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Comparison of Project Duration Optimization for Speed Boat Production Using PERT and Critical Chain Project Management Methods (Case Study: CV. Rahman Jaya Abadi)

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Abstract: This study aims to determine which method yields the shortest project duration between the Program Evaluation and Review Technique (PERT) and Critical Chain Project Management (CCPM). The results indicate that CCPM produces a faster project completion time. With the addition of buffers, the project completion duration using CCPM is 28,5 days. In comparison, the shortest project duration with the PERT method requires 35 days with a success probability of 0,13%, while the longest duration is 45 days with a success probability of 99,87%.

Keywords: *Project Management, Scheduling, Speed Boat, PERT, CCPM.*

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I. INTRODUCTION

CV. Rahman Jaya Abadi is a company engaged in the production of speed boats. However, the company faces challenges in the form of project completion delays. One of the factors contributing to these delays is the lack of well-planned project scheduling and the limited effectiveness of project control.

Project scheduling is a fundamental element of project management, comprising the duration of each task and the sequence in which tasks are carried out. This allows the project's start and end times to be determined, ensuring that project execution aligns with the agreed contract or, ideally, is completed earlier, thereby reducing overall project costs [1].

The most commonly used project scheduling analyses are the Critical Path Method (CPM) and the Program Evaluation and Review Technique (PERT). CPM is a critical path method, identifying a sequence of activities with the longest total duration, which represents the shortest possible project completion time [2]. In contrast, PERT is a network analysis method that seeks to improve project completion time by incorporating probabilistic methodologies [3].

However, in practice, planning with these traditional methods is often considered less efficient, as they do not adequately account for task productivity or human-related behavioral factors that tend to prolong project duration. Examples include student's syndrome, Parkinson's law, and multitasking. To address these challenges, the Critical Chain Project Management (CCPM) method has been developed. CCPM is a project planning approach that emphasizes the availability and management of resources required to execute project tasks [4]. Therefore, this study aims to apply the Critical Chain Project Management (CCPM) method to calculate the duration of a speed boat construction project, with results compared to those obtained using the PERT method.

II. LITERATURE REVIEW

➢ *Project*

A project is a combination of interrelated activities that must be carried out in a specific sequence, where certain activities cannot begin until others have been completed [5]. To ensure the smooth implementation of a project from initiation to completion, project management is required. Project management is a series of processes consisting of

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planning, scheduling, and controlling multiple project activities [6]. Within project management, planning and control are critical stages in determining the success of a project. Scheduling involves defining the duration of each task and their sequence of execution, enabling the identification of project start and finish times. This ensures that the project timeline adheres to the agreed contract or, ideally, is completed earlier, thereby reducing project costs [1].

In the scheduling process, one commonly used approach is network planning [8]. A network is a diagram that represents the interrelationships among project activities [7]. The critical path is a sequence of activities within the network that represents the minimum project duration and consists of events that cannot be delayed without affecting the entire project schedule [8]. In addition to the critical path, there are also non-critical paths. A non-critical path consists of activities that have a time allowance, meaning the difference between the earliest possible start time and the latest permissible completion time is longer than the actual duration of the activity.

➢ *Speed Boat*

A speed boat is a fast-moving vessel made of fiberglass, equipped with an outboard engine ranging from 40 to 200 horsepower, and designed for high-speed operation. Its maximum passenger capacity is typically limited to only 6 to 8 people. This is possible due to the relatively small size of the speed boat, which allows for greater maneuverability [9].

➢ *Program Evaluation and Review Technique (PERT) Method*

The PERT method is a network analysis approach that seeks to improve project completion time by employing a probabilistic methodology [3]. In its application, PERT utilizes three time estimates: pessimistic time, most likely time, and optimistic time. The scheduling steps using the PERT approach are intended to determine the probability of project activities—particularly those on the critical path—being completed on time in accordance with the expected schedule [10]:

- *Determining the Expected Time Estimate for Each Activity*

$$te = \frac{(a + 4m + b)}{6}$$

- *Determining the Activity Variance*

$$\sigma_k = \sqrt{\sum \left(\frac{b - a}{6}\right)^2}$$

- *Determining the Activity Variance*

$$\sigma^2 = \left(\frac{b - a}{6}\right)^2$$

- *Calculating the Probability of Meeting the Project Deadline*

$$P\big(TE \leq T(d)\big) = P\left(Z \leq \frac{T(d) - TE}{\sigma_k}\right)$$

$$Z = \frac{T(d) - TE}{\sigma_k}$$

➢ *Notations:*

- te : Expected time of an activity
- a : Optimistic time
- m : Most likely time
- b : Pessimistic time
- σ_k : Standard deviation of the critical activity
- σ^2 : Activity variance
- Z : Standard normal variable representing the probability of meeting the target
- $T(d)$: Target schedule (deadline)
- TE : Total expected duration along the critical path

➢ *Critical Chain Project Management (CCPM) Method*

The CCPM method introduces safety time, which is typically added to each activity, but later removed and replaced with buffer time positioned at the end of the critical chain as a contingency for the overall project duration. If uncertainties arise during project execution, the buffer time can be utilized to mitigate delays. In CCPM, it is necessary to calculate the buffer size for both the critical chain (project buffer) and the non-critical chain (feeding buffer) [11]. The most commonly used approaches in the literature to determine buffer size are the simple allocation of project and feeding buffers, namely the Cut and Paste Method (C&PM, also known as the 50% rule) and the Root Square Error Method (RSEM) [12]:

- *C&PM (Cut and Paste Method):*

Reducing the duration of project activities by 50% with the purpose of eliminating safety time.

- *Root Square Error Method (RSEM):*

RSEM requires two task duration estimates. The first is the safe time (S), which includes sufficient precautionary measures to account for the most likely sources of delay. The second is the average 50% estimate of the task duration, referred to as the optimistic time (A). Assuming that task execution times are independent, the buffer size is set to two standard deviations, as shown in the following formula:

$$2\sigma = 2 \times \sqrt{\left(\frac{S_1 - A_1}{2}\right)^2 + \left(\frac{S_2 - A_2}{2}\right)^2 + \ldots + \left(\frac{S_n - A_n}{2}\right)^2}$$

➢ *Notations:*

- 2σ: Buffer time
- S : Safe time
- A : Optimistic time

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- n : Number of activities in the critical chain

To manage project uncertainties, the buffer requirement for each activity is estimated using buffer management [12], as presented in Table 1:

Table 1 Buffer Consumption Zones

Buffer Consumption	**Remarks**
0% - 33%	No preventive action required
33,1% - 66%	Plan preventive actions
66,1% - 100%	Implement preventive actions

Source: [4]

III. RESULTS AND DISCUSSION

This study examines the speed boat construction project carried out by CV. Rahman Jaya Abadi. The data were obtained through direct observation and interviews.

Table 2 Time Schedule Data for Speed Boat Construction

Activity	**Duration (Days)**		
	(a)	**(m)**	**(b)**
Mold/pattern fabrication	10	13	16
Mold construction	12	14	16
Mold surface polishing	0,4	0,4	1
Application of release agent	0,4	0,5	0,6
Base coating (gelcoat application)	0,3	0,5	0,7
Fine Fiber lamination	1	2	3
Roving lamination	0,5	0,9	1,9
Final lamination	0,5	1	1,5
Curing and mold release	0,5	0,9	1,9
Installation of structural framework	1	1,5	2
Deck/floor installation	1	1	1
Installation of seats and steering	0,4	0,5	0,6
Installation of cabin & ceiling	4	4	4
Installation of handrails	2,1	2,9	4,3
Surface putty application	0,4	0,5	0,6
Final sanding/polishing	5	7	9
Application of primer and topcoat painting	3	4	5
Electrical cable installation	0,5	1	1,5
Installation of engine and air conditioning system	0,4	0,5	0,6

Source: CV. Rahman Jaya Abadi, 2025.

The durations are measured in days. The daily working hours for the project are from 07:00 to 17:00, with a total of 9 effective working hours per day, as 1 hour is allocated for breaks.

