International Journal of ASRO
Volume 9, Number 2, pp. 87-106
July-December 2018

TIME SCHEDULING AND COST OF THE INDONESIAN NAVY SHIP DEVELOPMENT PROJECT USING NETWORK DIAGRAM AND EARNED VALUE METHOD (EVM) (CASE STUDY OF FAST MISSILE BOAT DEVELOPMENT)

Ahmadi[1], Suparno[2], Okol Sri Suharyo[3], Arica Dwi Susanto[4]

[1,3,4] Indonesian Naval Technology College, STTAL.
Bumimoro-Morokrembangan, Surabaya 60187, Indonesia
[2] Sepuluh Nopember Institute of Technology, ITS
Raya ITS, Keputih, Sukolilo, Surabaya 60111, Indonesia

ABSTRACT

Missile Boat is one of Indonesian Navy Warship (KCR-60) which has a length of 60 meters and made domestically by Indonesian people at the PT. X in Surabaya. Time delay and cost overruns are the problems in the Missile Boat construction project (KCR-60). The purpose of this research was to schedule the time and cost of the project so that it can be completed on time and there is no swelling of costs for the implementation of the construction of the Missile Boats (KCR-60). The scheduling method used in this study was Precedence Diagram Method (PDM) on Network Diagram and Earned Value Method (EVM). Precedence Diagram Method (PDM) was used for scheduling the project time and showing the critical trajectory of project activities along with the acceleration time (Crashing Project) while Earned Value Method (EVM) was used to determine the costs and time performance and the factors that cause delays or progress of the project. The results showed that the project schedule had 13 activities that had a zero slack or critical activities which were in activities 1, 2, 3, 4, 5, 6, 16, 18, 21, 23, 26, 27, 28. There acceleration of time (Crashing Project) by adding hours of work or overtime for 1 hour every day to 21 activities (1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19) will accelerate and reduce the duration of project completion, which was originally 414 days from the completion of the actual work of implementation to 363 days, thus the difference of effectiveness was 51 days (more effective). Meanwhile, for cost efficiency, based on the analysis of the real cost of project implementation, the amount of Idr. 20.407,094,998, - became Rp. 18,410,738,982, thus it became more efficient by Idr. 2,470,548,998, -.

Keywords: *Network Diagram, PDM, Crashing Project, EVM, KCR-60.*

1. INTRODUCTION.

Fast Missile Boat is one of Indonesian Navy Warship (KCR-60) which has a length of 60 meters and made domestically by Indonesian people at the PT. X in Surabaya which engaged in the production of warships and commercial vessels, providing ship repair and maintenance services as well as general engineering with order-based specifications (Silvianita, 2018).

Along with the development of the technology industry, ship production requires every shipyard to evaluate the system used. The new shipbuilding 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 delay is caused by several factors, namely: the limited number of local workers, the ineffectiveness of the use of subcontractors due to lack of firmness to subcontractors who work beyond the schedule and are less selective in choosing subcontractors, delays in material ordering,

damage to shipyard machinery, lack of better technology to support the process, unpredictable weather factors, and several other unexpected factors.

The literature used in this paper were obtained to support the research. This literature includes a 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 (Alecu, 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 (Fatemeh Nouban, 2017). Construction 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).

Network Diagram is in Precedence Diagram Method (PDM) and Earned Value Method (EVM) techniques. The Earned Value Method (EVM) is able to find deviations between plans and reality, and encourage to look for the causes. While the calculation technique of the Precedence Diagram Method (PDM) on the Network Diagram that we use has important advantages, which are: Project scheduling in the form of a network diagram shown by lines / arrows with a very clear dependency relationship and showing the critical path of project activities so that if there are project delays, the priority of project work to be corrected will be easy to do, and the solution is given if there is a time constraint, which is a Crashing Project.

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

2. MATERIALS/METHODOLOGY.

2.1. Technical Concept

This study used the Precedence Diagram Method (PDM) for scheduling the time of 60 meter ship development project and showing the critical trajectory of project activities and the acceleration of time by adding labor or Crashing Projects while the Earned Value Method (EVM) was used to

determine the cost and time performance, as well as the factors that cause the delay or progress of the project.

2.2. Network Diagram

Networking is a tool used to plan, schedule, and control project progress. Stages of compiling a Network Diagram:

a. Inventory activities from the Work Breakdown Structure (WBS) package based on work items, then given an activation code to facilitate identification.

b. Estimating the duration of each activity by considering the type of work, work volume, number of resources, work environment, and worker productivity.

c. Determination of the logic of dependence between activities carried out with three possible relationships, namely predecessor activities, activities that are preceded (successors), and free.

d. Analysis calculation of time and location of resources, this would be performed after the steps above are carried out accurately and thoroughly.

2.2. 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.

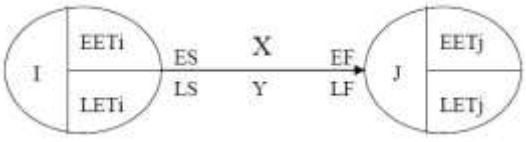

Fig. 1 Activity On Arrow

Fig. 2 Activity On Node

2.3. Work Breakdown Structure (WBS)

WBS is a method of organizing projects into hierarchical reporting structures. WBS is used to break down or solve each work process in more detail.

2.4. 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.

On the precedence method, a diagram can be described as there are four relations of activity/logic, Each node has two ends, namely the beginning or beginning = (S) and the end or end = (F).

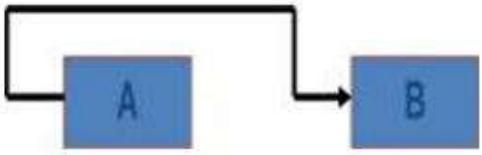

Fig. 3 Activity Relation of Start-to-Start (SS)

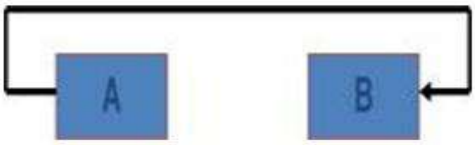

Fig. 4 Activity Relation of Start-to-Finish (SF)

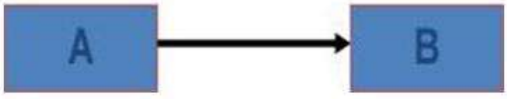

Fig. 5 Activity Relation of Finish-to-Start (FS)

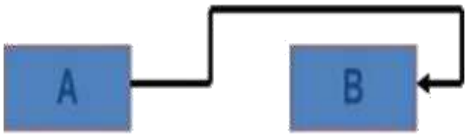

Fig. 6 Activity Relation of Finish-to-Finish (FF)

Fig. 7 Network Diagram PDM

2.5. Crashing Project

The method for shortening the length of project time by reducing the time of one or more so that the important project activities becomes less than the normal time of activity.

2.6. Earned Value Method

EVM is one of the tools used in project management that integrates cost and time by presenting three dimensions, namely the physical completion of the project (the percent complete) which reflects the budgeted cost, actual costs that have been incurred or what is called actual cost and what obtained from costs already incurred.

