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Analysis of Improving the Efficiency and Effectiveness of Company Resource Utilization Using CPM and PERT Approaches: A Case Study

Wagimin[1], Anwar Fattah[1]

[1]Department of Industrial Engineering, Faculty of Electrical Engineering, Balikpapan University, Indonesia

**Corresponding Author: Wagimin*
Email: wgimn54@gmail.com

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Abstract

Effective project management is essential for technology service companies to improve resource efficiency and minimize project delays. PT XYZ has experienced an increase in project demand, but several projects have not been completed according to the planned schedule, resulting in financial losses and potential client dissatisfaction. This study aims to analyze the scheduling of the Hospital Informatics Project at PT XYZ using the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT). A descriptive quantitative case study approach was applied by identifying project activities, determining activity dependencies, allocating human resources, developing a project network, and calculating project duration and completion probability. The CPM analysis shows that the critical path of the project is C–F–H–J, with an optimal completion time of 45 months. The PERT analysis indicates that the probability of completing the project within the target duration is 24.51%. The findings also show that project delays may be influenced by work methods, environmental conditions, material availability, human resources, and extraordinary circumstances. Therefore, the integration of CPM and PERT can help PT XYZ improve project scheduling, monitor critical activities, reduce delay risks, and enhance the efficiency and effectiveness of company resources.

Introduction

The rapid development of technology has encouraged the growth of companies engaged in technology services, including consulting and software development (Alt et al., 2018; Joshi & Singh, 2023; Rajala & Westerlund, 2007). This condition has also increased the demand for technology-based projects, particularly in companies such as PT XYZ. Based on company project data from 2021 to 2025, the number of projects handled by PT XYZ continued to increase, as shown in Figure 1. This increase provides opportunities for business growth, but it also creates managerial challenges, especially in ensuring that each project can be completed according to the planned schedule.

Project delays have become one of the main issues faced by PT XYZ. In 2025, 3 out of 15 projects, or approximately 23%, were not completed according to the initial project plan. These delays had financial consequences because the company was required to provide compensation or refunds to clients when project completion exceeded the agreed schedule. Based on the company's financial report, losses caused by project delays reached approximately 7% of annual revenue. Therefore, PT XYZ needs a more systematic project

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planning and control approach to reduce potential delays and improve the efficiency of company resources.