Table 3 Data on Activity Dependencies and Workforce

Code	**Activity**	**Predecessor**	**Workforce**
A	Mold/pattern fabrication	-	2
B	Mold construction	-	3
C	Mold surface polishing	A, B	2
D	Application of release agent	C	2
E	Base coating (gelcoat application)	D	1
F	Fine Fiber lamination	E	5
G	Roving lamination	F	5
H	Final lamination	G	5
I	Curing and mold release	H	2
J	Installation of structural framework	I	4
K	Deck/floor installation	J	4
L	Installation of seats and steering	K	1
M	Installation of cabin & ceiling	K	3
N	Installation of handrails	K	2

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O	Surface putty application	L, M, N	3
P	Final sanding/polishing	O	2
Q	Application of primer and topcoat painting	P	2
R	Electrical cable installation	Q	2
S	Installation of engine and air conditioning system	R	2

Source: CV. Rahman Jaya Abadi, 2025.

- *Implementation of the Program Evaluation and Review Technique (PERT) Method*

- *Step 1 Determining the Expected Time*

Table 4 Expected Time Values

Code	Activity	Duration (Days)			te
		(a)	(m)	(b)	
A	Mold/pattern fabrication	10	13	16	13
B	Mold construction	12	14	16	14
Code	Activity	Duration (Days)			te
		(a)	(m)	(b)	
C	Mold surface polishing	0,4	0,4	1	0,5
D	Application of release agent	0,4	0,5	0,6	0,5
E	Base coating (gelcoat application)	0,3	0,5	0,7	0,5
F	Fine Fiber lamination	1	2	3	2
G	Roving lamination	0,5	0,9	1,9	1
H	Final lamination	0,5	1	1,5	1
I	Curing and mold release	0,5	0,9	1,9	1
J	Installation of structural framework	1	1,5	2	1,5
K	Deck/floor installation	1	1	1	1
L	Installation of seats and steering	0,4	0,5	0,6	0,5
M	Installation of cabin & ceiling	4	4	4	4
N	Installation of handrails	2,1	2,9	4,3	3
O	Surface putty application	0,4	0,5	0,6	0,5
P	Final sanding/polishing	5	7	9	7
Q	Application of primer and topcoat painting	3	4	5	4
R	Electrical cable installation	0,5	1	1,5	1
S	Installation of engine and air conditioning system	0,4	0,5	0,6	0,5

Source: Processed Data, 2025.