2.7. Method of Research.

This study uses Microsoft Project 2007 computer program for the analysis of Precedence Method Diagram and Earned Value Method analysis.

The instruments for analyzing Precedence Diagram Method are as follows:

a. Time Schedule of Missile Boats (KCR-60) Development

b. Gantt Chart for the development of Missile Boats (KCR-60)

c. Budget Plan (RAB) for the development of Missile Boats (KCR-60)

d. Price of wages and materials.

The instruments for Earned Value Method analysis are described as follows:

a. S-Curve (Plan and Realization)

b. Employment / Budget Prices

c. Financial Report, in the form of actual costs incurred by the Contractor (Actual Costs).

3. RESULT AND DISCUSSION.

In this part, the authors would like to discuss about the critical path with PDM, Crashing Project for accelerating the time and cost with the EVM method, so that the time and costs are expected to be in accordance with the planning of the construction of Missile Fast Ships (KCR-60).

3.1. object Time Planning Data

Time planning data for the Missile Fast Ship construction project (KCR-60) for 363 days. The data on the schedule of the Missile Fast Ship development planning project (KCR-60) along with the duration of the project are listed in the table below:

Table 1. Schedule and Duration of the 60 Meter 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	138	26/10/2016	06/05/2017

No	Activity	Duration (day)	Start	Finish
4	Hull Erection	138	25/11/2016	06/06/2017
	Painting anode Cathodic Protection		01/10/2016	22/05/2017
5	Blasting and Painting Raw Material	54	10/10/2016	15/12/2016
6	Block Blasting and Painting	142	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	87	10/10/2016	07/02/2017
11	Deck Machinery and Equipment	87	07/02/2017	07/06/2017
12	Interior	173	07/02/2017	05/10/2017
	Machinery Outfitting		10/10/2016	05/10/2017
13	Piping System Including Ducting	182	10/10/2016	20/06/2017
14	Shafting	52	20/06/2017	30/08/2017
15	Machinery Outfitting	26	31/08/2017	05/10/2017
	Electric, Electronic Outfitting		10/10/2016	05/10/2017
16	Cabling	173	10/10/2016	07/06/2017
17	Power Supply	173	02/11/2016	01/07/2017
18	Illumination	173	26/11/2016	26/07/2017
19	Communication and Instrumentation	179	21/12/2016	18/08/2017
20	Computing and Information	173	13/01/2017	12/09/2017
21	Nautical and Radio	173	07/02/2017	05/10/2017
	Function and Commisioning		05/10/2017	30/10/2017
22	Machinery Commisioning	10	05/10/2017	18/10/2017
23	Equipment Commisioning	9	10/10/2017	21/10/2017
24	Lighting commisioning	5	18/10/2017	24/10/2017
25	System Control Commisioning	5	24/10/2017	30/10/2017
	HAT and SAT		02/11/2017	18/12/2017
26	Harbour Acceptance Test	32	02/11/2017	16/12/2017
27	Yard Trial	15	27/11/2017	18/12/2017
	Delivery		20/12/2017	20/12/2017
28	Delivery to Customer	0	20/12/2017	20/12/2017

3.2. Project Cost Planning Data

The project cost budget is very important in the Missile Boat (KCR-60) construction project. After the contractor designed the time planning data for the Missile Boat construction project (KCR-60), the contractor also carried out a project cost budget plan based on existing market experience and prices. The Budget Plan (RAB) is listed in the table below:

Table 2. Budget planning

No.	Job Description		Cost (Thousand Rupiah)	
A	**Hull Construction**			
	1	Hull Fabrication	Rp	502.424
	2	Hull Sub Assembly	Rp	746.459
	3	Hull Assembly	Rp	990.494
	4	Hull Erection	Rp	990.494
B	**Painting anode Cathodic Protection**			
	5	Blasting and Painting Raw Material	Rp	387.584
	6	Block Blasting and Painting	Rp	1.019.203
	7	Finishing Hull	Rp	193.792
	8	Painting Outfitting	Rp	567.022
	9	Anode	Rp	136.372
C	**Hull Outfitting**			
	10	Seat and Foundation	Rp	624.442
	11	Deck Machinery and Equipment	Rp	624.442
	12	Interior	Rp	1.241.706
D	**Machinery Outfitting**			
	13	Piping System Including Ducting	Rp	1.306.303
	14	Shafting	Rp	373.229
	15	Machinery Outfitting	Rp	186.615
E	**Electric, Electronic Outfitting**			
	16	Cabling	Rp	1.220.173
	17	Power Supply	Rp	1.263.238
	18	Illumination	Rp	1.241.706
	19	Communication and Instrumentation	Rp	1.284.771
	20	Computing and Information	Rp	1.291.948
	21	Nautical and Radio	Rp	1.191.463
E	**Function and Commisioning**			
	22	Machinery Commisioning	Rp	71.775
	23	Equipment Commisioning	Rp	64.597
	24	Lighting commisioning	Rp	35.887
	25	System Control Commisioning	Rp	35.887
F	**HAT and SAT**			
	26	Harbors Acceptance Test	Rp	229.680
	27	Yard Trial	Rp	107.662
G	**Delivery**			
	28	Delivery to Customer	Rp	7.177
	TOTAL		**Rp**	**17.936.546**

3.3. Gantt Chart Planning Project for Missile Boat Construction (KCR-60).

The making of schedule plan for a Missile Boat (KCR-60) construction project used Gantt Chart to determine when the activities would be started, postponed and completed. The planned schedule of the Missile Boat construction project (KCR-60) can be seen in the following figure below:

