



Analysis Of Fbb Block (Fore Bulbous Bow) Scheduling Using The PDM Method

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Abstract

A shipyard is a special place equipped with facilities to support the process of building, repairing and maintaining ships. Scheduling is an important part of a new ship building project, apart from prioritizing a minimum budget and maximizing project quality. Careful project scheduling planning will support the achievement of production targets, both in quantity and quality. In determining scheduling there are several influencing factors, such as: number of workers, level of work difficulty, production facilities, and material availability. In this research, the PDM (Precedence Diagramming Method) method was used. A method that can be done without waiting for the previous activity to complete is by overlapping. This way you can speed up the project completion time. Therefore, work scheduling must be prepared using effective and efficient methods. In determining scheduling, there are several influencing factors, such as the number of workers, level of work difficulty, production facilities, and material availability. This research aims to optimize processing time planning for ship X's FBB block (rescheduling) based on various delay factors to obtain the fastest processing time for the production process. The results of accelerating critical activities using the PDM method with the alternative of additional labor are considered more efficient, where the actual duration can be accelerated by 35.6%.

Keyword: bulbous bow, scheduling, PDM.

1. INTRODUCTION

Indonesia is a maritime country. The vastness of Indonesia's maritime territory makes Indonesia a country that has great potential in the maritime sector. With such a large water area, of course there must be supporting facilities so that people can explore Indonesia's sea areas which are rich in various marine resources. From this, a transportation service was created in the form of a ship which became supporting transportation for the community to carry out activities via sea routes. Along with technological developments, the ship production process is also required to be more efficient in terms of costs and time spent [1]. In the shipbuilding process, the hull construction stage is the most crucial stage. At this stage, the ship blocks will be assembled and put together into one complete part [2]. Careful project scheduling planning will support the achievement of production targets, both in terms of quantity and quality. Scheduling is an important part of a ship building project, apart from prioritizing a minimum budget and maximizing project quality. Scheduling must be considered in project management in order to determine the most effective duration or time for project continuity. Therefore, work scheduling must be prepared using an effective and efficient method. The use of application programs such as Primavera, Microsoft Excel, and Microsoft Project can be a project management advantage that can increase the efficiency of time use [3]. In determining scheduling there are several influencing factors, such as: number of workers, level of work difficulty, production facilities, and material availability. In this research, the PDM (Precedence Diagramming Method) method was used. A method that can be done without waiting for the previous activity to complete is by overlapping. This way you can speed up the project completion time [4]. Apart from that, the author also uses the PDM method with the aim of being able to use it when carrying out analyzes related to the productivity of workers involved in the construction of the ship project block X which will then be accelerated. Previous researchers who analyzed project productivity using the PERT method on different types of ships and work volumes, from a total of 39 activities there were 101 problems which were divided into 7 factors. And the biggest factors in this project



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problem are other factors at 38%, material factors 25%, managerial factors 25%, equipment factors 15%, labor factors 2%, while cost and location factors are 0 [4]. In other research, the author chose the Precedence Diagram Method (PDM) not only to clarify the tasks but also to improve project management efficiency and effectiveness to achieve optimal results. According to [5], the advantage of the Precedence Diagram Method (PDM) is that it does not require dummy or additional activities, simplifies the project network creation, and the interdependence between activities can be arranged without adding new tasks. The accelerated tasks include mobility work, reduced from 7 days to 2 days, and demobilization, reduced from 7 days to 1 day. The occupational safety and health management system (K3) is reduced from 7 days to 2 days, and utility tasks (PDAM, PLN, Telkom) are reduced from 7 days to 2 days. The initial project scheduling indicates a duration of 210 days, but with optimization, the project is completed in 196 days, resulting in a time savings of 13 days. The research provides insights into the effectiveness of the PDM method in addressing critical challenges in construction projects, with implementation leading to more efficient planning and timely project completion. In this research, the PDM method is also intended to be used when carrying out analyzes related to the productivity of workers involved in construction work on ship project block X, which will then be accelerated. This research will focus on analysis of the scheduling of the FBB block for Ship X, starting from the fabrication to assembly process stages. With the aim of getting a comparison between planning and actual and factors causing delays and factors inhibiting the production process.

2. METHODS

This chapter explains the flow of scheduling analysis research on the FBB block starting from the problem identification process to drawing conclusions. For this reason, the author created a flowchart or research flow diagram in Figure 1 below so that the research flow can be understood.

