard Trial	14	27/11/2017	18/12/2017
	Delivery		20/12/2017	20/12/2017
28	Delivery to Customer	0	20/12/2017	20/12/2017

**Table. 2** Budget Plan

No.	Job Description		Cost
			(Thousands Rupiah)
<b>A</b>	<b><u>Hull Construction</u></b>		
	1	Hull Fabrication	Rp 46.176.942
	2	Hull Sub Assembly	Rp 6.244.996
	3	Hull Assembly	Rp 8.286.629
	4	Hull Erection	Rp 8.286.629
<b>B</b>	<b><u>Painting anode Catodic Protection</u></b>		
	5	Blasting and Painting Raw Material	Rp 3.242.594
	6	Block Blasting and Painting	Rp 2.522.018
	7	Finishing Hull	Rp 1.621.297
	8	Painting Outfitting	Rp 4.743.795
	9	Anode	Rp 1.140.913

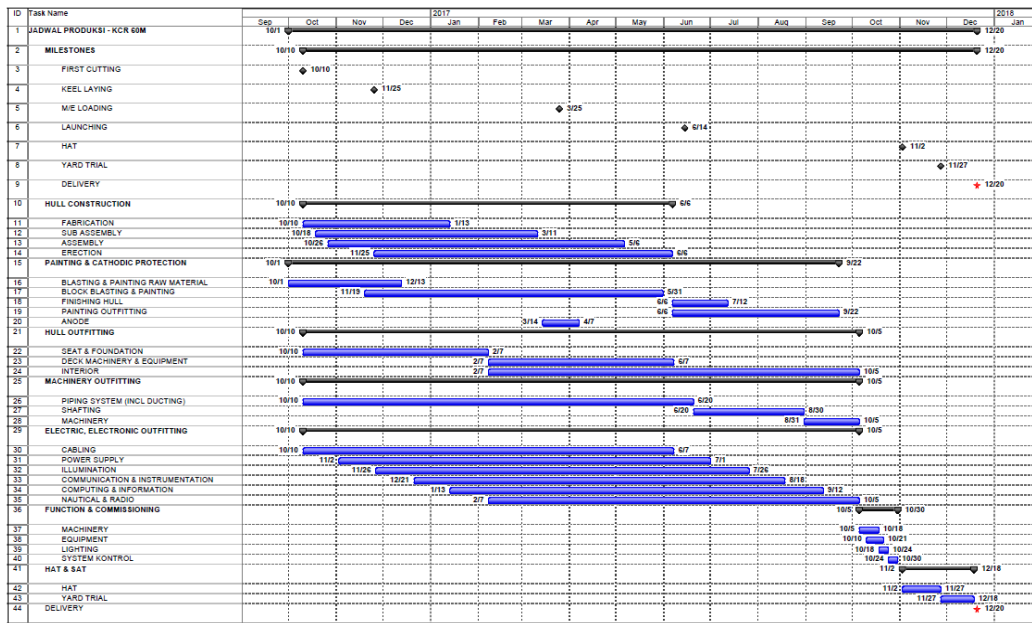
No.	Job Description		Cost	
			(Thousands Rupiah)	
<b>C</b>	<b><u>Hull Outfitting</u></b>			
	10	Seat and Foundation	Rp	5.224.179
	11	Deck Machinery and Equipment	Rp	5.224.179
	12	Interior	Rp	10.388.311
<b>D</b>	<b><u>Machinery Outfitting</u></b>			
	13	Piping System Including Ducting	Rp	10.928.743
	14	Shafting	Rp	3.122.498
	15	Machinery Outfitting	Rp	1.561.249
<b>E</b>	<b><u>Electric, Electronic Outfitting</u></b>			
	16	Cabling	Rp	4.203.363
	17	Power Supply	Rp	4.563.651
	18	Illumination	Rp	4.383.507
	19	Communication and Instrumentation	Rp	4.743.795
	20	Computing and Information	Rp	4.803.843
	21	Nautical and Radio	Rp	3.963.171
<b>E</b>	<b><u>Function and Commisioning</u></b>			
	22	Machinery Commisioning	Rp	600.480
	23	Equipment Commisioning	Rp	540.432
	24	Lighting Commisioning	Rp	120.096
	25	System Control Commisioning	Rp	420.336
<b>F</b>	<b><u>HAT and SAT</u></b>			
	26	Harbour Acceptance Test	Rp	1.921.537
	27	Yard Trial	Rp	900.721
<b>G</b>	<b><u>Delivery</u></b>			
	28	Delivery to Customer	Rp	120.096
	<b>TOTAL</b>		Rp	150.000.000

**Gantt Chart Planning Data for 60 Meter Commercial Ship Construction Project**

Making a planning schedule for a 60 meter commercial ship construction project used the Gantt Chart to determine when the

activities / activities were started, postponed and completed.