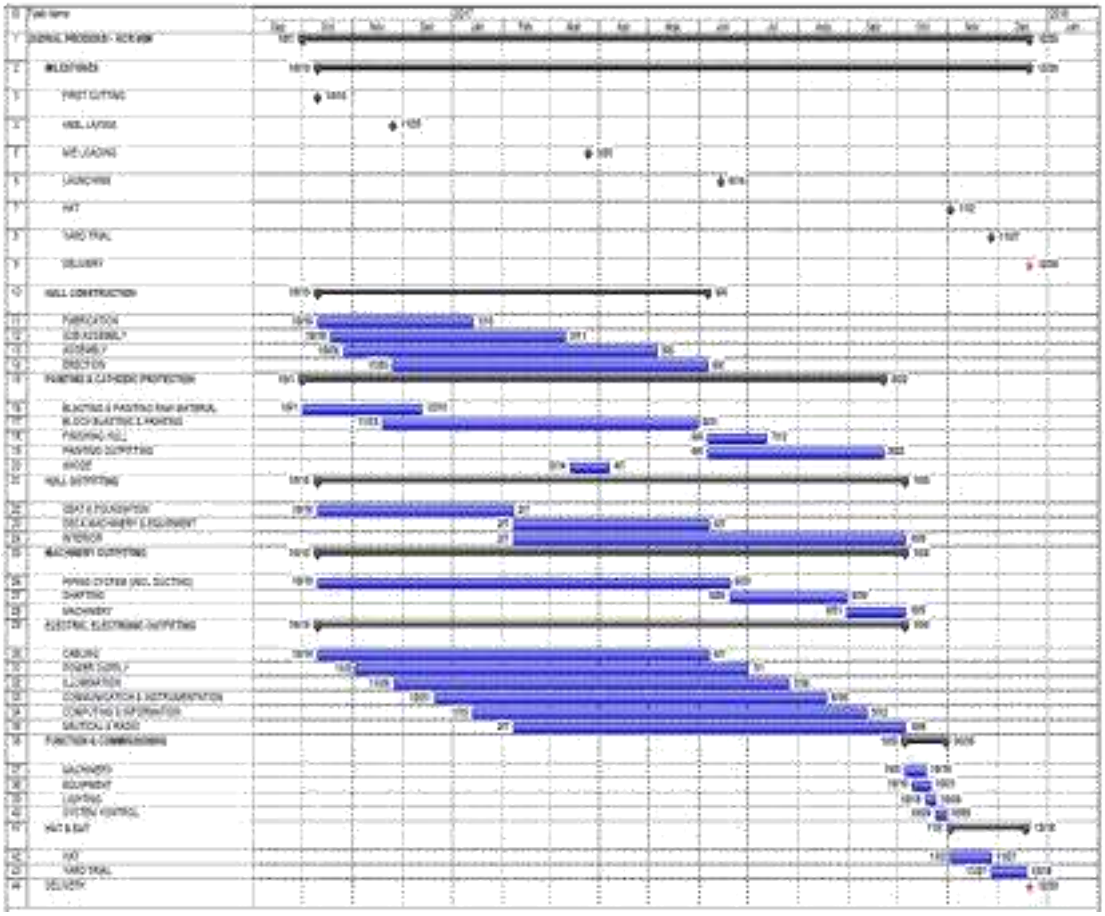

Fig. 8 Gantt Chart Planning Project for Missile Boat Construction (KCR-60).

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

The results of data processing for construction determination on the Missile Boat (KCR-60) construction project can be seen in the following table:

Table 3. Constraint Determination of Missile Boat (KCR-60) Construction Project

No	Activity	Duration (days)	Constraint
1	Hull Fabrication	70	-
2	Hull Sub Assembly	104	SS(1-2) = 8
3	Hull Assembly	138	SS(2-3) = 8
4	Hull Erection	138	SS(3-4) = 30
5	Blasting and Painting Raw Material	54	-
6	Block Blasting and Painting	142	SS(5-6) = 40
7	Finishing Hull	27	FS(9-7) = 29
			FS(3-7) = 32

No	Activity	Duration (days)	Constraint
			FS(4-7) = 0
			FS(6-7) = 6
8	Painting Outfitting	79	FS(4-8) = 0
			FS(6-8) = 6
9	Anode	19	FS(2-9) = 3
10	Seat and Foundation	87	-
11	Deck Machinery and Equipment	87	FS(10-11) = 0
12	Interior	173	FS(10-12) = 0
13	Piping System Including Ducting	182	-
14	Shafting	52	FS(11-14) = 13
			FS(13-14) = 0
15	Machinery Outfitting	26	FS(7-15) = 27
			SS(8-15) = 76
			FS(14-15) = 1
16	Cabling	173	0
17	Power Supply	173	SS(16-17) = 22
18	Illuminiation	173	SS(16-18) = 49
19	Communication and Instrumentation	179	SS(16-19) = 72
20	Computing and Information	173	SS(16-20) = 95
21	Nautical and Radio	173	SS(16-21) = 120
22	Machinery Commisioning	10	FS(12-22) = 0
			FS(15-22) = 0
23	Equipment Commisioning	9	FS(16-23) = 125
			FS(17-23) = 102
			FS(18-23) = 76
			FS(19-23) = 43
			FS(20-23) = 28
			FS(21-23) = 5
24	Lighting Commisioning	5	SS(23-24) = 8
25	System Control Commisioning	5	FS(24-25) = 0
26	Harbour Acceptance Test	32	FS(22-26) = 16
			FS(23-26) = 13
			FS(25-26) = 3
27	Yard Trial	15	SS(26-27) = 26
28	Delivery to Customer	0	FS(27-28) = 2

Determination of PDM-based Gantt Chart

Determination of PDM-based Gantt Chart in this thesis can be seen in Figure 9 below, which is where the Gantt Chart has the principle to describe work activities in graphical form with a timescale.

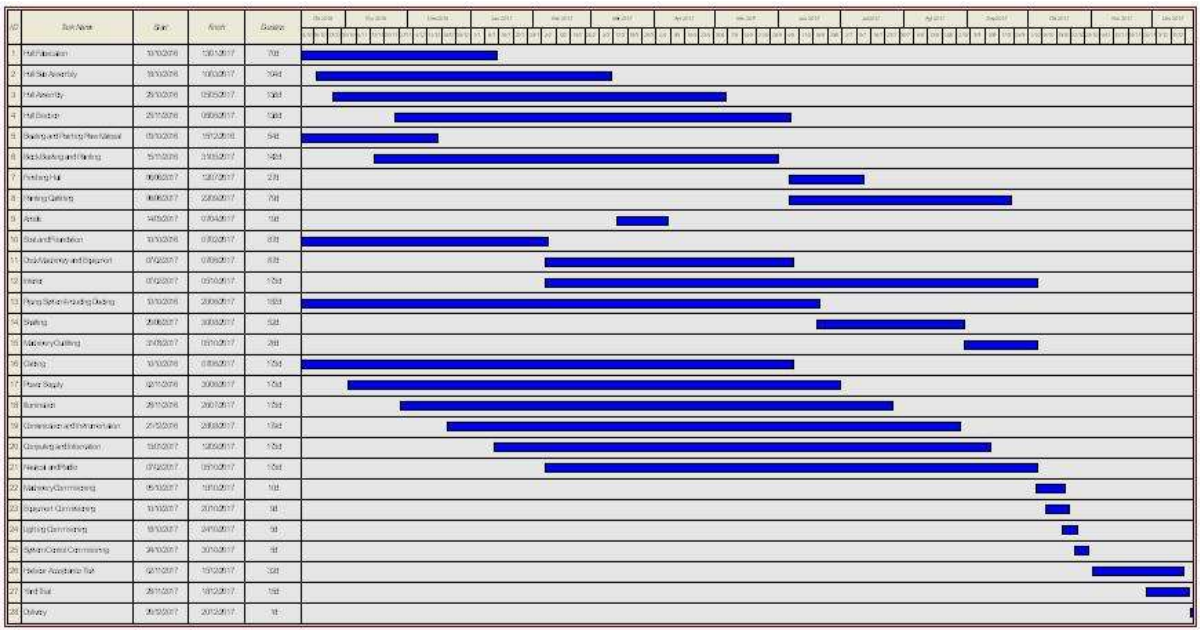

Fig. 9 Gantt Chart Planning Project for Missile Boat Construction (KCR-60) based on PDM

Determination of Time Schedule using PDM One of the important things in project analysis is knowing when the project can be completed. The relationship with other activities and when the activity begins and ends. Precedence Diagram Method (PDM) is one of the scheduling techniques included in network planning scheduling techniques or network plans.