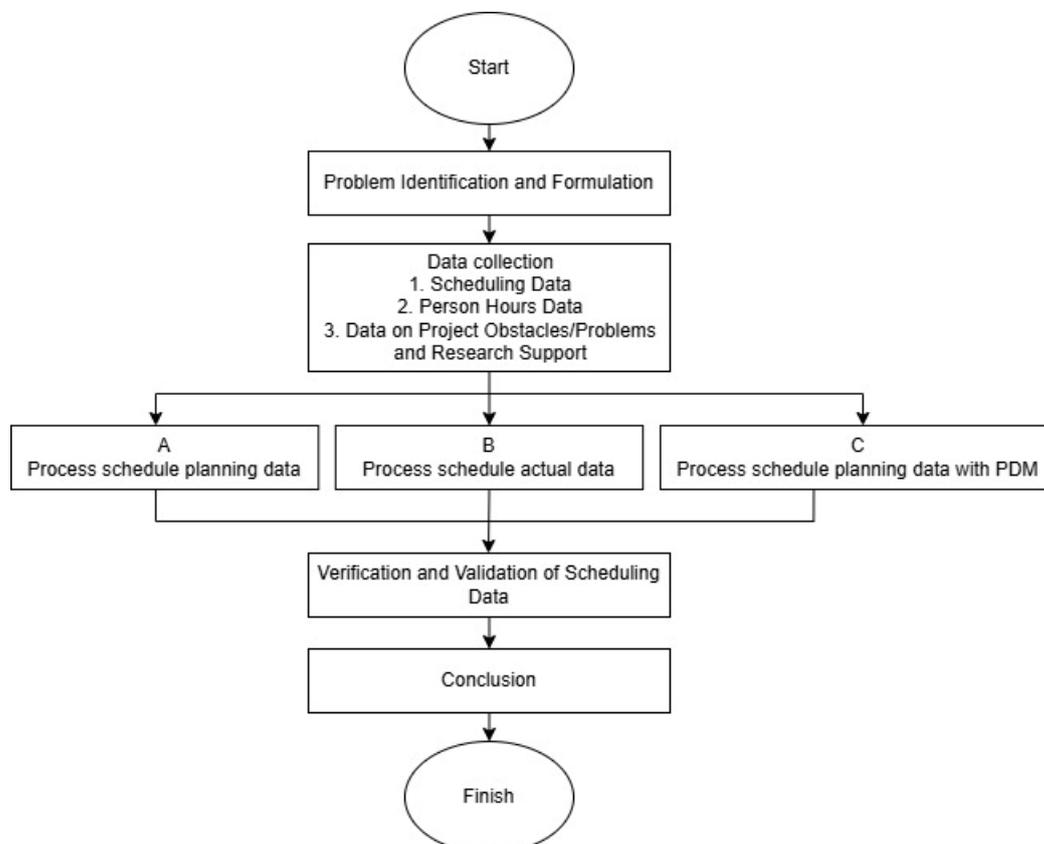


Figure 1. Research Flowchart

The following is an explanation of the flow diagram above:

- Identification and formulation of problems, determining the problems to be discussed in research after identifying them in the field.



- The field study includes scheduling activities and production processes for the construction of the FBB block of ship X which is carried out in the Hull construction department.
- Literature study, collecting and compiling a theoretical basis related to the research title.
- Data collection, research data collection stage such as scheduling data, person hours and problems in the production process.
- After the data has been collected, the next stage is processing the data according to its classification in the form of initial planning, planning with PDM, and actual data in the field.
- After the data processing analysis is correct, the next step is to draw conclusions from the research.
- Conclusion, the conclusion section will briefly explain the results of the research that has been carried out.

According to [6], modern ship building systems are divided into three types. The following is an explanation of the three systems, namely the sectional system, block system and modular system. Currently, the development of the shipping industry, especially in Indonesia, is growing very rapidly. One of the factors influencing the development of the shipping engineering and manufacturing industry is the existence of a government program that will make Indonesia a world maritime axis country by 2045. This has greatly influenced the development of shipping engineering and manufacturing technology. Apart from that, another factor that influences the development of the shipping industry is the development of the Industrial Revolution 4.0 and the increasing number of global shipping and trade flows passing through Indonesia. Based on this, it is necessary to develop Shipping Engineering and Manufacturing Technology.

2.1 Research Object

In the process of building ship X there is one main process that makes the shape of the ship visually visible, namely the block building process. This process is an effort to combine and form the body of a ship which has been divided into each block which is ready to use and equipped with a piping system (block division). In the process of building ship X there are a total of 161 blocks divided into 6 modules. The 6 modules are as follows:

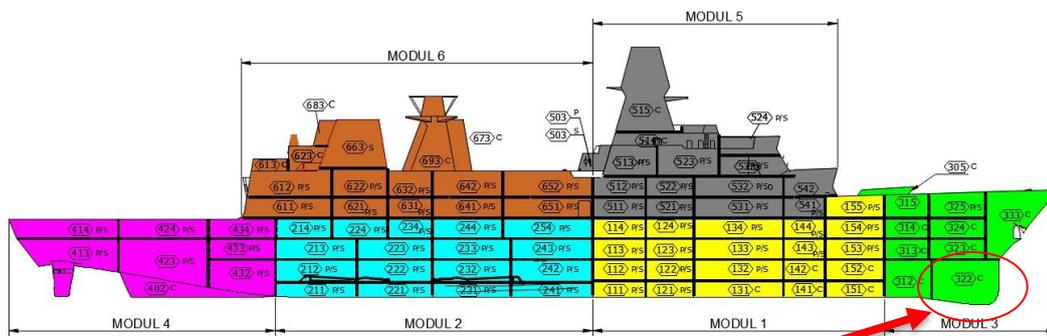


Figure 2. Research Block Location

- Module 1
The blocks in module 1 are the blocks that will become the ship's cargo hold, with a total of 37 blocks in this zone.
- Module 2
The blocks in module 2 are the blocks that will become the ship's engine room, which will function as an area for placing the engines on board the ship, including the main engine, auxiliary engine and other engines. In module 2 it consists of 38 blocks.
- Module 3
The blocks in module 3 are blocks that will be the bow area of the ship, which will function as an area for placing the ship's mooring system and several supporting rooms. In module 3 it consists of 12 blocks.
- Module 4
The block in module 4 is the block area which will be the stern or rear of the ship, which will function as an area for the propulsion system in particular. In module 4 there are 17 blocks.
- Module 5
The blocks in module 5 are block areas that will be part of the navigation system in particular, and include the boat deck, poop deck, bridge deck and navigation deck. In module 5 there are 28 blocks.
- Module 6



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The blocks in module 6 are a block area that is almost similar to module 5 which will be part of the boat deck, poop deck and bridge deck. In module 6 there are 29 blocks.