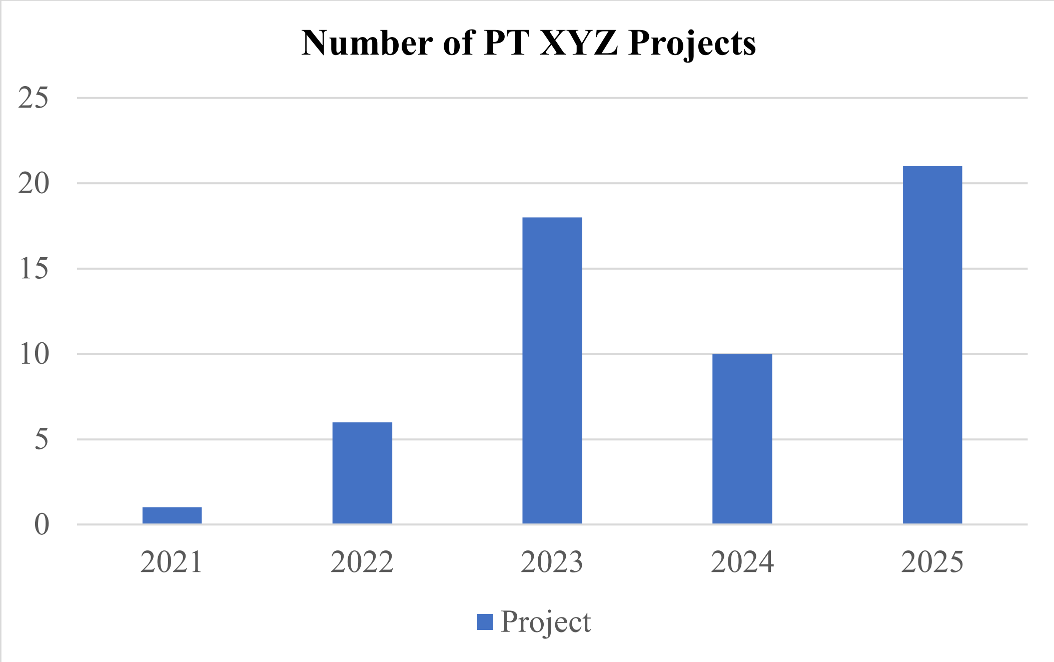

Figure 1. Number of PT.XYZ Projects in 2021-2025

Project management plays an important role in planning, organizing, implementing, and controlling project activities to achieve predetermined objectives. According to Dimyati and Nurjaman (2014), project management aims to manage resources effectively and efficiently so that project targets can be achieved according to the expected quality, cost, and time. Soeharto (1999) also emphasized that effective project management requires structured planning and control to minimize risks during project implementation. Project scheduling becomes an essential component because it helps companies determine activity sequences, allocate resources, and estimate project completion time (Hansen et al., 2023; Goda et al., 2023; Barua, 2026; Haque & Mathur, 2025).

One method that can be used to support project scheduling is the Critical Path Method (CPM). CPM is useful for identifying the sequence of activities that directly determines the total project duration (Zareei, 2018; Atin & Lubis, 2019; Agyei, 2015). Activities located on the critical path require special attention because delays in these activities will affect the overall project completion time. In addition, the Program Evaluation and Review Technique (PERT) can be used to estimate project duration under uncertainty by considering optimistic, most likely, and pessimistic time estimates. Soeharto (2002) explained that PERT is useful for calculating expected activity duration and estimating the probability of project completion within a certain time target.

Previous project management studies have shown that structured planning can help companies improve project implementation efficiency (Papke-Shields & Boyer-Wright, 2017). Noerlina (2008) stated that good project management can create more detailed and efficient implementation stages. Similarly, Duncan (1996) emphasized the importance of defining project scope and work breakdown structure to support project planning and monitoring. However, in the case of PT XYZ, project delays still occur, indicating the need for a more measurable scheduling approach using CPM and PERT (Nasution & Tanjung, 2026; Pellerin & Perrier, 2019; Andiyan et al., 2021).

Based on these conditions, this study focuses on the Hospital Informatics Project at PT XYZ (Larasati et al., 2023; Purnomo, 2025; Hanifudin & Satrio, 2026).The objectives of this study

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are to identify the main project activities, allocate the required human resources, develop a project network, determine the critical path using CPM, and estimate the probability of project completion using PERT. The results of this study are expected to help PT XYZ improve project scheduling, reduce delay risks, and increase the efficiency and effectiveness of company resources.

Literature Study

Project Management

Project management is an important approach used to plan, organize, implement, and control project activities so that project objectives can be achieved effectively and efficiently. According to Dimyati and Nurjaman (2014), project management refers to the process of managing organizational activities and resources to achieve predetermined objectives. Similarly, Soeharto (1999) stated that project management aims to ensure that project implementation can meet the expected targets in terms of time, cost, quality, and resource utilization.

In technology-based projects, project management is needed to reduce the risk of delays and to ensure that each activity is carried out according to the planned schedule. A project that is not properly managed may cause inefficiency, poor coordination, increased costs, and reduced client satisfaction. Therefore, systematic project planning is required to support the efficient use of company resources.

Project Management Functions

Project management consists of several main functions, namely planning, organizing, actuating, and controlling. The planning function is used to determine project objectives, activity sequences, schedules, and resource requirements. The organizing function aims to arrange human resources and responsibilities so that each project activity can be implemented properly. The actuating function focuses on directing and motivating project members to complete their assigned tasks. Meanwhile, the controlling function is used to monitor project progress, evaluate performance, and provide corrective actions when deviations from the plan occur.