The plan schedule of a 60 meter commercial ship construction project can be seen in the following figure below:



**Fig. 5** Gantt Chart Planning Data for 60 Meter Commercial Ship Construction Project

**IV DISCUSSION**

In this study, the PDM method used one determinant number and four constraints. The four constraints in the Precedence Diagram Method (PDM) are important components in the formation of its network. In addition, the four constraints give different

forms by placing activity information in the display of precedent diagrams as nodes.

The results of the construction data determination on the 60 meter commercial ship construction project can be seen in the following table:

**Table. 3** Determination the Construction of the 60 Meter Commercial Ship Construction Project

No	The Activities	Konstrain
1	Hull Fabrication	-
2	Hull Sub Assembly	SS(1-2) = 6
3	Hull Assembly	SS(2-3) = 6
4	Hull Erection	SS(3-4) = 22
5	Blasting and Painting Raw Material	-
6	Block Blasting and Painting	SS(5-6) = 30
7	Finishing Hull	FS(9-7) = 42
		FS(3-7) = 22
		FS(4-7) = 0
		FS(6-7) = 4
8	Painting Outfitting	FS(4-8) = 0
		FS(6-8) = 4
9	Anode	FS(2-9) = 2
10	Seat and Foundation	-
11	Deck Machinery and Equipment	FS(10-11) = 0
12	Interior	FS(10-12) = 0
13	Piping System Including Ducting	-
14	Shafting	FS(11-14) = 9
		FS(13-14) = 0
15	Machinery Outfitting	FS(7-15) = 37
		SS(8-15) = 63
		FS(14-15) = 1
16	Cabling	
17	Power Supply	SS(16-17) = 17
18	Illumination	SS(16-18) = 35
19	Communication and Instrumentation	SS(16-19) = 52

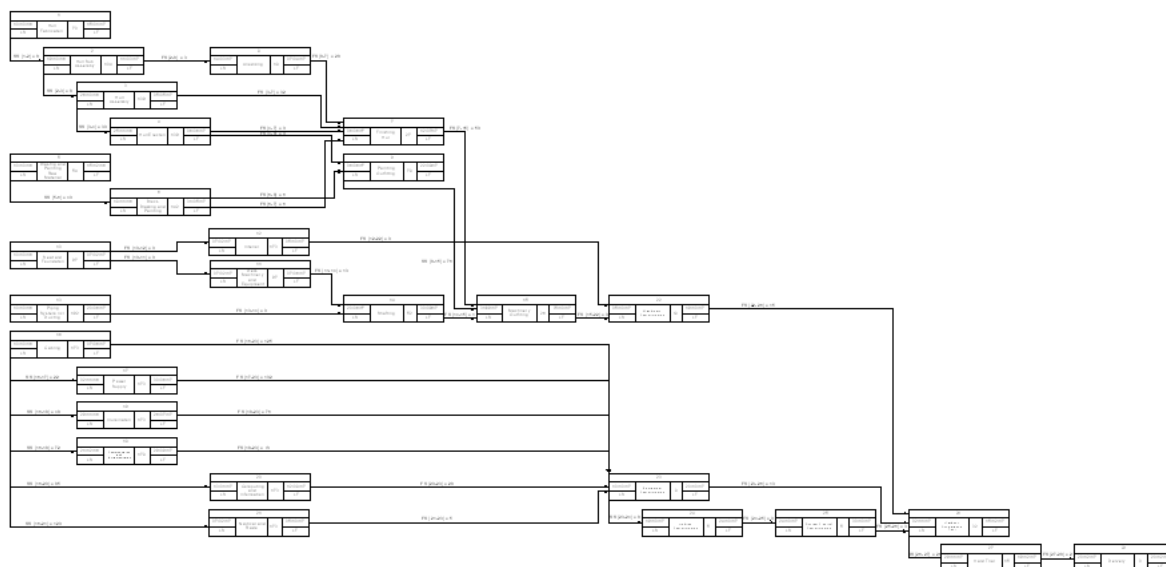
No	The Activities	Konstrain
20	Computing and Information	SS(16-20) = 70
21	Nautical and Radio	SS(16-21) = 86
22	Machinery Commissioning	FS(12-22) = 0
		FS(15-22) = 0
23	Equipment Commissioning	FS(16-23) = 89
		FS(17-23) = 72
		FS(18-23) = 54
		FS(19-23) = 31
		FS(20-23) = 20
		FS(21-23) = 4
24	Lighting Commissioning	SS(23-24) = 6
25	System Control Commissioning	FS(24-25) = 0
26	Harbour Acceptance Test	FS(22-26) = 11
		FS(23-26) = 9
		FS(25-26) = 3
27	Yard Trial	SS(26-27) = 18
28	Delivery to Customer	FS(27-28) = 2