2.2 Causes of Project Delays

Management's active role is one of the main keys to successful project management. A review of the project schedule is needed to determine fundamental change steps so that delays in project completion can be avoided or reduced [2]. The factors causing project delays can be very diverse and can differ from one project to another according to the conditions faced. Potential factors that can cause delays in project implementation time consist of seven (7) categories [4], namely:

- Labor factors
- Material factors (material)
- Equipment factor
- Site Characteristic Factors.
- Managerial Factors (Managerial)
- Cost Factors (Finance)
- Other factors (Other Factors)

2.3 Work Productivity

Productivity is a comparison between output and input, or a comparison between product output and the total resources used. Productivity can be interpreted as a comparison between work results and hours worked. Productivity depends on 2 main factors, namely labor factors and length of working time. [4].

$$\text{PHN} = \text{work volume} / \text{duration} \quad (1)$$

The formula above is a productivity formula (PHN) where the volume of work comes from the amount of work done by workers, both in units of weight and length. For the productivity formula that is calculated to determine the results of work that is accelerated by adding working hours or Productivity by adding working hours (PPJK), you can use the following formula:

$$\begin{aligned} \text{PNJ} &= \text{PHN} / \text{working time} & (2) \\ \text{PPJK} &= \text{PHN} + (\text{PNJ} \times \text{EP} \times \text{PJL}) & (3) \end{aligned}$$

Where, PNJ is Normal Hourly Productivity, PHN is Normal Daily Productivity, PPJK is Additional Working Hours Productivity, EP is Production Efficiency (0.6), PJL is Additional Overtime Hours (4 hours)

2.4 Crash Cost

Crash Cost is the cost incurred to complete a project after the acceleration process is carried out. The crash cost calculation is due to additional working hours (overtime) and also additional labor (man power). Based on interviews with the company, the maximum crash cost value generated cannot exceed 5% of the actual total work costs. This is intended so that the additional costs are not too large even though the work duration is faster. In calculating crash costs for additional labor, an initial value is needed which is related to the initial number of labor and initial costs before the addition. For this reason, the formula used to calculate the crash cost of an additional workforce (CCTK) is as follows:

$$\text{CCTK} = \text{NCPH} \times \text{JTK} \times \text{CD} \quad (4)$$

Where NCPH is Normal cost per day, JTK is the number of workers, and CD is Crash duration (duration of acceleration results). Crash cost is to calculate additional work hours. This calculation requires initial values relating to the duration of overtime, number of workers and initial costs before additional working hours. So, to calculate the crash cost of additional working hours there must be a normal cost and overtime cost value. The formula used to calculate the crash cost of additional working hours (CCJL) and where CL is the cost of overtime. The formula is as follows:

$$\text{CCJL} = (\text{NCPH} + \text{CL}) \times \text{JTK} \times \text{CD} \quad (5)$$



2.5 Precedence Diagram Method (PDM)

The precedence diagram method is a network that includes the AON (Activity On Node) classification, where an activity is written in a node which is generally rectangular in shape, while the arrows only indicate relationships between other activities [6]. One of the main advantages of the PDM method is its flexibility in planning and managing projects. This method allows project planners to visualize each task in the form of a diagram consisting of a series of nodes connected by arrows, making it easy for the entire project team to understand. However, the PDM method also has several disadvantages. It takes significant time and effort to develop and maintain accurate and up-to-date diagrams. Additionally, the PDM method also requires strong technical skills in project planning and control, and may not be suitable for small or simple projects. Some attributes that are often included are activity period (D), activity identity (number and name), activity start and end (ES, LS, EF, LF, etc.). The PDM activity symbol can be seen in Figure 3 below.

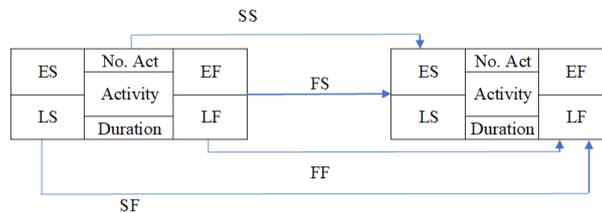


Figure 3. PDM Diagram

Boundaries show relationships between activities with lines from the previous node to the next node. One constraint can only connect two nodes. Because each node has two ends, namely the initial end or start = (S) and the final end or end = (F), there are 4 types of boundaries, namely start to start (SS), start to end (SF), end to end (FF) and end to start (FS). On the boundary line, an explanation is given regarding lead time or lag time [7].