Before scheduling, a table of project activities is first prepared as listed in the following table:

Table 4. Table of Activities for Missile Boat (KCR-60) 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	138
4	Hull Erection	4	3	138
	Painting anode Cathodic Protection			
5	Blasting and Painting Raw Material	5	-	54

No	Job Description	Activity Code	Initial Activity	Duration (day)
6	Block Blasting and Painting	6	5	54
7	Finishing Hull	7	3,4,6,9	142
8	Painting Outfitting	8	4, 6	27
9	Anodizing	9	2	19
	Hull Outfitting			
10	Seat and Foundation	10	-	87
11	Deck Machinery and Equipment	11	10	87
12	Interior	12	10	173
	Machinery Outfitting			
13	Piping System Including Ducting	13	-	182
14	Shafting	14	11, 13	52
15	Machinery Outfitting	15	7. 8. 14	26
	Electric, Electronic Outfitting			
16	Cabling	16	-	173
17	Power Supply	17	16	173
18	Illumination	18	16	173
19	Communication and Instrumentation	19	16	179
20	Computing and Information	20	16	173
21	Nautical and Radio	21	16	173
	Function and Commisioning			
22	Machinery Commisioning	22	12, 15	10
23	Equipment Commisioning	23	16,17,18,19,20, 21	9
24	Lighting commisioning	24	23	5
25	System Control Commisioning	25	24	5
	HAT and SAT			
26	Harbour Acceptance Test	26	22, 23, 25	32
27	Yard Trial	27	26	15
	Delivery			
28	Delivery to Customer	28	27	0

To prepare a complete network, long processes and rules are needed. This begins with the technique of creating a network and ends with improving its quality. Regarding the terminology and basic rules of the work network, the most important are activities which are components of the project and dependency relationships with one another. Based on the series of project activities in the table above with the addition of constraints 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:

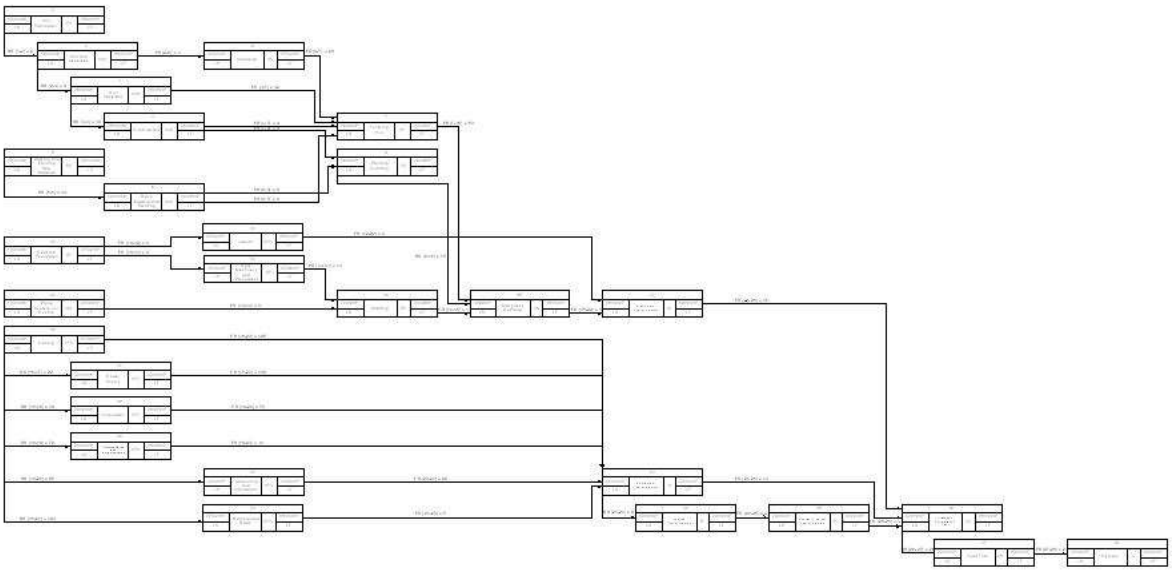

Fig. 10 Activity On Node Missile Boat (KCR-60) Construction Project

After the Time Schedule was known, the next step was the researcher performs the PDM calculation to find out the project completion time. There were two stages in the PDM, namely forward pass, which calculates the fastest occurrence of events and the quickest start and completion of activities and the backward pass to calculate when the latest activities start and finish at the latest.

Table 5. Recapitulation of Value Calculation of ES, EF, SL, LS, and LF Missile Boat (KCR-60) Construction Project

Activity Code	Duration (Day)	ES	EF	SL	LS	LF
1	**70**	**0**	**70**	**0**	**0**	**70**
2	**104**	**8**	**112**	**0**	**8**	**112**
3	**138**	**16**	**154**	**0**	**16**	**154**
4	**138**	**46**	**192**	**0**	**46**	**192**
5	**54**	**0**	**54**	**0**	**0**	**54**
6	**142**	**40**	**186**	**0**	**40**	**186**
7	27	188	215	4	192	219
8	79	188	267	5	193	272
9	19	125	144	9	144	163
10	87	0	87	29	29	122
11	87	87	174	29	116	203
12	173	87	260	35	122	295
13	182	0	182	34	34	216
14	52	187	239	29	216	268
15	26	265	291	4	269	295
16	**173**	**0**	**173**	**0**	**0**	**173**
17	173	22	195	1	23	196
18	**173**	**49**	**222**	**0**	**49**	**222**
19	179	72	251	4	76	255

Activity Code	Duration (Day)	ES	EF	SL	LS	LF
20	173	95	268	2	97	270
21	**173**	**120**	**293**	**0**	**120**	**293**
22	10	291	301	4	295	305
23	**9**	**298**	**307**	**0**	**298**	**307**
24	5	306	311	1	307	312
25	5	311	316	1	312	317
26	**32**	**321**	**352**	**0**	**320**	**352**
27	**15**	**346**	**361**	**0**	**346**	**361**
28	**0**	**363**	**363**	**0**	**363**	**363**

Based on Table 5, the critical path from the PDM calculation was obtained. The critical path is the path through which critical work passes, ie the work that has the earliest start time equals the last start time (ES = LS) and the earliest completion time is the latest finish time (EF = LF). The critical path on PDM can be seen in the following figure:

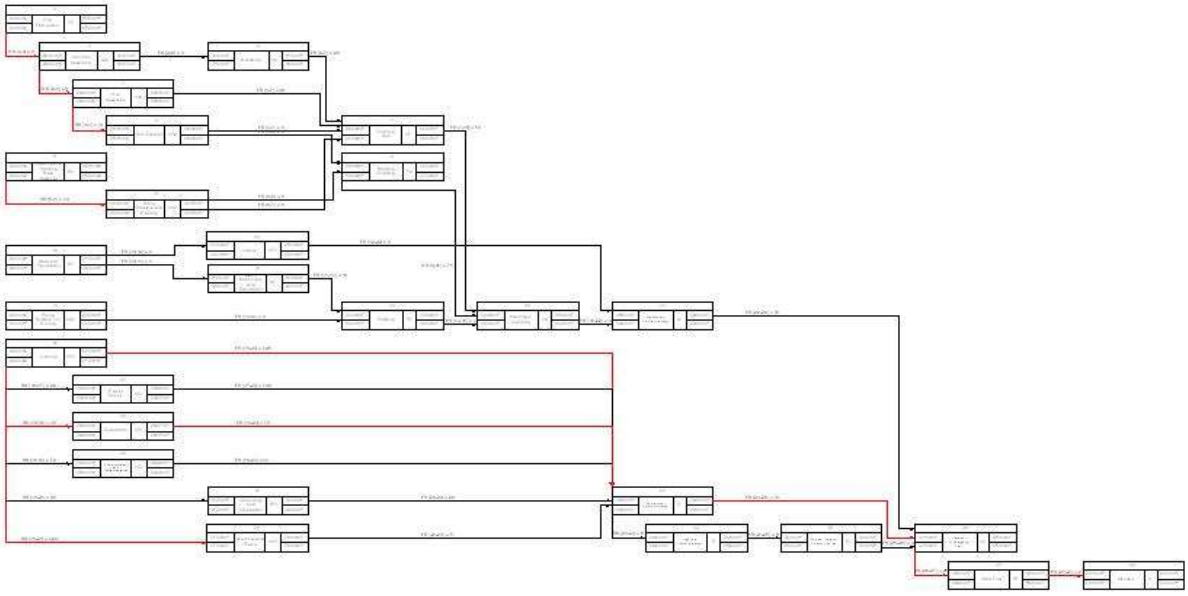

Fig. 11 PDM critical lane on Missile Boat (KCR-60) Construction Project

Project Scheduling With Microsoft Project

Microsoft Project is a computer program that assists in the preparation of planning and monitoring the schedule of a project, in which there is a detailed calculation of the project schedule for activities and recording, monitoring the use of resources, both in the form of human resources, equipment, and material.

The following are the results of project scheduling analysis using Microsoft Project 2010 software in the form of a network diagram and Gantt Chart as listed in the following picture:

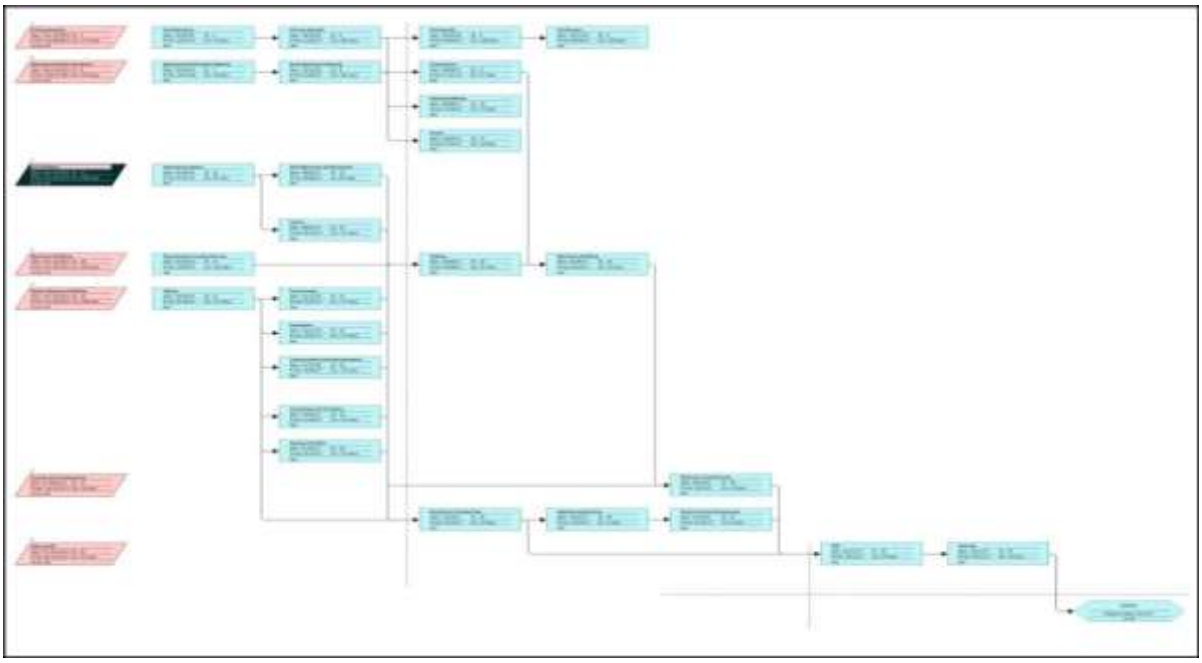

Fig.12 Network Diagram Output MS. Projection Construction Project of (KCR-60)

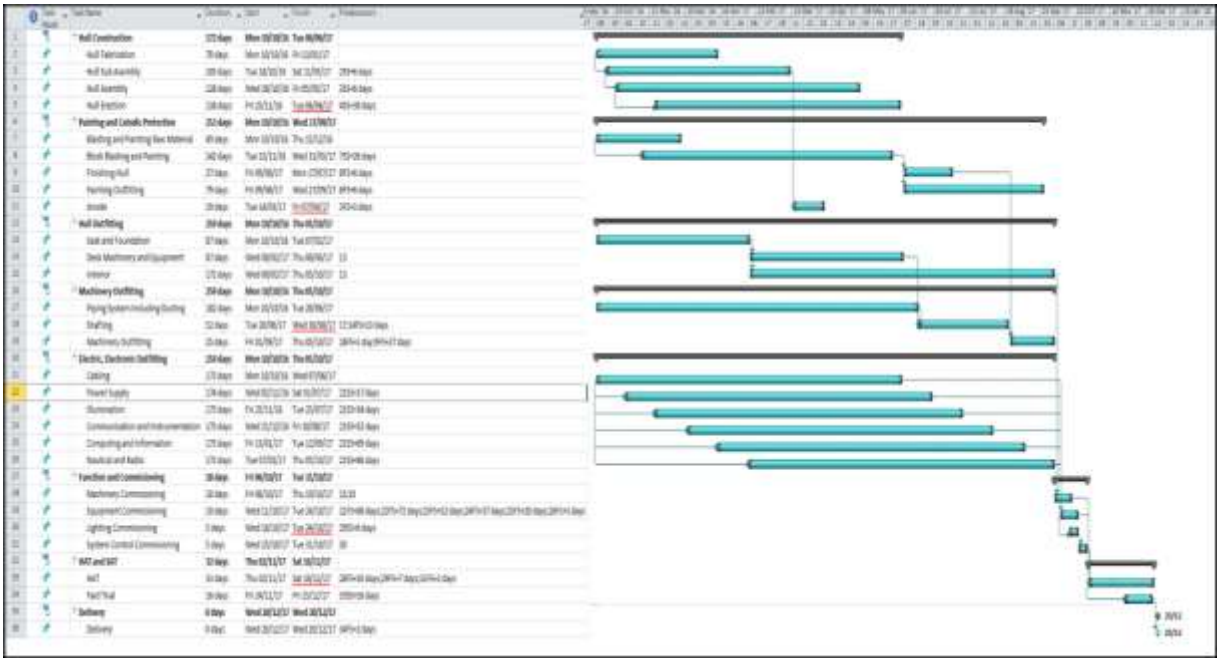

Fig. 13 Gantt Chart Output MS Projection Construction Project of (KCR-60)

Calculation Earned Value Method (EVM)

Calculation of Earned Value Method (EVM) on this project resulted in the value of the Budget Cost Work Schedule (BCWS), Budget CostWork Performed (BCWP), Actual Cost Work Performed (ACWP), Cost Variance Analysis and Schedule Variance, along with Productivity and Performance Indexes.