**Table. 4** Table of Activities for Construction of a 60 Meter Commercial Ship Construction Project

No	Job Description	Activity Code	Initial Activity	Duration (Day)
	Hull Construction			
1	Hull Fabrication	1	-	70
2	Hull Sub Assembly	2	1	104
3	Hull Assembly	3	2	137
4	Hull Erection	4	3	137
	Painting anode Catodic Protection			
5	Blasting and Painting Raw Material	5	-	48
6	Block Blasting and Painting	6	5	137
7	Finishing Hull	7	3, 4, 6, 9	27
8	Painting Outfitting	8	4, 6	79
9	Anodizing	9	2	19
	Hull Outfitting			
10	Seat and Foundation	10	-	86
11	Deck Machinery and Equipment	11	10	86
12	Interior	12	10	171
	Machinery Outfitting			
13	Piping System Including Ducting	13	-	181
14	Shafting	14	11, 13	51
15	Machinery Outfitting	15	7, 8, 14	25
	Electric, Electronic Outfitting			
16	Cabling	16	-	172
17	Power Supply	17	16	172
18	Illumination	18	16	172
19	Communication and Instrumentation	19	16	178
20	Computing and Information	20	16	172
21	Nautical and Radio	21	16	172
	Function and Commissioning			
22	Machinery Commissioning	22	12, 15	9
23	Equipment Commissioning	23	16,17,18,19,20,21	8
24	Lighting Commissioning	24	23	4
25	System Control Commissioning	25	24	4
	HAT and SAT			
26	Harbour Acceptance Test	26	22, 23, 25	31
27	Yard Trial	27	26	14
	Delivery			
28	Delivery to Customer	28	27	0

Based on the series of project activities in the table above with the addition of constrains provisions in table 4, they were then described in the form of a networking

planning diagram using activity signs in the activity on node (AON) model as shown below:



**Fig. 6** Activity On Node of 60 Meter Commercial Ship Construction Project

After the Time Schedule was known, the next step was the researcher to perform the PDM calculation to find out the project completion time. The PDM it consists of two stages, namely forward pass and backward pass.

1. *Forward Pass*

- Activity 1  
 ES (1) = 0  
 EF (1) = 0 + 70 = 70
- Activity 2  
 ES (2) = 0 + 6 = 6  
 EF (2) = 6 + 104 = 110
- Activity 3  
 ES (3) = 6 + 6 = 12  
 EF (3) = 12 + 137 = 149
- Activity 4  
 ES (4) = 12 + 22 = 34  
 EF (4) = 34 + 137 = 171
- Activity 5  
 ES (5) = 0  
 EF (5) = 0 + 48 = 48
- Activity 6  
 ES = 0 + 30 = 30  
 EF = 30 + 137 = 167
- Activity 7  
 ES (7) = 130 + 42 = 172  
 = 149 + 22 = 171