Constrain	Forward	Reverse
Start to Start (SS)	$ES_j = ES_i + SS_{ij}$	$LS_i = LS_j - SS_{ij}$
	$EF_j = EF_i + D_j$	$LF_i = LS_i + D_i$
Start to Finish (SF)	$EF_j = ES_i + SF_{ij}$	$LS_i = LF_j - SF_{ij}$
	$ES_i = EF_j - D_j$	$LF_i = LS_i + D_i$
Finish to Start (FS)	$ES_j = EF_i + FS_{ij}$	$LF_j = LS_i - FS_{ij}$
	$EF_j = ES_j + D_j$	$LS_i = LF_i - D_i$
Finish to Finish (FF)	$EF_j = EF_i + FF_{ij}$	$LF_i = LF_j - FF_{ij}$
	$ES_j = EF_j - D_j$	$LS_i = LF_i - D_i$

Figure 4. Constraints of PDM

To determine critical activities and then determine the critical path, forward calculations (Forward Analysis) and backward calculations (Backward Analysis) can be carried out. Forward calculations (Forward Analysis) are carried out to obtain the Earliest Start (ES) and Earliest Finish (EF), namely the predecessor activity is activity I, while the activity being analyzed is activity J. The relationship between activities I and J can be seen in Figure 5 below.



Figure 5. Relationship between Activities i and j

The ES_j and EF_j values are calculated by $ES_j = ES_i + SS_{ij}$ or $ES_j = EF_i + FS_{ij}$ $EF_j = ES_i + SF_{ij}$ or $EF_j = EF_i + FF_{ij}$ or $ES_j + D_j$. Backward analysis is carried out to obtain the Latest Start (LS) and Latest Finish (LF)



values. The activity that is the successor is activity J, while the activity being analyzed is I. The values of LS_j and LF_j are calculated by $LF_i = LF_j - F_{fij}$ or $LF_i = LS_j - FS_{ij}$ $LS_i = LS_i - S_{sij}$ or $LS_j = LF_j - S_{fij}$ or $LF_i =$ The critical path is marked by several conditions such as Earliest Start (ES) = Latest Start (LS), Earliest Finish (EF) = Latest Finish (LF), Latest Finish (LF) – Earliest Start (ES) = Activity Duration.

3. RESULT AND DISCUSSION

The main data that the author obtained from the field is scheduling data and working hours data. From this main data, the author obtained data in the form of master schedule data for planning and actual work in the FBB-C block, and working hours (JO) data. To calculate labor costs, JO data is used with a JO rate of Rp. 85,000. (Source: Primary research data). The following are planning and actual data for the JO FBB-C block shown in Table 1 below.

Table 1. Planning and actual working hours

Planning (JO)					
Block	Weight (Kg)	Fabrication	Sub Assembly	Assembly	JO
	25982.677	296	173	703	1172
Actually (JO)					
Block	Weight (Kg)	Fabrication	Sub Assembly	Assembly	JO
	25982.677	978	215	1509	2702

In the scheduling data in the form of a master schedule, information on the start date of work planning is displayed in blocks starting from the fabrication, sub-assembly and assembly stages. As well as data based on actual field work carried out at the fabrication, sub-assembly and assembly stages. In Table 2 is the planning and actual data for scheduling the FBB-C block.

Table 2. Actual and planning scheduling

Planning			
Workshop	Start	Finish	Duration (day)
Fabrication	Tue 01/10/24	Mon 16/12/24	55
Sub Assembly	Mon 11/11/24	Mon 11/11/24	50
Assembly	Thu 16/01/25	Thu 16/01/25	55
Total			160
Actual			
Workshop	Start	Finish	Duration (day)
Fabrication	Tue 01/10/24	Tue 01/10/24	55
Sub Assembly	Mon 16/12/24	Mon 16/12/24	50
Assembly	Mon 11/11/24	Mon 11/11/24	64
Total			169

During the construction of the FBB-C block of ship X, several obstacles occurred which resulted in delays in completing the project being worked on. Based on the results of interviews with the company, the author has summarized and analyzed the factors that caused work problems in the FBB-C block construction project as in Table 3 below.

Table 3. Percentage of factors causing delays

Problem	Amount	Total (%)
Labor	9/57 x 100%	15,78%
Material	15/57 x 100%	26,31%



Problem	Amount	Total (%)
Tools	13/57 x 100%	22,80%
Locaiton	5/57 x 100%	8,77%
Managerial	4/57 x 100%	7,01%
Expense	0/57 x 100%	0%
Drawing revision	11/57 x 100%	19%

The results of the research process and data collection from the company show that the cost per internal JO on this project is IDR. 85,000 (Source: Main Research Data). Next, the JO price will be used to calculate the total cost of the job. Table 4 below provides details of JO data management for planning and actual.