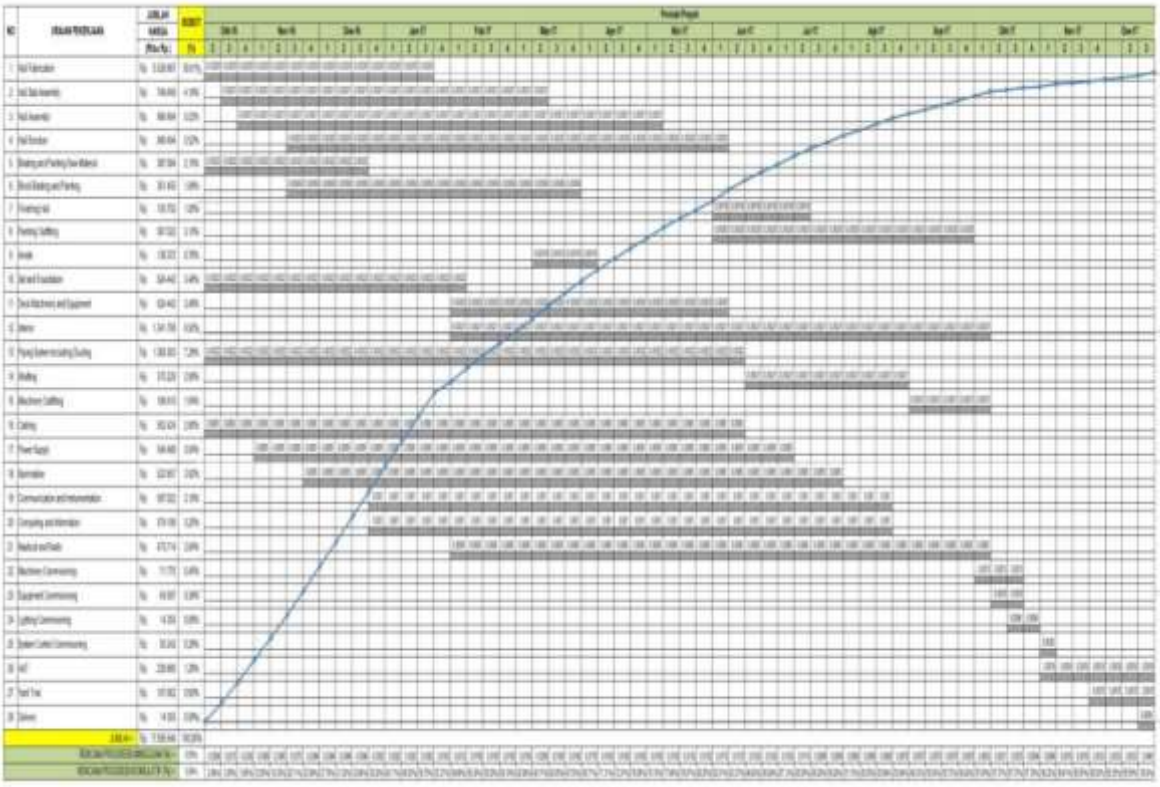

Fig. 14 S-Curve

The result of the S-curve drawing shows that the completion of the project was completed on the 363rd day. Because this project is already underway, a project reporting period is created, where at the end of the period the work progress is submitted to the Contractor as presented in the following table:

Table 6. Project Planning Period Date

Period	Day	Date Period	Plan Weight
1	16	10 Oct 16 – 31 Oct 16	9,45%
2	38	1 Nov 16 – 30 Nov 16	14,50%
3	60	1 Dec 16 – 31 Dec 16	15,34%
4	82	1 Jan 16 – 31 Jan 17	13,09%
5	102	1 Feb 17 – 28 Feb 17	7,81%
6	125	1 Mar 17 – 31 Mar 17	7,75%
7	145	1 Apr 17 – 30 Apr 17	6,58%
8	168	1 May 17 – 31 May 17	5,75%
9	190	1 Jun 17 – 30 Jun 17	5,62%
10	223	1 Jul 17 – 31 Jul 17	4,38%
11	244	1 August 17 – 31 Agust 17	3,38%
12	262	1 Sep 17 – 30 Sep 17	2,78%
13	301	1 Oct 17 – 31 Oct 17	1,34%
14	342	1 Nov 14 – 31 Nov 17	1,16%
15	363	1 Dec 17 – 20 Dec 17	1,08%

Table 7. BCWS Recapitulation

Period	Plan Weight		BCWS	BCWS Cumulative
1	9,45%	Rp	1.694.815.426	Rp 1.694.815.426
2	14,50%	Rp	2.599.969.130	Rp 4.294.784.556

Period	Plan Weight	BCWS	BCWS Cumulative
3	15,34%	Rp 2.751.371.109	Rp 7.046.155.666
4	13,09%	Rp 2.347.323.316	Rp 9.393.478.981
5	7,81%	Rp 1.400.811.892	Rp10.794.290.874
6	7,75%	Rp 1.389.417.628	Rp12.183.708.501
7	6,58%	Rp 1.179.595.688	Rp13.363.304.189
8	5,75%	Rp 1.031.214.898	Rp14.394.519.087
9	5,62%	Rp 1.008.844.859	Rp15.403.363.946
10	4,38%	Rp 786.266.776	Rp16.189.630.722
11	3,38%	Rp 605.966.339	Rp16.795.597.061
12	2,78%	Rp 498.976.888	Rp17.294.573.948
13	1,34%	Rp 240.032.645	Rp17.534.606.594
14	1,16%	Rp 208.403.531	Rp17.743.010.125
15	1,08%	Rp 193.535.875	Rp17.936.546.000