These functions are important because project success depends not only on the availability of resources but also on the company's ability to coordinate activities and control project implementation. In this study, these project management functions are applied through activity identification, human resource allocation, project network development, and project duration analysis.

Work Breakdown Structure

A Work Breakdown Structure (WBS) is used to divide a project into smaller and more manageable activities. Duncan (1996) explained that defining project scope through a structured work breakdown is an important part of project planning and monitoring. Through WBS, the project manager can identify the main activities, determine the responsible personnel, and understand the relationship between activities.

In the Hospital Informatics Project, the WBS is used to classify project activities into several stages, such as requirements collection, design, development, integration, testing, deployment, and warranty. This structure helps the company understand the overall scope of the project before preparing the project network and determining the critical path.

Critical Path Method

The Critical Path Method (CPM) is a project scheduling method used to determine the sequence of activities that directly affects the total project completion time. According to

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Schroeder, as cited in Dimyati and Nurjaman (2014), CPM uses a project network and activity duration to identify the critical path. The critical path consists of activities that have no delay tolerance. Therefore, if one activity on the critical path is delayed, the overall project completion time will also be delayed.

Several important terms are used in CPM analysis. Earliest Start (ES) refers to the earliest time an activity can begin. Earliest Finish (EF) is the earliest time an activity can be completed. Latest Start (LS) is the latest time an activity can begin without delaying the project, while Latest Finish (LF) is the latest time an activity can be completed without affecting the overall project duration. These calculations help project managers identify which activities require strict monitoring.

CPM is useful because it provides clear information about activity sequences, dependencies, and project completion time. In this study, CPM is used to determine the project network and identify the critical path of the Hospital Informatics Project at PT XYZ.

Program Evaluation and Review Technique

PERT is used to schedule, organize, and coordinate the various activities within a project. According to Soeharto (2002), the PERT method includes three time estimates, namely:

Pessimistic time (t_p), is the longest time that an activity might require.

likely estimated time (t_m) is the completion time for project activities that is most possible, or has the highest probability.

Optimistic time (t_o), is the fastest time that can be used to carry out a project activity.

After determining the three estimated times, we can determine the expected activity time (*Expected Timed*) using the following formula:

$$\text{Expected Time} = \frac{optimistic + (4\ x\ most\ likely) + pesimistic}{6}$$

In determining the estimated project time, it can be calculated using probability calculations and completed with a normality table.

$$Z = \frac{x - \mu}{\sigma}$$

With the information that x is the expected amount of project implementation time, μ is the average project completion time, and σ is the standard deviation.

Methods

This study used a descriptive quantitative case study approach to analyze the scheduling efficiency of the Hospital Informatics Project at PT XYZ. The research focused on identifying project activities, determining activity dependencies, estimating project duration, and calculating the probability of project completion using the Critical Path Method (CPM) and Program Evaluation and Review Technique (PERT). The object of this study was the Hospital Informatics Project, which includes requirements collection, system design, system development, integration, testing, server deployment, and project warranty activities.

The data used in this study consisted of primary and secondary data (Ahmad, 2025; Latifah & Safrida, 2025; Sugiarto, 2025). Primary data were obtained through discussions and interviews with the project manager, designer, lead programmer, programmers, and testers involved in the project. Secondary data were collected from project documents, work schedules, previous project records, and internal project planning reports. The data collected included activity descriptions, responsible personnel, predecessor activities, normal activity duration, optimistic time, most likely time, and pessimistic time (Ahmetoglu et al., 2025; Gupta et al., 2025; Firdaus & Hermawan, 2025).