Table 4. Number of planned and actual JO details

Planning				
	Working Item	JO	Expense	Amount (%)
	Fabrication			
1	M/C CNC plat	27	Rp. 2.295.000	2,3
2	M/C manual plat	59	Rp. 5.015.000	5,1
3	Cutting manual profil	59	Rp. 5.015.000	5,1
4	Grinding	71	Rp. 6.035.000	6,1
5	Bending	74	Rp. 6.290.000	6,3
6	Transportation	6	Rp. 510.000	0,5
	Amount of JO	296	Rp. 25.160.000	25,4
	Sub Assembly			
7	Sub assembly fitting	34	Rp. 2.890.000	2,9
8	Sub assembly welding	34	Rp. 2.890.000	2,9
9	Sub assembly grinding	41	Rp. 3.485.000	3,5
10	Sub assembly fairing	61	Rp. 5.185.000	5,2
11	Transportation	3	Rp. 255.000	0,3
	Amount of JO	173	Rp. 14.705.000	14,8
	Assembly			
12	Panel assembly fitting	89	Rp. 7.565.000	7,5
13	panel assembly welding	89	Rp. 7.565.000	7,5
14	Panel assembly grinding	77	Rp. 6.545.000	6,5
15	Block assembly fitting	115	Rp. 9.775.000	9,8
16	Block assembly welding	115	Rp. 9.775.000	9,8
17	Block assembly grinding	77	Rp. 6.545.000	6,5
18	Block assembly fairing	127	Rp. 10.795.000	11
19	Transportation	14	Rp. 1.190.000	1,2
	Amount of JO	703	Rp. 59.755.000	59,8
	Amount of All Items		Rp. 99.755.000	100
Actual				
	Working Items	JO	Expense	Amount (%)
	Fabrication			
1	M/C CNC plat	88	Rp. 7.480.000	3,2
2	M/C manual plat	196	Rp. 16.660.000	7,2
3	Cutting manual profil	196	Rp. 16.660.000	7,2
4	Grinding	234	Rp. 19.890.000	8,6
5	Bending	244	Rp. 20.740.000	9
6	Transportation	20	Rp. 1.700.000	0,7
	Amount of JO	978	Rp. 83.130.000	35,9
	Sub Assembly			
7	Sub assembly fitting	43	Rp. 3.655.000	1,5
8	Sub assembly welding	43	Rp. 3.655.000	1,5
9	Sub assembly grinding	52	Rp. 4.420.000	1,9
10	Sub assembly fairing	73	Rp. 6.205.000	2,7
11	Transportation	4	Rp. 340.000	0,1



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	Amount of JO	215	Rp. 18.275.000	7,7
	Assembly			
12	Panel assembly fitting	190	Rp. 16.150.000	7
13	panel assembly welding	190	Rp. 16.150.000	7
14	Panel assembly grinding	141	Rp. 11.985.000	5,5
15	Block assembly fitting	259	Rp. 22.015.000	9,5
16	Block assembly welding	259	Rp. 22.015.000	9,5
17	Block assembly grinding	164	Rp. 13.940.000	6
18	Block assembly fairing	283	Rp. 24.055.000	11
19	Transportation	23	Rp. 1.955.000	0,9
	Amount of JO	1509	Rp. 128.265.000	56,4
	Amount of All Items		Rp. 229.670.000	100

From the main data for scheduling the FBB-C block, this was done by looking at the sequence of design work and reinforced by the results of interviews and discussions with the company. The scheduling data results which display details of each job can be seen in the table below. This planning data processing is shown in Table 5, the duration and specific dates for each FBB-C block work which has a total work duration of 160 days with details of fabrication work having a duration of 55 days, sub assembly 50 days, and assembly 55 days.

Table 5. Planning Scheduling Details

Working Items	Duration (days)	Start	Finish
Fabrication	55	Tue 01/10/24	Mon 16/12/24
M/C CNC plat	5	Tue 01/10/24	Fri 04/10/24
M/C manual plat	11	Mon 07/10/24	Mon 21/10/24
Cutting manual profil	11	Thu 24/10/24	Thu 07/11/24
Grinding	13	Fri 08/11/24	Tue 26/11/24
Bending	14	Wed 27/11/24	Mon 16/12/24
Transportation	1	Mon 16/12/24	Mon 16/12/24
Sub Assembly	50	Mon 11/11/24	Thu 16/01/25
Sub assembly fitting	10	Mon 11/11/24	Fri 22/11/24
Sub assembly welding	10	Mon 25/11/24	Fri 06/12/24
Sub assembly grinding	12	Mon 09/12/24	Tue 24/12/24
Sub assembly fairing	17	Wed 25/12/24	Thu 16/01/25
Transportation	1	Thu 16/01/25	Thu 16/01/25
Assembly	55	Fri 29/11/24	Mon 27/01/25
Panel assembly fitting	7	Fri 29/11/24	Mon 09/12/24
panel assembly welding	7	Tue 10/12/24	Wed 18/12/24
Panel assembly grinding	6	Thu 19/12/24	Thu 26/12/24
Block assembly fitting	9	Mon 09/12/24	Thu 19/12/24
Block assembly welding	9	Fri 20/12/24	Wed 01/01/25
Block assembly grinding	6	Thu 02/01/25	Thu 09/01/25
Block assembly fairing	10	Fri 10/01/25	Thu 23/01/25
Transportation	1	Mon 27/01/25	Mon 27/01/25
Total	160		

Meanwhile, the actual implementation data processing shown in Table 6 is the specific duration and date for each FBB-C block work, which has a total work duration of 169 days, with details of fabrication work having a duration of 55 days, sub-assembly 50 days, and assembly 64 days.

Table 6. Actual scheduling details

Working Items	Duration (days)	Start	Finish
Fabrication	55	Tue 01/10/24	Mon 16/12/24
M/C CNC plat	5	Tue 01/10/24	Fri 04/10/24
M/C manual plat	11	Mon 07/10/24	Mon 21/10/24
Cutting manual profil	11	Thu 24/10/24	Thu 07/11/24