- *Step 2 Constructing the Project Network Diagram*

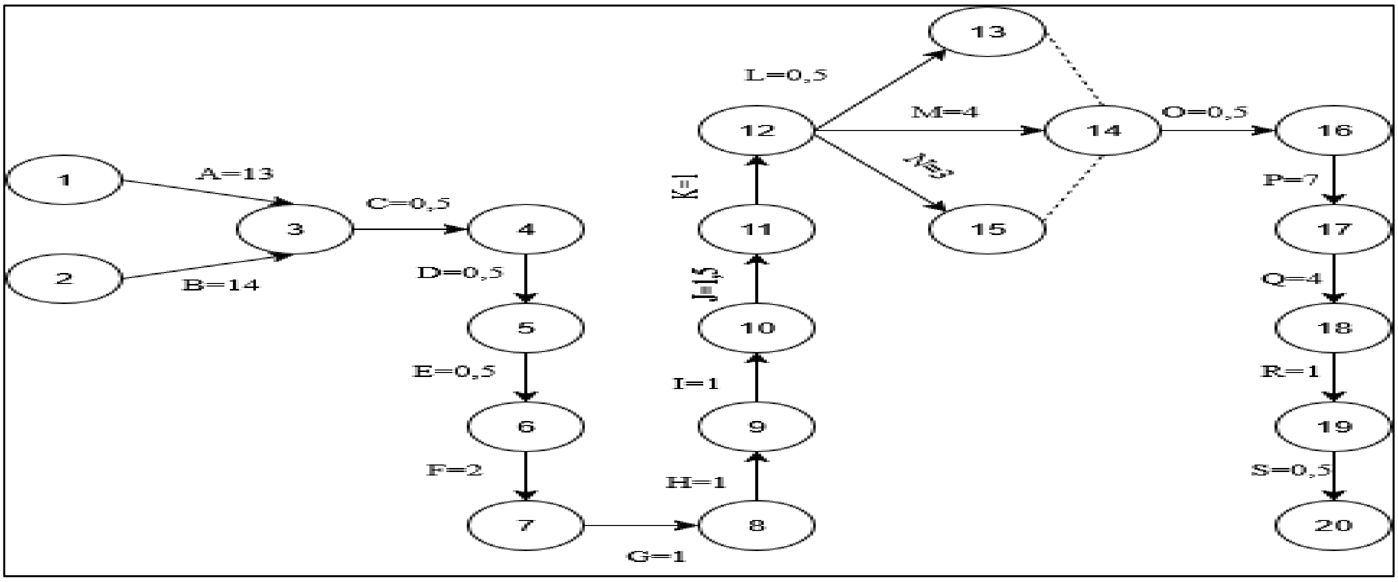

Fig 1 Project Network Diagram of the Speed Boat Construction
Source: Processed Data, 2025.

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- *Step 3 Determining the Critical Path*

Table 5 ES, EF, LS, LF, and Slack Data

Code	***Earliest***		***Latest***		***Slack***	**Characteristic**
	Start	***Finish***	***Start***	***Finish***		
A	0	13	1	14	1,5	Non Critical
B	0	14	0	14	0	Critical
C	14	14,5	14	14,5	0	Critical
D	14,5	15	14,5	15	0	Critical
E	15	15,5	15	15,5	0	Critical
F	15,5	17,5	15,5	17,5	0	Critical
G	17,5	18,5	17,5	18,5	0	Critical
H	18,5	19,5	18,5	19,5	0	Critical
I	19,5	20,5	19,5	20,5	0	Critical
J	20,5	22	20,5	22	0	Critical
K	22	23	22	23	0	Critical
L	23	23,5	26,5	27	3,5	Non Critical
M	23	27	23	27	0	Critical
N	23	26	24	27	1	Critical
O	27	27,5	27	27,5	0	Critical
P	27,5	34,5	27,5	34,5	0	Critical
Q	34,5	38,5	34,5	38,5	0	Critical
R	38,5	39,5	38,5	39,5	0	Critical
S	39,5	40	39,5	40	0	Critical

Source: Processed Data, 2025.

Therefore, the critical path obtained is B – C – D – E – F – G – H – I – J – K – M – O – P – Q – R – S, with a total project completion time of 40 days or TE=40

- *Step 4 Determining Activity Variance and Standard Deviation.*

By calculating the variance value of each activity, the total variance is obtained as follows:

$$\sigma^2 = \sum \left(\frac{b-a}{6}\right)^2 = 2{,}456$$

After obtaining the variance values, the next step is to calculate the standard deviation, resulting in:

$$\sigma_k = \sqrt{2{,}456}$$

$$\sigma_k = 1{,}567$$

Thus, the total variance is found to be 2,456 and the standard deviation is 1,567.

- *Step 5 Probability of Meeting the Project Schedule.*

Based on the analysis, the expected project duration is TE = 40 days, with a standard deviation of 1.567. Referring to the characteristics of the normal distribution, the completion time is expected to fall within the interval (TE-3 σ) and (TE+3 σ) where 3σ = 3 × 1,567 = 4,701. Accordingly, the potential range of project completion is estimated as 40 ± 4,701. Earliest completion time is 40 – 4,701 = 35,299, so T(d) = 35,229 days. When the target duration is set at T(d)=35.229 days, the probability of achieving such a schedule can be evaluated as follows.:

$$Z = \frac{35{,}229-40}{1{,}567} = -3{,}00$$

Using the cumulative normal distribution table with a z-value of –3.00, the corresponding probability is 0.0013. This indicates that the likelihood of completing the project within 35.229 days (approximately 35 days) is only about 0.13%, which is extremely unlikely. On the other hand, the estimated latest completion time is 44.701 days, yielding:

$$Z = \frac{44{,}701-40}{1{,}567} = 3{,}00$$

Referring again to the cumulative normal distribution table, the probability associated with z = 3.00 is 0.9987. This result implies that the probability of completing the project within 44.701 days (approximately 45 days) is as high as 99.87%.