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The research procedure consisted of several stages. First, the project activities were identified and arranged into a Work Breakdown Structure (WBS) to describe the overall scope of work. Second, each activity was coded and linked to its predecessor activity to construct the project network. Third, the Critical Path Method (CPM) was applied by calculating the Earliest Start (ES), Earliest Finish (EF), Latest Start (LS), Latest Finish (LF), and slack for each activity. Activities with zero slack were classified as critical activities, and the longest path in the project network was determined as the critical path (Raihan & Sidabalok, 2025; Vazquez et al., 2023).

Next, the PERT method was used to estimate the expected duration and variance of each activity. The expected time was calculated using three time estimates: optimistic time, most likely time, and pessimistic time. The expected activity time was calculated using the formula:

$$TE = (a + 4m + b) / 6$$

where TE is the expected time, a is the optimistic time, m is the most likely time, and b is the pessimistic time. The activity variance was calculated using the formula:

$$\text{Variance} = [(b - a) / 6]^2$$

After obtaining the expected time and variance, the total variance of the critical path was calculated by summing the variances of all activities on the critical path. The standard deviation was then obtained from the square root of the total variance. Finally, the probability of project completion within the target duration was calculated using the Z-score formula:

$$Z = (T - TE) / \sigma$$

where T is the target project completion time, TE is the expected project completion time on the critical path, and σ is the standard deviation of the critical path. The Z-score was then interpreted using the standard normal distribution table to determine the probability of completing the project within the planned duration.

Results and Discussion

Project Activity Identification

The first stage in developing project management planning for the Hospital Informatics Project was identifying all project activities that must be completed from the initial planning stage to the final project handover. Activity identification is an important step because it provides a clear overview of the project scope, work sequence, resource requirements, and responsibilities of each project member. In this study, the project activities were grouped into several main stages, namely requirements, design, development, and integration and testing. These stages represent the general workflow of the Hospital Informatics Project, starting from collecting client needs, preparing system design, developing the system, conducting quality control, uploading the system to the public server, and providing warranty or final consultation to the client.

The identification of activities was also used as the basis for determining the relationship between one activity and another. Each activity needs to be arranged logically so that the project team can understand which activities must be completed first and which activities can be carried out afterward. This process is essential in CPM and PERT analysis because both methods require clear information regarding activity sequence, predecessor activities, and activity duration. Therefore, activity identification not only helps describe the project workflow but also supports the preparation of a more accurate project network.

Global activity planning includes the allocation of human resources, time, and project activities. Human resource allocation was carried out by assigning responsible personnel to each activity, such as the project manager, designer, lead programmer, programmers, and

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testers. This allocation is important to ensure that every activity has a clear person in charge and that project monitoring can be conducted more effectively. In addition, the grouping of activities into a Work Breakdown Structure (WBS) helps simplify the project into smaller and more manageable work components. The Work Breakdown Structure (WBS) of the Hospital Informatics Project is presented in Figure 2.