- = 171 + 0 = 171
- = 167 + 4 = 171
- EF (7) = 172 + 27 = 199
- Activity 8  
 ES (8) = 171 + 0 = 171  
 = 167 + 4 = 170  
 EF (8) = 171 + 79 = 250
- Activity 9  
 ES (9) = 110 + 2 = 112  
 EF (9) = 112 + 18 = 130
- Activity 10  
 ES (10) = 0  
 EF (10) = 0 + 86 = 86
- Activity 11  
 ES (11) = 87 + 0 = 86  
 EF (11) = 86 + 86 = 172
- Activity 12  
 ES (12) = 86 + 0 = 86  
 EF (12) = 86 + 171 = 257
- Activity 13  
 ES (13) = 0  
 EF (13) = 0 + 181 = 181
- Activity 14  
 ES (14) = 172 + 9 = 181  
 = 181 + 0 = 181  
 EF (14) = 181 + 51 = 232
- Activity 15  
 ES (15) = 199 + 36 = 235  
 = 171 + 62 = 233



- $= 232 + 1 = 233$
- EF (15)  $= 235 + 25 = 260$
- Activity 16
  - ES (16)  $= 0$
  - EF (16)  $= 0 + 172 = 172$
- Activity 17
  - ES (17)  $= 0 + 17 = 17$
  - EF (17)  $= 17 + 172 = 189$
- Activity 18
  - ES (18)  $= 0 + 35 = 35$
  - EF (18)  $= 35 + 172 = 207$
- Activity 19
  - ES (19)  $= 0 + 52 = 52$
  - EF (19)  $= 52 + 178 = 230$
- Activity 20
  - ES (20)  $= 0 + 70 = 70$
  - EF (20)  $= 70 + 172 = 242$
- Activity 21
  - ES (21)  $= 0 + 86 = 86$
  - EF (21)  $= 86 + 172 = 258$
- Kegiatan 22
  - ES (22)  $= 257 + 0 = 257$
  - $= 260 + 0 = 260$
  - EF (22)  $= 260 + 9 = 269$
- Activity 23
  - ES (23)  $= 172 + 89 = 261$
  - $= 189 + 72 = 261$
  - $= 207 + 54 = 261$
  - $= 230 + 31 = 261$
  - $= 242 + 20 = 262$
  - $= 258 + 3 = 261$
  - EF (23)  $= 262 + 9 = 271$
- Activity 24
  - ES (24)  $= 262 + 6 = 268$
  - EF (24)  $= 268 + 4 = 272$
- Activity 25
  - ES (25)  $= 272 + 0 = 272$
  - EF (25)  $= 272 + 4 = 276$
- Activity 26
  - ES (26)  $= 269 + 11 = 280$
  - $= 269 + 9 = 278$
  - $= 275 + 3 = 279$
  - EF (26)  $= 280 + 31 = 311$
- Activity 27
  - ES (27)  $= 280 + 18 = 298$
  - EF (27)  $= 298 + 14 = 312$
- Activity 28
  - ES (28)  $= 312 + 2 = 314$
  - EF (28)  $= 314 + 0 = 314$

2. Backward Pass.

- Activity 28
  - LF (28)  $= 314$
  - LS (28)  $= 314 - 0 = 314$
- Activity 27
  - LF (27)  $= 314 - 2 = 312$
  - LS (27)  $= 312 - 14 = 298$
- Activity 26
  - LF (26)  $= 298 - 18 + 31 = 311$
  - LS (26)  $= 311 - 31 = 280$
- Activity 25
  - LF (25)  $= 280 - 3 = 277$
  - LS (25)  $= 277 - 4 = 273$
- Activity 24
  - LF (24)  $= 273 - 0 = 273$
  - LS (24)  $= 273 - 4 = 269$
- Activity 23
  - LF (23)  $= 269 - 6 + 8 = 271$
  - $= 280 - 9 = 271$
  - LS (23)  $= 271 - 9 = 262$
- Activity 22
  - LF (22)  $= 280 - 11 = 269$
  - LS (22)  $= 269 - 9 = 260$
- Activity 21
  - LF (21)  $= 262 - 3 = 259$
  - LS (21)  $= 259 - 172 = 87$
- Activity 20
  - LF (20)  $= 262 - 20 = 242$
  - LS (20)  $= 242 - 172 = 70$
- Activity 19
  - LF (19)  $= 262 - 31 = 231$
  - LS (19)  $= 231 - 178 = 53$
- Activity 18
  - LF (18)  $= 262 - 54 = 208$
  - LS (18)  $= 208 - 173 = 36$
- Activity 17
  - LF (17)  $= 262 - 72 = 190$
  - LS (17)  $= 190 - 172 = 18$
- Activity 16
  - LF (16)  $= 262 - 89 = 172$
  - LS (16)  $= 173 - 172 = 1$
  - $= 18 - 17 = 1$
  - $= 36 - 35 = 1$
  - $= 53 - 52 = 1$
  - $= 70 - 70 = 0$
  - $= 87 - 86 = 1$
- Activity 15
  - LF (15)  $= 260 - 0 = 260$
  - LS (15)  $= 260 - 25 = 235$
- Activity 14
  - LF (14)  $= 235 - 1 = 234$