➢ *Implementation of the Critical Chain Project Management (CCPM).*

- *Step 1 Identifying the Critical Chain*

In the Critical Chain Project Management (CCPM) method, the activity duration, or safety time (S), is represented by the expected time (te) previously obtained through the PERT method. Based on this adjustment, the critical path is identified as B – C – D – E – F – G – H – I – J – K – M – O – P – Q – R – S, with a total project completion time of 40 days.

- *Step 2 Eliminating Safety Time Using the C&PM Method*

In the Critical Chain Project Management (CCPM), the safe time (S) is defined as the expected time (te) obtained from the PERT method, while the optimistic time (A) is determined as 50% of the safe time:

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Table 6 Calculation of Activity Duration Reduction

Code	Activity	Predecessor	(S)	(A)
A	Mold/pattern fabrication	-	13	6,5
B	Mold construction	-	14	7
C	Mold surface polishing	A, B	0,5	0,25
D	Application of release agent	C	0,5	0,25
E	Base coating (gelcoat application)	D	0,5	0,25
F	Fine Fiber lamination	E	2	1
G	Roving lamination	F	1	0,5
H	Final lamination	G	1	0,5
I	Curing and mold release	H	1	0,5
J	Installation of structural framework	I	1,5	0,75
K	Deck/floor installation	J	1	0,5
L	Installation of seats and steering	K	0,5	0,25
M	Installation of cabin & ceiling	K	4	2
N	Installation of handrails	K	3	1,5
O	Surface putty application	L, M, N	0,5	0,25
P	Final sanding/polishing	O	7	3,5
Q	Application of primer and topcoat painting	P	4	2
R	Electrical cable installation	Q	1	0,5
S	Installation of engine and air conditioning system	R	0,5	0,25

Source: Processed Data, 2025.

* *Step 3 Eliminating Multitasking*

Allocation

Activity																															
A	2	2	2	2	2	2	2																								
B	3	3	3	3	3	3	3	3																							
C									2																						
D										2																					
E											1																				
F												5																			
G													5																		
H														5																	
I															2																
J																4															
K																	4														
L																		1													
M																		3	3	3	3	3									
N																		2	2	2											
O																							3								
P																								2	2	2	2				
Q																												2	2		
R																														2	
S																															2
Duration	1	2	3	4	5	6	6,5	7	7,25	7,5	7,75	8,75	9,25	9,75	10,25	11	11,5	11,75	12	13	13,25	13,5	13,75	14	15	16	17,25	18	19,25	19,75	20
Total Worker	5	5	5	5	5	5	5	3	2	2	1	5	5	5	2	4	4	6	5	5	3	3	3	2	2	2	2	2	2	2	2

Fig 2 Allocation of Workforce Distribution
Source: Processed Data, 2025.

It can be observed that Activities L, M, and N on day 11,75 exceed the available workforce capacity, as the maximum number of workers allocated for this project is limited to five. This indicates that an overallocation of resources has occurred, resulting in certain workers being assigned to two activities requiring the same resources at the same time. Therefore, resource leveling needs to be implemented by rescheduling one of the activities utilizing the same resources in order to avoid overallocation, as illustrated in the following figure:

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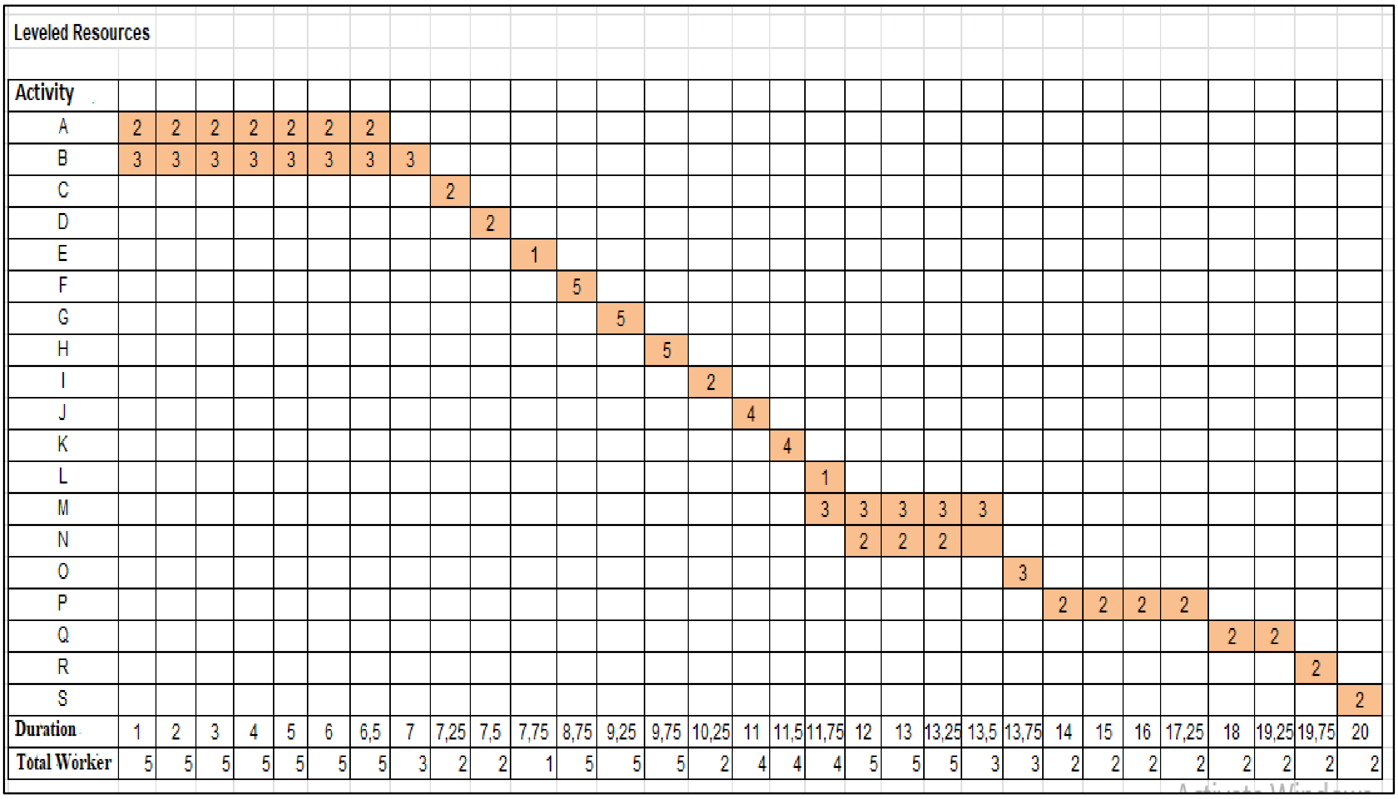

Leveled Resources

Activity																															
A	2	2	2	2	2	2	2																								
B	3	3	3	3	3	3	3	3																							
C									2																						
D										2																					
E											1																				
F												5																			
G													5																		
H														5																	
I															2																
J																4															
K																	4														
L																		1													
M																		3	3	3	3	3									
N																			2	2	2										
O																							3								
P																								2	2	2	2				
Q																												2	2		
R																														2	
S																															2
Duration	1	2	3	4	5	6	6,5	7	7,25	7,5	7,75	8,75	9,25	9,75	10,25	11	11,5	11,75	12	13	13,25	13,5	13,75	14	15	16	17,25	18	19,25	19,75	20
Total Worker	5	5	5	5	5	5	5	3	2	2	1	5	5	5	2	4	4	4	5	5	5	3	3	2	2	2	2	2	2	2	2

Fig 3 Diagram Following the Elimination of Multitasking
Source: Processed Data, 2025.

From the diagram, it can be observed that the types of workers previously involved in multitasking have been eliminated, reducing the total number from 6 workers to 4 workers. The figure of 4 represents the maximum reduction of resources achieved by rescheduling activity durations without altering the worker composition in each activity and without changing the critical path obtained from the CPM scheduling results.

- *Step 4 Rescheduling Using the CCPM Method*

The next step is to identify the critical chain by applying the optimistic values (A) of the CCPM method.