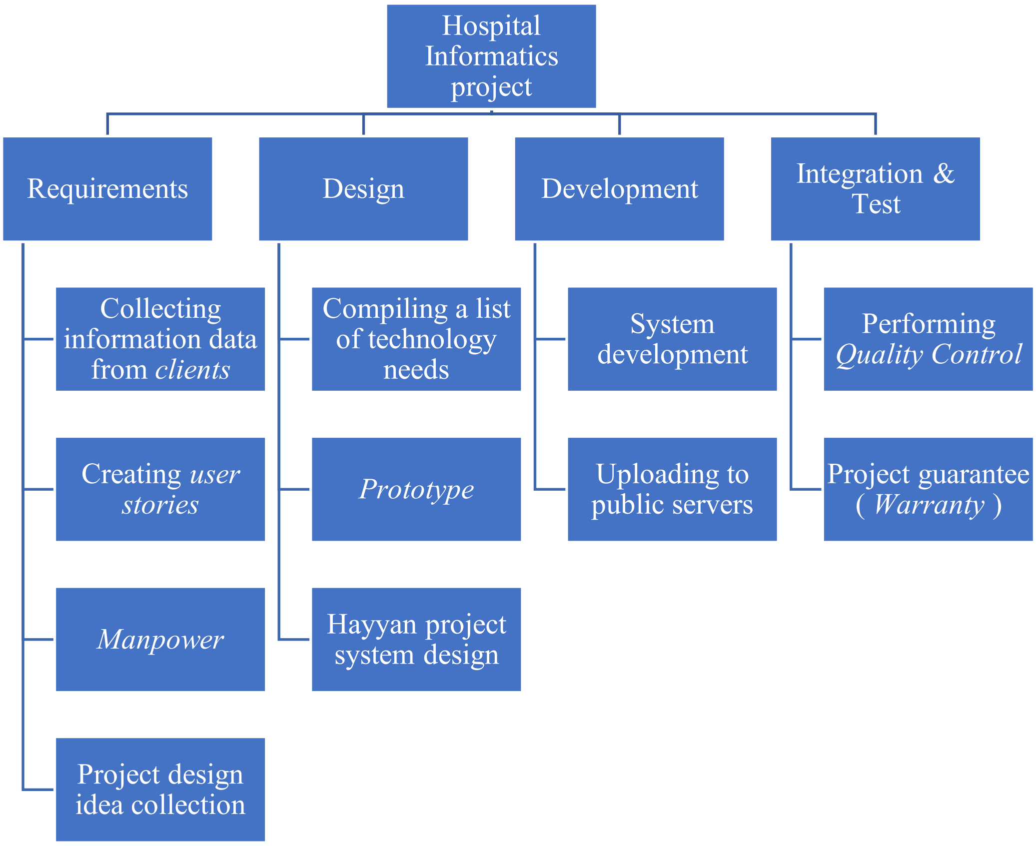

Figure 2. Work Breakdown Structure

The human resources assigned to each project activity are presented in Table 1. This allocation helps the project manager monitor responsibilities in each stage of the project.

Table 1. Human Resource Allocation for Project Activities

No.	Activity Description	PIC
1	Collecting all data and information requirements from Hospital Informatics Project clients	Project Manager
2	Creating user stories or project function descriptions based on the needs of the Hospital Informatics Project	Project Manager, Designer, Lead Programmer
3	Allocating manpower	Project Manager
4	Collecting design ideas	Designer
5	Compiling a list of technology requirements, including software and hardware needs	Lead Programmer
6	Compiling a design in prototype form as the initial step in approving the project design with the client	Designer
7	Compiling the Hospital Informatics Project system design that has been approved by the client	Lead Programmer
8	Starting project system development	Programmer
9	Monitoring quality control and testing	Testers

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10	Uploading the Hospital Informatics Project to public servers	Programmers
11	Providing guarantee or warranty in the form of final consultation with the client	Programmers and Testers

Project Network and Critical Path Determination

After identifying the project activities, the next stage was determining the relationship between activities, predecessor activities, and activity duration. These data were used to develop the project network and determine the critical path using the Critical Path Method (CPM). The project activities, predecessor activities, and activity durations are shown in Table 2.

Table 2. Hospital Informatics Project Activities

No.	Activity	Previous Activities	Activity Time (Month)
1	C	-	9
2	B	-	8
3	C	-	12
4	D	A	7
5	E	B	11
6	F	C	10
7	G	C	12
8	H	E, F	10
9	I	D	14
10	J	H, G	12
	Total		105

Based on the activity sequence and predecessor relationships, the project network was developed using the CPM method. The network diagram is presented in Figure 3.