- LS (14) = 234 - 51 = 183
- Activity 13
  - LF (13) = 183 - 0 = 183
  - LS (13) = 183 - 182 = 1
- Activity 12
  - LF (12) = 260 - 0 = 260
  - LS (12) = 260 - 171 = 89
- Activity 11
  - LF (11) = 183 - 9 = 174
  - LS (11) = 174 - 87 = 86
- Activity 10
  - LF (10) = 87 - 0 = 87
  - = 89 - 0 = 89
  - LS (10) = 87 - 86 = 1
- Activity 9
  - LF (9) = 172 - 42 = 130
  - LS (9) = 130 - 18 = 112
- Activity 8
  - LF (8) = 235 - 62 + 79 = 252
  - LS (8) = 252 - 79 = 173
- Activity 7
  - LF (7) = 235 - 36 = 199
  - LS (7) = 199 - 27 = 172
- Activity 6
  - LF (6) = 172 - 4 = 168
- = 173 - 4 = 169
- Activity 5
  - LF (5) = 31 - 30 + 54 = 55
  - LS (5) = 55 - 54 = 0
- Activity 4
  - LF (4) = 173 - 0 = 173
  - = 172 - 0 = 172
  - LS (4) = 172 - 138 = 34
- Activity 3
  - LF (3) = 172 - 22 = 150
  - = 34 - 22 + 137 = 149
  - LS (3) = 149 - 137 = 12
- Activity 2
  - LF (2) = 112 - 2 = 110
  - = 12 - 6 + 104 = 110
  - LS (2) = 110 - 104 = 6
- Activity 1
  - LF (1) = 6 - 6 + 70 = 70
  - LS (1) = 70 - 70 = 0

**Table. 5** Recapitulation of ES, EF, SL, LS and LF Value Calculation of the 60 Meter Commercial Ship Construction Project

Activity Code	Duration (Day)	ES	EF	SL	LS	LF
<b>1</b>	<b>70</b>	<b>0</b>	<b>70</b>	<b>0</b>	<b>0</b>	<b>70</b>
<b>2</b>	<b>104</b>	<b>6</b>	<b>120</b>	<b>0</b>	<b>6</b>	<b>120</b>
<b>3</b>	<b>137</b>	<b>12</b>	<b>149</b>	<b>0</b>	<b>12</b>	<b>149</b>
<b>4</b>	<b>137</b>	<b>34</b>	<b>173</b>	<b>0</b>	<b>34</b>	<b>173</b>
<b>5</b>	<b>48</b>	<b>0</b>	<b>48</b>	<b>0</b>	<b>0</b>	<b>48</b>
6	137	30	167	1	31	168
<b>7</b>	<b>27</b>	<b>172</b>	<b>199</b>	<b>0</b>	<b>172</b>	<b>199</b>
8	79	171	250	2	173	252
<b>9</b>	<b>19</b>	<b>112</b>	<b>130</b>	<b>0</b>	<b>112</b>	<b>130</b>
10	86	0	86	1	1	87
11	86	86	172	1	87	173
12	171	86	257	1	87	258
13	181	0	181	1	1	183
14	51	181	232	2	183	234
<b>15</b>	<b>25</b>	<b>235</b>	<b>260</b>	<b>0</b>	<b>235</b>	<b>260</b>
<b>16</b>	<b>172</b>	<b>0</b>	<b>172</b>	<b>0</b>	<b>0</b>	<b>172</b>
17	172	17	189	1	18	190
18	172	35	207	1	36	208
19	178	52	230	1	53	231
<b>20</b>	<b>172</b>	<b>70</b>	<b>242</b>	<b>0</b>	<b>70</b>	<b>242</b>
21	172	86	258	1	87	259
<b>22</b>	<b>9</b>	<b>260</b>	<b>269</b>	<b>0</b>	<b>260</b>	<b>269</b>
<b>23</b>	<b>8</b>	<b>262</b>	<b>271</b>	<b>0</b>	<b>262</b>	<b>271</b>
24	4	268	272	1	269	273
25	4	272	276	1	273	277