Table 7 ES, EF, LS, LF, and Slack Data

Code	Predecessor	***Earliest***		***Latest***		Slack
		Start (ES)	***Finish (EF)***	***Start (LS)***	***Finish (LF)***	
A	-	0	6,5	0,5	7	0,5
B	-	0	7	0	7	0
C	A, B	7	7,25	7	7,25	0
D	C	7,25	7,5	7,25	7,5	0
E	D	7,5	7,75	7,5	7,75	0
F	E	7,75	8,75	7,75	8,75	0
G	F	8,75	9,25	8,75	9,25	0
Code	**Predecessor**	***Earliest***		***Latest***		***Slack***
		Start (ES)	***Finish (EF)***	***Start (LS)***	***Finish (LF)***	
H	G	9,25	9,75	9,25	9,75	0
I	H	9,75	10,25	9,75	10,25	0
J	I	10,25	11	10,25	11	0
K	J	11	11,5	11	11,5	0
L	K	11,5	11,75	11,75	12	0,25
M	K	11,5	13,5	11,5	13,5	0
N	L	11,75	13,25	12	13,5	0,25
O	L, M, N	13,5	13,75	13,5	13,75	0
P	O	13,75	17,25	13,75	17,25	0
Q	P	17,25	19,25	17,25	19,25	0

R	Q	19,25	19,75	19,25	19,75	0
S	R	19,75	20	19,75	20	0

Source: Processed Data, 2025.

Based on the table, the critical chain obtained is B – C – D – E – F – G – H – I – J – K – M – O – P – Q – R – S, with a total project completion time of 20 days. The following figure presents the project network diagram that illustrates the critical path.