Table 8. BCWP Recapitulation

Period	Realization	Cumulative Realization	BCWP	BCWP Cumulative
1	7,98%	7,98%	Rp 1.432.119.035	Rp 1.432.119.035
2	12,86%	20,84%	Rp 2.306.172.618	Rp 3.738.291.653
3	13,15%	33,99%	Rp 2.357.925.041	Rp 6.096.216.694
4	11,80%	45,79%	Rp 2.117.285.631	Rp 8.213.502.325
5	7,02%	52,81%	Rp 1.259.329.891	Rp 9.472.832.216
6	6,11%	58,92%	Rp 1.096.250.508	Rp 10.569.082.725
7	5,84%	64,76%	Rp 1.047.480.971	Rp 11.616.563.695
8	4,39%	69,16%	Rp 787.848.182	Rp 12.404.411.877
9	4,46%	73,62%	Rp 800.013.973	Rp 13.204.425.850
10	3,20%	76,82%	Rp 574.761.013	Rp 13.779.186.863
11	2,93%	79,75%	Rp 525.372.816	Rp 14.304.559.679
12	2,54%	82,29%	Rp 456.064.875	Rp 14.760.624.555
13	1,25%	83,55%	Rp 224.670.556	Rp 14.985.295.111
14	1,02%	84,57%	Rp 183.186.704	Rp 15.168.481.815
15	0,79%	85,36%	Rp 141.861.796	Rp 15.310.343.611
16	7,40%	92,76%	Rp 1.327.304.404	Rp 16.637.648.015
17	3,10%	95,86%	Rp 556.032.926	Rp 17.193.680.941
18	4,14%	100,00%	Rp 742.573.004	Rp 17.936.546.000

Table 9. ACWP Recapitulation

Period	ACWP	ACWP Cumulative
1	Rp1.575.330.939	Rp 1.575.330.939
2	Rp2.582.913.332	Rp 4.158.244.271
3	Rp2.711.613.797	Rp 6.869.858.068
4	Rp2.413.705.619	Rp 9.283.563.687
5	Rp1.410.449.478	Rp10.694.013.165
6	Rp1.326.463.115	Rp12.020.476.280
7	Rp1.152.229.068	Rp13.172.705.348
8	Rp 882.389.964	Rp14.055.095.312
9	Rp 904.015.789	Rp14.959.111.101
10	Rp 678.217.996	Rp15.637.329.097
11	Rp 619.939.923	Rp16.257.269.020

12	Rp 533.595.904	Rp16.790.864.924
13	Rp 251.631.023	Rp17.042.495.947
14	Rp 214.328.444	Rp17.256.824.391
15	Rp 158.885.212	Rp17.415.709.602
16	Rp1.499.853.977	Rp18.915.563.579
17	Rp 644.998.194	Rp19.560.561.773
18	Rp 846.533.225	Rp20.407.094.998

Table 10. Calculation of Cost Varians dan Schedule Varians

Period	Cost Variant	Schedule Variant
1	-Rp143.211.904	-Rp 262.696.391
2	-Rp276.740.714	-Rp 293.796.512
3	-Rp353.688.756	-Rp 393.446.069
4	-Rp296.419.988	-Rp 230.037.685
5	-Rp151.119.587	-Rp 141.482.001
6	-Rp230.212.607	-Rp 293.167.119
7	-Rp104.748.097	-Rp 132.114.717
8	-Rp 94.541.782	-Rp 243.366.716
9	-Rp104.001.816	-Rp 208.830.886
10	-Rp103.456.982	-Rp 211.505.763
11	-Rp 94.567.107	-Rp 80.593.523
12	-Rp 77.531.029	-Rp 42.912.012
13	-Rp 26.960.467	-Rp 15.362.089
14	-Rp 31.141.740	-Rp 25.216.827
15	-Rp 17.023.416	-Rp 51.674.079
16	-Rp172.549.573	
17	-Rp 88.965.268	
18	-Rp103.960.221	

Table 11. Value of Project Performance in CPI and SPI

Period	CPI	SPI	Information
1	0,91	0,85	Cost overrun & Schedule overrun
2	0,90	0,87	Cost overrun & Schedule overrun
3	0,89	0,87	Cost overrun & Schedule overrun
4	0,88	0,87	Cost overrun & Schedule overrun
5	0,89	0,88	Cost overrun & Schedule overrun
6	0,88	0,87	Cost overrun & Schedule overrun
7	0,88	0,87	Cost overrun & Schedule overrun
8	0,88	0,86	Cost overrun & Schedule overrun
9	0,88	0,86	Cost overrun & Schedule overrun
10	0,88	0,85	Cost overrun & Schedule overrun
11	0,88	0,85	Cost overrun & Schedule overrun
12	0,88	0,85	Cost overrun & Schedule overrun
13	0,88	0,85	Cost overrun & Schedule overrun
14	0,88	0,85	Cost overrun & Schedule overrun
15	0,88	0,85	Cost overrun & Schedule overrun
16	0,88	0,93	Cost overrun & Schedule overrun
17	0,88	0,96	Cost overrun & Schedule overrun
18	0,88	1,00	Cost overrun & Schedule overrun

Acceleration of Project Completion Time (Crashing Project)

Based on the PDM calculation, the addition of work time or overtime applies to all work activities, especially in activities that have a critical path, namely activities 1, 2, 3, 4, 5, 6, 16, 18, 21, 23, 26, 27, 28. Based on the regulation of the Minister of Labor Number KEP.102/ MEN /VI/2004 contained in article 11, That working hours in a day have 8 normal working hours, namely 08.00-12.00 WIB, 13.00-17.00 WIB and 1 hour break. If daily overtime work is held for a maximum of 3 hours, starting from 17.00-20.00 WIB, overtime wages are calculated every working day according to the occupation position of each worker. The following tabulation of the calculation of the duration after 1 hour overtime is carried out for all activities.

Table 12. Calculation of Work After OvertimeDuration

Activity	Plan Duration	Implementation Duration	Duration of 1 hour overtime
Hull Fabrication	70	75	67
Hull Sub Assembly	104	113	102
Hull Assembly	138	153	138
Hull Erection	138	153	137
Blasting and Painting Raw Material	54	57	51
Block Blasting and Painting	54	59	53
Finishing Hull	142	145	131
Painting Outfitting	27	28	25
Anode	19	20	18
Seat and Foundation	87	93	84
Deck Machinery and Equipment	87	92	83
Interior	173	186	167
Piping System Including Ducting	182	204	182
Shafting	52	53	48
Machinery Outfitting	26	27	24
Cabling	173	194	173
Power Supply	173	194	173
Illumination	173	194	173
Communication and Instrumentation	179	198	178
Computing and Information	173	188	169
Nautical and Radio	173	186	167
Machinery Commisioning	10	10	-
Equipment Commisioning	9	9	-
Lighting commisioning	5	5	-
System Control Commisioning	5	5	-
Harbors Acceptance Test	32	32	-
Yard Trial	15	15	-
Delivery to Customer	0	0	-

Table 13. Daily Overtime Wages

No.	Type of Worker	Hour	Overtime Wages of 1 hour	Overtime wages of 2 hours etc
1	Head of Fabrication	Rp 28.038	Rp 42.057	Rp 56.076
2	Group Leader	Rp 24.230	Rp 36.346	Rp 48.452
3	Technician	Rp 20.200	Rp 30.300	Rp 43.400
4	Workman	Rp 17.064	Rp 25.596	Rp 34.128