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Working Items	Duration (days)	Start	Finish
Grinding	13	Fri 08/11/24	Tue 26/11/24
Bending	14	Wed 27/11/24	Mon 16/12/24
Transportation	1	Mon 16/12/24	Mon 16/12/24
Sub Assembly	50	Mon 11/11/24	Thu 16/01/25
Sub assembly fitting	10	Mon 11/11/24	Fri 22/11/24
Sub assembly welding	10	Mon 25/11/24	Fri 06/12/24
Sub assembly grinding	12	Mon 09/12/24	Tue 24/12/24
Sub assembly fairing	17	Wed 25/12/24	Thu 16/01/25
Transportation	1	Thu 16/01/25	Thu 16/01/25
Assembly	64	Thu 28/11/24	Tue 04/02/25
Panel assembly fitting	8	Thu 28/11/24	Mon 09/12/24
panel assembly welding	8	Tue 10/12/24	Thu 19/12/24
Panel assembly grinding	6	Fri 20/12/24	Fri 27/12/24
Block assembly fitting	11	Fri 06/12/24	Fri 20/12/24
Block assembly welding	11	Mon 23/12/24	Mon 06/01/25
Block assembly grinding	7	Tue 07/01/25	Wed 15/01/25
Block assembly fairing	12	Thu 16/01/25	Fri 31/01/25
Transportation	1	Tue 04/02/25	Tue 04/02/25
Total	169		

3.1 Analyst With PDM

This method can be used to analyze project schedules that have been worked on or to plan project schedules that will be worked on. The first step to create a PDM network using Microsoft Project, we will enter the initial project data, namely the project name, start date, then set the project calendar that will be used. In this calendar setting, any day will be a working day. Microsoft projects have standard working hours in general, namely working hours from 08.00-12.00, then continuing from 13.00-17.00, meaning that there are 8 hours in one working day. The relationships between jobs on this project are not all the same, there are jobs that start or finish simultaneously, there are also jobs that start after other jobs have finished. The dependency relationship (predecessor) can be seen in Table 7 below.

Table 7. Dependency relationships in Microsoft projects

Working Items	Duration	Start	Finish	Predecessor (days)
M/C CNC plate	5 days	Tue 01/10/24	Fri 04/10/24	
M/C manual plate	11 days	Mon 07/10/24	Mon 21/10/24	1
Cutting manual profile	11 days	Thu 24/10/24	Thu 07/11/24	2FS+2 days
Grinding	13 days	Fri 08/11/24	Tue 26/11/24	3
Bending	14 days	Wed 27/11/24	Mon 16/12/24	4
Transportation	1 day	Mon 16/12/24	Mon 16/12/24	5FS-1 day
Sub assembly fitting	10 days	Mon 11/11/24	Fri 22/11/24	4SS+1 day
Sub assembly welding	10 days	Mon 25/11/24	Fri 06/12/24	7
Sub assembly grinding	12 days	Mon 09/12/24	Tue 24/12/24	8
Sub assembly fairing	17 days	Wed 25/12/24	Thu 16/01/25	9
Transportation	1 day	Thu 16/01/25	Thu 16/01/25	10FF
Panel assembly fitting	8 days	Thu 28/11/24	Mon 09/12/24	8FF+1 day
panel assembly welding	8 days	Tue 10/12/24	Thu 19/12/24	12
Panel assembly grinding	6 days	Fri 20/12/24	Fri 27/12/24	13
Block assembly fitting	11 days	Fri 06/12/24	Fri 20/12/24	13FF+1 day
Block assembly welding	11 days	Mon 23/12/24	Mon 06/01/25	15
Block assembly grinding	7 days	Tue 07/01/25	Wed 15/01/25	16
Block assembly fairing	12 days	Thu 16/01/25	Fri 31/01/25	17
Transportation	1 day	Tue 04/02/25	Tue 04/02/25	18FS+1 day

The PDM schedule shows the sequence of activities along with their critical paths, making it easier to control the process. Based on the PDM schedule, free float and total float can be determined, then it can be seen whether the work is on the critical path or not. The following series of project activities in Table 7 above can



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be described in the form of a work network planning diagram using the AON model shown in Figure 6 below and the details are shown in Table 8.