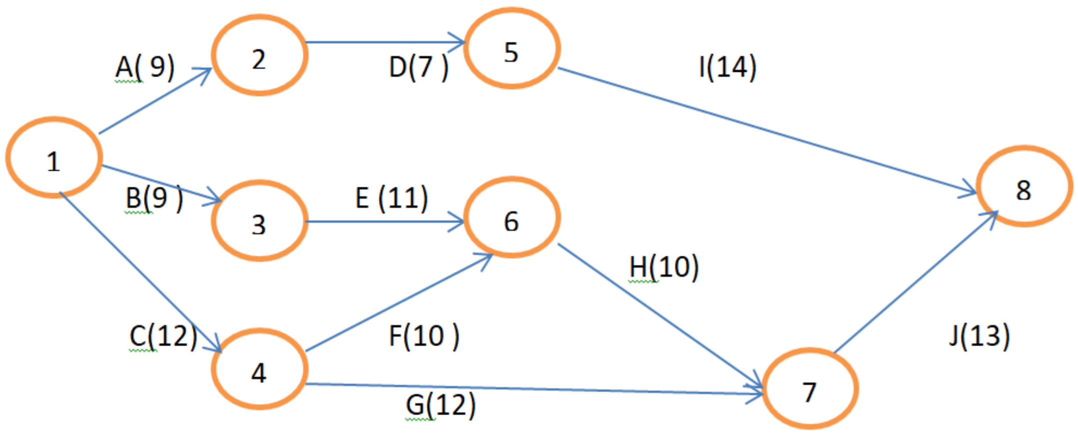

Figure 3. Hospital Informatics Project Network Using the CPM Method

The critical path was determined by calculating the total duration of each possible path in the project network. The path calculations are as follows:

ADI = 9 + 7 + 14 = 30 months
BEHJ = 9 + 11 + 10 + 13 = 43 months
C-F-H-J = 12 + 10 + 10 + 13 = 45 months
C-G-J = 12 + 12 + 13 = 37 months

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Based on these calculations, the longest path is C-F-H-J, with a total project duration of 45 months. Therefore, the critical path of the Hospital Informatics Project is C-F-H-J, and the optimal project completion time is 45 months.

PERT Analysis

After determining the critical path using CPM, the Program Evaluation and Review Technique (PERT) was applied to calculate the average activity time and variance. The PERT calculation used three time estimates, namely optimistic time, most likely time, and pessimistic time. The results of the PERT calculation are presented in Table 3.

Table 3. Average Activity Time and Variance Using the PERT Method

Activity	Predecessor	Fastest Time / Optimistic (a)	Normal Time / Most Likely (m)	Longest Time / Pessimistic (b)	Average Activity Time	Variance
C	-	7	9	11	9.00	0.44
B	-	6	8	13	8.50	1.36
C	-	10	12	14	12.00	0.44
D	A	5	7	9	7.00	0.44
E	B	9	11	14	11.16	0.69
F	C	7	10	13	10.00	1.00
G	C	6	12	15	11.50	2.25
H	E, F	5	10	14	9.83	2.25
I	D	11	14	19	14.33	1.77
J	H, G	7	12	20	12.50	4.69

Based on the critical path C-F-H-J, the total variance of the critical path was calculated as follows:

Variance of critical path = 0.44 + 1.00 + 2.25 + 4.69 = 8.38

The standard deviation was then calculated from the square root of the total variance:

$S = \sqrt{8.38} = 2.89$

The probability calculation was conducted to determine the possibility of completing the Hospital Informatics Project within 47 months. The target duration of 47 months was obtained from the expected completion time of 45 months plus 2 months.

$Z = (47 - 45) / 2.89$
$Z = 2 / 2.89$
$Z = 0.69$

Based on the standard normal distribution table, the Z value of 0.69 corresponds to 0.2451. Therefore, the probability of completing the project is:

$0.2451 \times 100\% = 24.51\%$

Thus, the probability of completing the Hospital Informatics Project within the expected project duration is 24.51%.

Project Delay Factors

The analysis also indicates that project delays at PT XYZ may occur due to several factors, including methods, environment, materials, human resources, and extraordinary circumstances. Therefore, activities located on the critical path require more intensive monitoring because delays in these activities will directly affect the overall project completion time.