Activity Code	Duration (Day)	ES	EF	SL	LS	LF
26	31	280	311	0	280	311
27	14	298	312	0	298	312
28	0	314	314	0	314	314

Based on Table 5, the critical path from the PDM calculation was obtained. The critical path is the path through which critical work passes, namely the work that has the earliest start time equals with the last start

time (ES = LS) and the earliest completion time equals with the latest finish time (EF = LF). The critical path on PDM can be seen in the following figure:

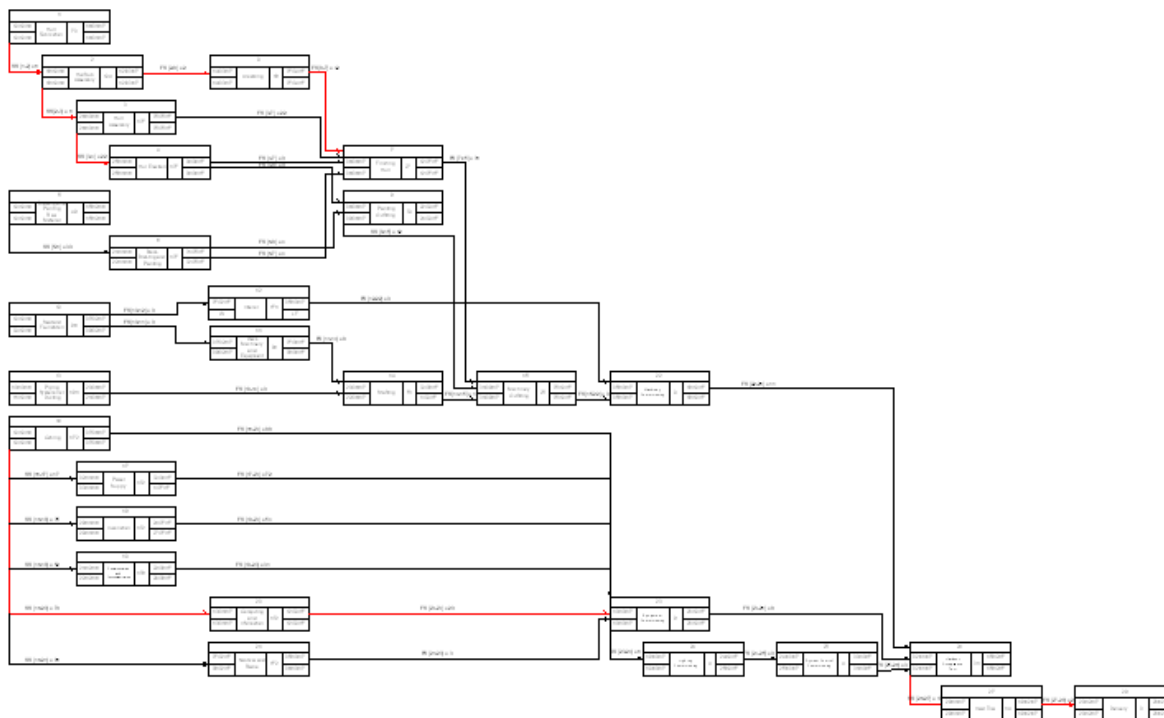


Fig. 7 PDM critical track on the 60 Meter Commercial Ship Construction Project

V. CONCLUSION

Based on the calculations obtained, activity Hull Fabrication, Hull Sub Assembly, Hull Assembly, Hull Erection, Blasting and Painting Raw Material, Finishing Hull, Anode, Machinery Outfitting, Cabling, Computing and Information, Machinery Commissioning, Equipment Commissioning, Harbour Acceptance Test, Yard Trial, Delivery to Customer are critical paths. Thus, control and supervision is more stringent in carrying out the activities of the 60 meter commercial ship building project activities than the contractor on each activity to avoid delays so that the project can be completed on time.

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