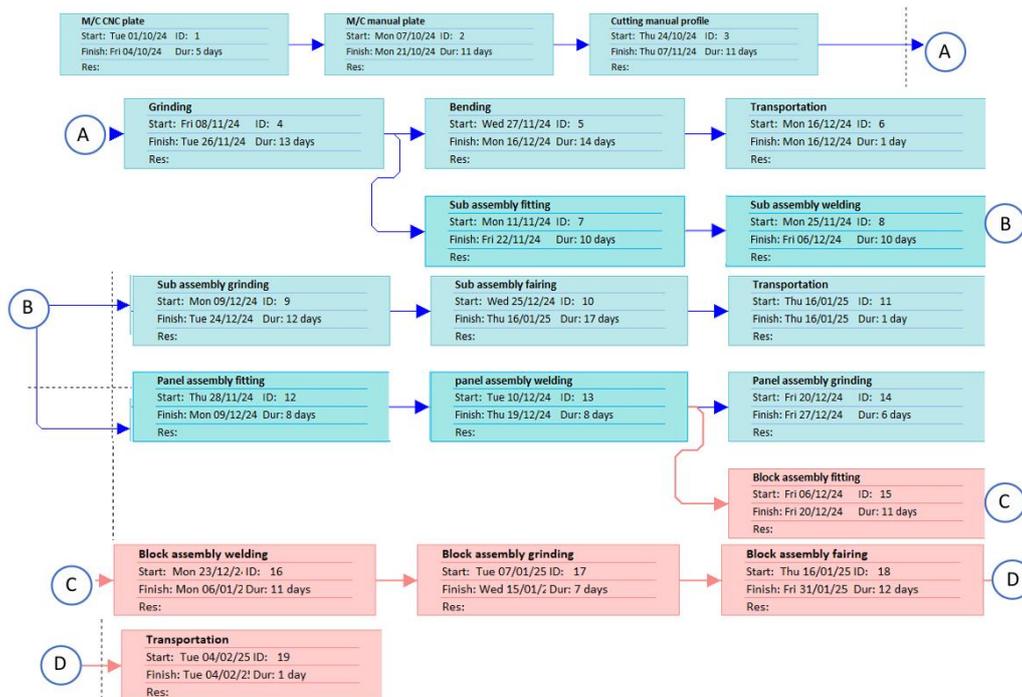


Figure 6. AON model network planning diagram

Microsoft Project offers a variety of benefits in project scheduling, including more structured planning, better visibility, easy progress tracking, as well as gestation in customizing schedules. With features like Gantt charts, resource management, and reporting, Microsoft Project helps project managers manage projects effectively and efficiently. The dots (A, B, C, D) are used to connect the diagram to the next activity. Based on the PDM network image above, there are blue and red boxes. Blue boxes are activities that are not assessed as critical (slack $\neq 0$) and activities in red are critical activities (slack = 0). Critical here is meant by activities that could potentially cause the project to be late because any delay in this activity will immediately cause a delay in the completion of the project as a whole. These activities are blocking assembly fitting, block assembly welding, block assembly grinding, block assembly fairing, and transportation during the assembly process. To make it easier to read the network above, a recap is made according to Table 8 below.

Table 8. Recapitulation of ES, EF, LS, LF, and SL calculations

Working Items	Early Start (ES)	Early Finish (EF)	Late Start (LS)	Late Finish (LF)	Total Slack	Critical
Fabrication						
M/C CNC plate	Tue 01/10/24	Fri 04/10/24	Tue 19/11/24	Tue 26/11/24	35	NO
M/C manual plate	Mon 07/10/24	Mon 21/10/24	Tue 26/11/24	Wed 11/12/24	35	NO
Cutting manual profil	Thu 24/10/24	Thu 07/11/24	Fri 13/12/24	Mon 30/12/24	35	NO
Grinding	Fri 08/11/24	Tue 26/11/24	Mon 30/12/24	Thu 16/01/25	35	NO
Bending	Wed 27/11/24	Mon 16/12/24	Thu 16/01/25	Tue 04/02/25	35	NO
Transportation	Mon 16/12/24	Mon 16/12/24	Tue 04/02/25	Tue 04/02/25	37	NO
Sub Assembly						
Sub assembly fitting	Mon 11/11/24	Fri 22/11/24	Mon 11/11/24	Mon 25/11/24	27	NO
Sub assembly welding	Mon 25/11/24	Fri 06/12/24	Mon 25/11/24	Mon 09/12/24	27	NO
Sub assembly grinding	Mon 09/12/24	Tue 24/12/24	Thu 26/12/24	Mon 13/01/25	38	NO
Sub assembly fairing	Wed 25/12/24	Thu 16/01/25	Mon 13/01/25	Tue 04/02/25	38	NO
Transportation	Thu 16/01/25	Thu 16/01/25	Tue 04/02/25	Tue 04/02/25	38	NO
Assembly						
Panel assembly fitting	Thu 28/11/24	Mon 09/12/24	Thu 28/11/24	Tue 10/12/24	16	NO



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Working Items	Early Start (ES)	Early Finish (EF)	Late Start (LS)	Late Finish (LF)	Total Slack	Critical
panel assembly welding	Tue 10/12/24	Thu 19/12/24	Tue 10/12/24	Fri 20/12/24	16	NO
Panel assembly grinding	Fri 20/12/24	Fri 27/12/24	Tue 28/01/25	Tue 04/02/25	41	NO
Block assembly fitting	Fri 06/12/24	Fri 20/12/24	Fri 06/12/24	Mon 23/12/24	0	YES
Block assembly welding	Mon 23/12/24	Mon 06/01/25	Mon 23/12/24	Tue 07/01/25	0	YES
Block assembly grinding	Tue 07/01/25	Wed 15/01/25	Tue 07/01/25	Thu 16/01/25	0	YES
Block assembly fairing	Thu 16/01/25	Fri 31/01/25	Thu 16/01/25	Mon 03/02/25	0	YES
Transportation	Tue 04/02/25	Tue 04/02/25	Tue 04/02/25	Tue 04/02/25	0	YES

3.2 Alternatives to Extra Work and Overtime

With the PDM method, the life of a project can be shortened by increasing the labor resources involved in certain activities. This stage will focus on adding labor which will further affect daily productivity and can speed up the duration of work assuming the materials and equipment used are ready. The daily productivity formula (PHN) which can be calculated using formula 1 above is detailed in Table 9 below.

Table 9. Critical path productivity with the option of adding human power.

Working Items	Duration (Actual)	Labor	Addition	Daily Productivity	After Addition	Results (days)
Block assembly fitting	11 days	2 Fitter	2 Fitter	2362,06Kg	3543,09 kg	8
Block assembly welding	11 days	2 Welding	2 Welding	2362,06Kg	3543,09 kg	8
Block assembly grinding	7 days	1	1	3711,80kg	7423,6kg	4
Block assembly fairing	12 days	1	1	2165,22Kg	4330,44Kg	6
Transportation	1 day	1	1	25982.677 kg	25982.677 kg	1

In the PDM method, apart from adding labor, an alternative that can be used to speed up project completion is to increase working hours or what is usually called overtime hours. Additional working hours (overtime) are carried out 4 hours after normal working hours have finished. The details can be seen in Table 10 below.