The findings show that the Hospital Informatics Project at PT XYZ requires stronger schedule control because several activities are highly dependent on one another (Firmansyah et al.,

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2025; Muchtiar et al., 2026; Sabila et al., 2025). The use of CPM helps identify activities that must be prioritized so that delays in critical activities can be minimized. This is in line with Ren and Li (2023), who stated that CPM is useful for mapping activity dependencies in software project scheduling. The result also supports Putra et al. (2025), who found that CPM and PERT can be applied effectively in information system project management.

The critical path identified in this study indicates that project completion depends on the company's ability to control the most sensitive activities in the project network. CPM is useful because it allows managers to focus on activities that directly affect total project duration. Romadhani et al. (2025) found that CPM helps project managers identify work packages that require priority control. Similarly, Hadicara et al. (2023) explained that CPM can reduce schedule uncertainty by clarifying the sequence of critical activities.

The use of PERT provides an important contribution because it considers uncertainty in project duration (Seyyedi et al., 2025; Feliu-Talegón et al., 2026; Wendpanga et al., 2024). Unlike CPM, which uses a single duration estimate, PERT uses optimistic, most likely, and pessimistic time estimates. Bachmid et al. (2022) emphasized that PERT is more suitable when project duration contains uncertainty. Fauzah et al. (2024) also showed that PERT can help estimate the probability of project completion within a certain time target. Therefore, the relatively low completion probability in this study indicates that PT XYZ needs to strengthen schedule monitoring and risk anticipation (Lubis et al., 2023; Sihombing & Prabowo, 2026; Jufiter et al., 2026).

The findings also show that project efficiency is closely related to human resource coordination. The project involves several key roles, including the project manager, designer, lead programmer, programmers, and testers (Cinkusz et al., 2024; Galster et al., 2022; Ahmed et al., 2024). Husna et al. (2022) explained that project scheduling becomes more reliable when activity duration is supported by clear resource allocation. Astari et al. (2021) also emphasized that expert judgment is important in estimating activity duration, especially when historical project data are limited.

In technology-based projects, delay can occur not only because of technical problems but also because of changing requirements, weak communication, and limited coordination between development and testing teams. Hanifa (2024) stated that CPM and PERT are useful for projects with sequential and uncertain activities. Ridwan (2025) also argued that combining CPM and PERT helps managers understand both the critical path and possible schedule risk. This means that PT XYZ should use CPM and PERT not only for initial planning but also for continuous project control.

The delay factors identified in the study, including methods, environment, materials, human resources, and extraordinary conditions, indicate that PT XYZ needs a more structured control system. Aulia and Cipta (2023) suggested that network planning should be used as a monitoring tool throughout project implementation. Perrucci et al. (2025) also highlighted that CPM can help prevent cascading delays when critical activities are not properly controlled. In addition, Sugianto et al. (2021) showed that CPM and PERT can support better time efficiency when project progress is evaluated periodically.

The results confirm that CPM and PERT are appropriate methods for improving project scheduling efficiency at PT XYZ. CPM helps determine activities that require strict control, while PERT provides insight into project uncertainty and completion probability. However, the effectiveness of both methods depends on the accuracy of activity data, consistency of time estimates, and regular monitoring of critical activities. Therefore, PT XYZ should integrate CPM–PERT analysis with periodic evaluation, resource planning, and risk mitigation to reduce the possibility of project delays.

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Conclusion

The implementation of the KRIS Building and Cytotoxic Building Project of Brebes Hospital in general shows a good level of schedule suitability because the project was successfully completed on time in the 32nd week according to the contract target. Of the total 32 weeks of implementation, 28 weeks ran as planned or faster, while delays only occurred in certain 4 weeks. The time deviation that occurred was temporary and successfully recovered through the acceleration of work with a 24-hour shift work system.

The results of the CPM analysis showed that several works such as foundation work, structures, utilities, interiors, mechanical ventilation, and cable installation were included in the critical track so that it greatly affected the overall duration of the project. The main factors causing delays include weather conditions, limited project space due to being in an active hospital environment, and insynchronization of material mobilization systems and work tools.

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