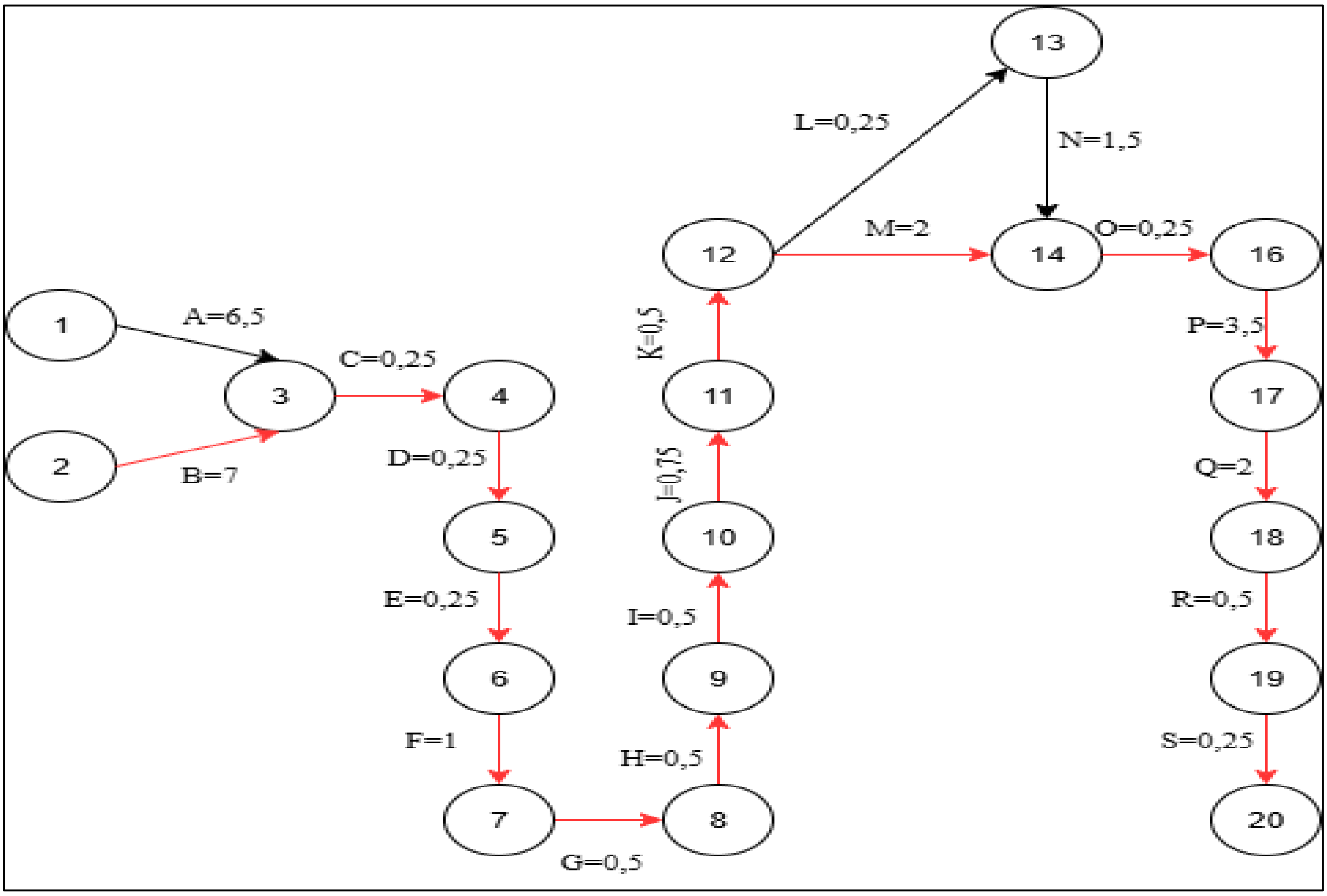

Fig 4 Critical Chain
Source: Processed Data, 2025.

- *Step 5 Buffer Calculation*

✓ *Project Buffer*

Table 8 Project Buffer Calculation

Code	**Safe Time (S)**	**Optimistic Time (A)**	$\left(\frac{S-A}{2}\right)^2$
B	14	7	12,25
C	0,5	0,25	0,015625
D	0,5	0,25	0,015625
E	0,5	0,25	0,015625
F	2	1	0,25
G	1	0,5	0,0625
H	1	0,5	0,0625
Code	**Safe Time (S)**	**Optimistic Time (A)**	$\left(\frac{S-A}{2}\right)^2$
I	1	0,5	0,0625
J	1,5	0,75	0,140625
K	1	0,5	0,0625

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M	4	2	1
O	0,5	0,25	0,015625
P	7	3,5	3,0625
Q	4	2	1
R	1	0,5	0,0625
S	0,5	0,25	0,015625
$\sum$			18,09375

Source: Processed Data, 2025.

The following is the calculation of the project buffer using the Root Mean Square Error Method (RSEM):

$$2\sigma = 2 \times \sqrt{\left(\frac{S_1 - A_1}{2}\right)^2 + \left(\frac{S_2 - A_2}{2}\right)^2 + \ldots + \left(\frac{S_n - A_n}{2}\right)^2}$$

$$2\sigma = 2 \times \sqrt{18{,}09375}$$

$$2\sigma = 2 \times 4{,}25$$

$$2\sigma = 8{,}5$$

Based on the calculation result, the project buffer value is 8,5 days. Thus, it can be concluded that the project has a contingency or additional time allowance of 8,5 days to complete the project, serving as an anticipation in case of delays during its execution..

- ✓ *Feeding Buffer*

Table 9 Summary of Feeding Buffer Calculation

Non Critical Chain	***Feeding buffer* (days)**
A	6,5
L – N	1,5

Source: Processed Data, 2025.

- *Step 6 Buffer Management Analysis*

Table 10 Buffer Management Analysis

Buffer Consumption	**Project Buffer (Days)**	**Duration Used (Days)**	**Remarks**
0% - 33%	8,5	< 2,8	No preventive action required
33,1% - 66%	8,5	2,81 – 5,6	Plan preventive actions
66,1% - 100%	8,5	5,61 – 8,5	Implement preventive actions

Source: Processed Data, 2025.

IV. CONCLUSION

- The fastest project completion time using the PERT method is 35 days with a success probability of 0,13%, while the longest completion time is 45 days with a success probability of 99,87%. Meanwhile, the total project completion time using the CCPM method is 20 days plus the project buffer value of 8,5 days, resulting in a total duration of 28,5 days.
- The CCPM method proves to be more effective in reducing project duration compared to the PERT method. This is demonstrated by the shorter duration achieved as well as CCPM’s ability to minimize delays caused by human behavior factors such as multitasking, student’s syndrome, and Parkinson’s law.

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