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Developing Project Schedule in Telecommunication Projects Using Critical Path Method (CPM)

Indri Alvi Kusumadarma[1], Devi Pratami[2*], I Putu Yasa[3], Wawan Tripiawan[4]

[1]School of Industrial and System Engineering, Telkom University, Bandung, 40257, INDONESIA

*Corresponding Author

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Abstract: Increased public demand for stable internet network services requires companies engaged in telecommunications to always improve their technological capabilities. One way to improve technological capability is to use basic materials or supporting materials, that is fiber optics (FO). PT. XYZ is a company engaged in the field of telecommunications in several years ago. In general, projects in PT. XYZ experience more frequent delays, one of the most influencing factors that they are not applying the method appropriate to the type of project. If the project schedule does not use a method that is appropriate to the type of project being undertaken, then the result is a delay in the implementation of the project. In a project with small or large scopes, processes such as defining activities, sorting activities, estimating duration and making the Schedule Model are so closely tied to each other that they can be viewed as a Single Process that can be done/done by a person in a relatively short period of time. Therefore, this study focuses on the design of the feeder cabling project schedule in STO Nanjung by using CPM method. The calculation results using the CPM method indicate that the completion time of the Feeder FO cable project is 46 days with 16 critical activities.

Keywords: Critical path method, project schedule, program evaluation, and review technique, project time management

1. Introduction

Increased public demand for stable internet network services requires companies engaged in telecommunications to always improve technological capabilities so that they can provide good service. These demands are the goal and motivation for the company to provide the best service. To provide the best service the company must use basic materials or supporting materials. One of the best materials to support the stability of an internet network is fiber optic (FO). In Indonesia, there are already companies engaged in telecommunications that have created fiber optic networks, namely PT. XYZ. The company provides several communication services such as telephone networks, multimedia, and services related to internet communication, satellite transponder leasing, paid television services and others. All programs or services offered by PT. XYZ require good speed internet access.

The process of replacing copper cables into fiber optics has several stages. The spread of Feeder and Distribution Cables is the first two stages of the project. At the implementation stage, a project begins with the planning or planning stage. The planning phase of a project includes a schedule planning or scheduling process. Scheduling is a device to determine the activities needed to complete a project in a certain period of time. Every activity must be carried out so that the project is completed on time and at an economical cost. One reason is the use of methods that do not match the type of project run by the project manager. If the project schedule does not use a method that matches the type of project implemented, the result is a delay in the implementation of the project. Because in some projects, both small and large, processes such as defining activities, sorting activities, estimating resources, estimating duration, and

*Corresponding author: devipratami@telkomuniversity.ac.id

making Schedule Models are very bound to each other until they can be seen as a Single Process that can be done/done by someone in a relatively short period of time.

A schedule is one parameter that becomes a benchmark for the success of a project, in addition to costs and quality. Scheduling needs to be considered in project management to determine the duration and sequence of project activities, so that logical and realistic scheduling is formed. In general, project scheduling uses definite duration estimates. There are several different techniques and tools to support project planning, namely Gantt Chart, Critical Path Method (CPM), and Program evaluation and Review Technique (PERT). The tool is used by project managers to identify critical activities and calculate the minimum time needed to complete the project. Among these methods, traditional scheduling techniques use Gantt Chart. Although these methods are still frequently used, specifically Gantt Charts or bar charts fail for large-scale scheduling [1].

The CPM method has been used extensively to assist project managers in planning and controlling large-scale and small-scale projects of all types including construction, research, development projects and many others [1]. CPM uses networks to coordinate activities, develop schedules and monitor project progress. By identifying activities on the critical path, a project scheduling approach that breaks down projects into several work activities describes them into flowcharts and then calculates the duration of the project based on the estimated duration for each activity. The critical path is the path that has the longest time of all paths starting from the initial event to the last event in the network activity diagram [2].

In addition, CPM has been used to calculate operating parameters including the earliest start time, the earliest start time, the earliest completion time, the last time, the maximum time and minimum time. The duration of the project will not be longer than the longest path through a network diagram. However, the total time spent to complete the project is equivalent to the length of the critical path, which is the longest path. The research is to determine the scheduling of projects using the CPM method. This is necessary for the owner to avoid project delays that have an impact on project failure.

2. Literature Review

Project Time Management is a set of processes needed to set the project completion time. In the Time Management Project, there is a Schedule Model, which is a representation of a plan to carry out project activities such as duration, dependence and other various planning information used to make the Project Schedule and other scheduling files [3]. Many things counted that can lead to a delay in the completion of a project. Some of the most common causes include changes in field conditions, changes in design or specifications, weather changes, unavailability of labor, materials, or equipment. In work planning often arise operational problems that hinder the activities of the completion of a project, such as lack of resources, improper allocation of resources, delay in project implementation and other issues outside the schedule in the work plan [2].