Table 10. Critical path productivity with the option to add overtime

Working Items	PHN (Kg/day)	PNJ	PPJK	Duration (days)
Block assembly fitting	2362,06Kg	295.2575	3070.678	9
Block assembly welding	2362,06Kg	295.2575	3070.678	9
Block assembly grinding	3711,80kg	463.975	4825,34	6
Block assembly fairing	2165,22Kg	270.6525	2814.786	10
Transportation	25982.677 kg	3247,8333	25.982.677	1

From the acceleration results that have been carried out using the PDM method, it is necessary to calculate crash costs (formulas 4 and 5) to compare the resulting cost values. Based on interviews with the company, the maximum crash cost value generated cannot exceed 5% of the actual total work costs. In the case of this company, crash costs cannot be more than Rp. 11.483.500.

Table 11. Comparison of duration and crash cost

Crash costs Additional Labor		Crash cost Additional Overtime	
Duration	Cost	Duration	Cost
27 days	Rp. 5.865.000	35 days	Rp. 6. 731.000

From Table 11 above, the results of the additional workforce option result in a faster duration acceleration compared to the duration of additional overtime hours. For this reason, the author concludes that accelerating



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critical activities using the PDM method with a more efficient alternative of adding labor, where the actual duration of 42 days can be accelerated by 15 days to 27 days at a cost Rp. 5.865.000.

3.3 Results Scheduling With PDM

The results of the scheduling analysis using the PDM method that have been carried out are based on the acceleration alternative by adding labor to critical activities. In detail, it can be seen in Table 12 below.

Table 12. Scheduling with PDM

Working Items	Duration (days)	Start	Finish
Fabrication	55	Tue 01/10/24	Mon 16/12/24
M/C CNC plate	5	Tue 01/10/24	Fri 04/10/24
M/C manual plate	11	Mon 07/10/24	Mon 21/10/24
Cutting manual profil	11	Thu 24/10/24	Thu 07/11/24
Grinding	13	Fri 08/11/24	Tue 26/11/24
Bending	14	Wed 27/11/24	Mon 16/12/24
Transportation	1	Mon 16/12/24	Mon 16/12/24
Sub Assembly	50	Mon 11/11/24	Thu 16/01/25
Sub assembly fitting	10	Mon 11/11/24	Fri 22/11/24
Sub assembly welding	10	Mon 25/11/24	Fri 06/12/24
Sub assembly grinding	12	Mon 09/12/24	Tue 24/12/24
Sub assembly fairing	17	Wed 25/12/24	Thu 16/01/25
Transportation	1	Thu 16/01/25	Thu 16/01/25
Assembly	48	Thu 28/11/24	Fri 17/01/25
Panel assembly fitting	8	Thu 28/11/24	Mon 09/12/24
panel assembly welding	8	Tue 10/12/24	Thu 19/12/24
Panel assembly grinding	6	Fri 20/12/24	Fri 27/12/24
Block assembly fitting	8	Wed 11/12/24	Fri 20/12/24
Block assembly welding	8	Mon 23/12/24	Wed 01/01/25
Block assembly grinding	4	Thu 02/01/25	Tue 07/01/25
Block assembly fairing	6	Wed 08/01/25	Wed 15/01/25
Transportation	1	Fri 17/01/25	Fri 17/01/25

From the results of the scheduling analysis carried out using the PDM method, a different duration was obtained between the planned duration schedule and the actual duration of the FBB-C block project as shown in Table 13 below.

Table 13. Scheduling Comparison

Working Items	Planning (days)	Actually (days)	PDM (days)
M/C CNC plate	5	5	5
M/C manual plate	11	11	11
Cutting manual profil	11	11	11
Grinding	13	13	13
Bending	14	14	14
Transportation	1	1	1
Sub assembly fitting	10	10	10
Sub assembly welding	10	10	10
Sub assembly grinding	12	12	12
Sub assembly fairing	17	17	17
Transportation	1	1	1
Panel assembly fitting	7	8	8



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Working Items	Planning (days)	Actually (days)	PDM (days)
panel assembly welding	7	8	8
Panel assembly grinding	6	6	6
Block assembly fitting	9	11	8
Block assembly welding	9	11	8
Block assembly grinding	6	7	4
Block assembly fairing	10	12	6
Transportation	1	1	1

4. CONCLUSION

From the results of research conducted by the author regarding the scheduling analysis of FBB-C blocks in fabrication to assembly work, the following conclusions can be explained that:

- 1) Planning scheduling has a duration of 160 days, while actual scheduling has a duration of 169 days. The difference between the planned and actual duration is 9 days.
- 2) There are 5 critical paths that must be considered in the construction of the FBB-C block. The results of accelerating critical activities using the PDM method with the alternative of additional labor are considered more efficient, where the actual duration of 42 days can be accelerated by 15 days to 27 days. Rescheduling using the PDM method resulted in a shorter time duration compared to planning and actual, namely 154 days. This means that the PDM scheduling results have a difference of 6 days from the planned schedule and 15 days from the actual schedule.
- 3) From the various project problems that occurred during the construction of the FBB-C block, a breakdown analysis of project problems was carried out in 7 categories for each job. And the biggest factors that cause problems are material delays amounting to 26.31%, equipment or production facilities experiencing problems or being maintained at 22.8%, and also work drawing revisions which often occur during the production period amounting to 19.29%.

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