Table 14. Calculation of Overtime Labor Costs

Activity	Overtime Hour	The amount of Labor				Overtime Wages
		Head of Fabrication	Group Leader	Technician	Workman	
Hull Fabrication	70	1	1	3	5	Rp 20.809.810
Hull Sub Assembly	104	0	0	0	5	Rp 13.309.920
Hull Assembly	138	0	0	3	5	Rp 30.205.440
Hull Erection	138	0	0	3	6	Rp 33.737.688
Blasting and Painting Raw Material	54	1	1	1	4	Rp 11.398.698
Block Blasting and Painting	54	0	0	1	3	Rp 5.782.752
Finishing Hull	142	0	0	2	6	Rp 30.412.992
Painting Outfitting	27	0	0	1	6	Rp 4.964.652
Anode	19	0	0	1	5	Rp 3.007.320
Seat and Foundation	87	1	1	2	5	Rp 23.227.521
Deck Machinery and Equipment	87	0	0	2	6	Rp 18.633.312
Interior	173	0	0	2	8	Rp 45.908.664
Piping System Including Ducting	182	1	1	1	7	Rp 52.393.250
Shafting	52	0	0	2	4	Rp 8.475.168
Machinery Outfitting	26	0	0	1	5	Rp 4.115.280
Cabling	173	1	1	2	4	Rp 41.759.951
Power Supply	173	0	0	2	4	Rp 28.196.232
Illumination	173	0	0	1	4	Rp 22.954.332
Communication and Instrumentation	179	0	0	1	4	Rp 23.750.436
Computing and Information	173	0	0	1	4	Rp 22.954.332
Nautical and Radio	173	0	0	2	4	Rp 28.196.232
		Total				**Rp 474.193.982**

4. CONCLUSION.

Based on the calculations, it was found that activity 1, 2, 3, 4, 5, 6, 16, 18, 21, 23, 26, 27, 28 are critical paths. With the Crashing Project which was originally 414 days from the end of the real work job to 363 days, resulted in 51 days of effectiveness. Meanwhile for cost efficiency, based on the analysis of the real cost of project implementation, Rp. 20.407,094,998, - became Rp. 18,410,738,982, so there are of Rp. 2,470,548,998, - of efficiency. Thus, control and supervision of the contractor are required in every activity in carrying out the activities of the Missile Boat (KCR-60) construction project so that it does not experience delays and the project can be completed on time.

Table 15. Simulation of Project Time and Costs (KCR-60)

	Contract	PDM-EVM-Crash Project	Real Implementation
Time	363 day	363 day	414 day
Cost	Rp. 17.936.546.000	Rp. 18.410.739.982	Rp. 20.407.094.998

5. ACKNOWLEDGEMENTS.

This research has been Supported by Indonesia Naval Technology College (STTAL).

6. BIBLIOGRAPHY.

Agarwal, R. (2013) 'Critical Path Method in Designing Feasible Solutions', *International Journal of Scientific Research and Reviews* , pp. 190-202.

Agyei, W. (2015) 'Project Planning And Scheduling Using PERT And CPM Techniques With Linear Programming: Case Study', *INTERNATIONAL JOURNAL OF SCIENTIFIC & TECHNOLOGY RESEARCH*, pp. 222-227.

Alecu, F. (2014) 'Cost Control and Performance Review of Software Projects by Using the Earned Value Management', *Oeconomics of Knowledge*, pp. 2-6.

Andawei, M.-E.M. (2014) 'Extension of Time Determination in Construction Projects in Nigeria: The Critical Path Method', *The International Journal Of Engineering And Science (IJES)*, pp. 48-51.

Arica Dwi Susanto, A.A.O.S.S. (2018) 'The Optimization of Multipurpose Building Development on Project Scheduling Using Precedence Diagram Method (PDM)', *ASRO JOURNAL-STTAL*, vol. 9, no. 1, pp. 1-7.

Balla, G.T. (1995) 'Critical path analysis for the management of fractured neck of femur', *AUSTRALIAN JOURNAL OF PUBLIC HEALTH*, pp. 155-159.

Czarnigowska, A. (2008) 'Earned value method as a tool for project control ', *Budownictwo i Architektura 3*, pp. 15-32.

Daniel Castro-Lacouture, A.M.A.G.A.S.J.G.-J.a.J.K.Y. (2009) 'Contruction Project Scheduling with Time, Cost and Material Restrictions Using Fuzzy Mathematical Models and Critical Path Method ', *JOURNAL OF CONSTRUCTION ENGINEERING AND MANAGEMENT*, pp. 1096-1104.

Dwaikat, L.N. (2016) 'Measuring the Actual Energy Cost Performance of Green Buildings: A Test of the Earned Value Management Approach', *Energies journal*, pp. 1-20.

Fatemeh Nouban, N.G. (2017) 'The Factors Affecting The Methods of Construction Projects Scheduling: An State of The Art and Overview', *Asian Journal of Natural & Applied Sciences*, vol. 6, no. 4, pp. 114-122.

K.K.Khandelwal, D.B. (2002) *PROJECT PLANNING AND CONTROL WITH PERT AND CPM*, New Delhi: LAXMI PUBLICATIONS (P) LTD.

Kim, S.-G. (2012) 'CPM Schedule Summarizing Function of the Beeline Diagram Method', *Journal of Asian Architecture and Building Engineering* , pp. 367-374.

M, S. (2015) 'Traditional Critical Path Method versus Critical Chain Project Management: A Comparative View', *International Journal of Economics & Management Sciences* , pp. 1-6.

Mazlum, M. (2015) 'CPM, PERT and Project Management With Fuzzy Logic Technique and Implementation On A Business', 4th International Conference on Leadership, Technology, Innovation and Business Management, Istanbul, 348-357.

Nafkha, R. (2016) 'THE CRITICAL PATH METHOD IN ESTIMATING PROJECT DURATION', *Information Systems in Management*, pp. 78-87.

R.Lin, H.J. (2009) 'A fuzzy pert approach to evaluate plant construction project scheduling risk under uncertain resources capacity', *Journal of Industrial Engineering and Management* , pp. 31-47.

Shailla (2014) 'Comparative Study of Management Operation System Techniques (MOST) and CPM in Construction Scheduling', *International Journal of Engineering Trends and Technology (IJETT)*, pp. 371-379.

Shan, Y. (2014) 'Integration of Building Information Modeling and Critical Path Method Schedules to Simulate the Impact of Temperature and Humidity at the Project Level', *buildings jounal*, pp. 295-319.

Silvianita, R.F.D.M.R.S.a.D.M.C. (2018) 'Fast Missile Boat Project Planning using CPM and What If Analysis Method', IOP Conf. Series: Earth and Environmental Science, jakarta, 1-6.

Wilson, B. (2013) 'Earned Value Management Systems: Challenges and Future Direction', *Journal of Integrated Enterprise Systems*, pp. 9-17.

Wong, Y. (1964) 'Critical Path Analysis for New Product Planning', *Journal of Marketing*, pp. 53-59.

Y. Arslan, H.B.M.E. (2017) 'Planning and Monitoring of industrial punch development processes ', *Journal of Engineering Research and Applied Science*, pp. 615-622.