According to Assaf and Al-Hejji [4] the causes of project delays can be seen in terms of material, labor, equipment, costs or capital, design changes, relationships with relevant agencies, scheduling and control, slow monitoring and testing procedures used in projects, environment, contract issues, and absence of manager consultants professional. Whereas the potential factors for project delays are according to [5] include incomplete images and specifications, changes in planning during the implementation process, poor managerial in the contractor organization, work plans that are not well organized / integrated, failure of contractors to carry out the work.

Other factors that have the potential to influence implementation time consist of seven categories: labor, materials, equipment, site characteristics, managerial, financial, the intensity of rainfall, economic conditions, and accidents work. Levis and Atherley [6] classifying causes of delays in a project into three parts, namely: excusable Non- Compensable Delays, excusable Compensable Delays, and non-excusable Delays. Project participants often underestimate project delays and do not make the incident a learned lesson in the next project implementation. Project delays can be seen in two things, namely the aspects that are affected and the factors that influence or cause. The factors that are affected by the project are late: material related delays, delays related to labor, delays related to equipment, inappropriate planning, weak project time control, subcontractor delays, weak coordination, inadequate supervision, inappropriate implementation methods, lack of technical personnel, and weak communication.

Delay in completing a project will have an impact on financial problems. Delays in a construction project increase cost. The impact of delay on the owner is the loss of potential income from the facilities built. While the contractor is the loss of opportunity to put the resources to other projects, increasing indirect costs (indirect-cost) due to increased expenditure on employee salaries, equipment rental and reduced profits [6,12,13]. The delay in the project must have caused a lot of harm to the project owner and service provider [13]. Because of this, Jones & O'brien [7] concluded that the losses incurred due to delays, namely:

- For owners, the delay causes loss of income from buildings that should have been able to be utilized.
- For contractors, delay means an increase in overhead. As a resulted of the increased in material prices due to labor wages, and other projects being blocked.
- For consultants, delays result in time losses that hinder other project activities.

According to Ali et. al., [8] and Sohu et. al (2019), impacts that often occur due to delays in construction projects, namely additional costs, additional project completion time, late payments, need for rescheduling, worsening the

reputation of the company, and loss of productivity and labor efficiency. Among six factors, this study only used 5 (five) indicators, namely additional costs, additional time, late payments, rescheduling, and decreasing labor productivity or efficiency. According to Adegoke [9] the critical path is a chain of activities through the network and contains activities that cannot be delayed. The critical path has the smallest possible cycle time for the process. The critical path will provide an estimate of the time cycle process. Whereas according to Heizer and Render [10] critical paths are the longest time paths found throughout the network.

In conducting critical path analysis according to Heizer and Render [10], a two-pass process that consists of forward pass and backward pass is used to determine the time schedule for an activity. ES and EF are determined during the forward pass. LS and LF are determined during the backward pass. ES (earliest start) is the earliest time an activity can start assuming all of its predecessors have finished. EF (earliest finish) is the earliest time an activity can be completed. LS (late start) is the last time an activity can begin so as not to delay the completion of the entire project. LF (late finish) is the last time an activity can be completed so it does not delay the completion of the entire project. Although network planning is a method that is widely used in scheduling and planning, but this method still has some disadvantages. According to Heizer and Render [10], the advantages and disadvantages of network planning methods include:

i. The Advantages
   - Very useful especially when scheduling and controlling large projects.
   - The concept is straightforward or straightforward (straightforward) and does not require mathematical and complicated calculations.
   - The graphics network helps to quickly see the relationships between project activities.
   - Critical path analysis and slack time help show activities that need closer attention.
   - Project documentation and drawings show who is responsible for diverse activities.
   - Can be applied to various projects.
   - Useful in monitoring schedules and costs.

ii. The Disadvantages
   - Project activities must be clearly defined and the relationship must be free and stable.
   - Prior relations must be explained and netted together.
   - Estimates of time tend to be subjective and depend on the honesty of managers who are afraid of danger too optimistic or not quite pessimistic. Estimates of time tend to be subjective and depend on the honesty of managers who are afraid of danger too optimistic or not quite pessimistic.
   - There is a hidden danger with too much emphasis on the longest or most critical path.

3. Methodology

This study discusses the design of a project schedule for feeder cable distribution and distribution for the construction of ODC and ODP. The research results are in the form of a project schedule needed by the owner as a reference material for implementing the project. Project Schedule: September 3, 2018. Based on Fig. 1, shows the conceptual model of the project development schedule used in the research of the STO Nanjung FO Feeder Installation Project. The conceptual model used is a develop schedule process contained in Project Time Management. The conceptual model shows four variables, namely the earliest start, earliest finish, latest start, and the latest finish. ES (earliest start) is the earliest time an activity can start assuming all of its predecessors have finished. EF (earliest finish) is the earliest time an activity can be completed. LS (late start) is the last time an activity can begin so as not to delay the completion of the entire project. LF (late finish) is the last time an activity can be completed so it does not delay the completion of the entire project.

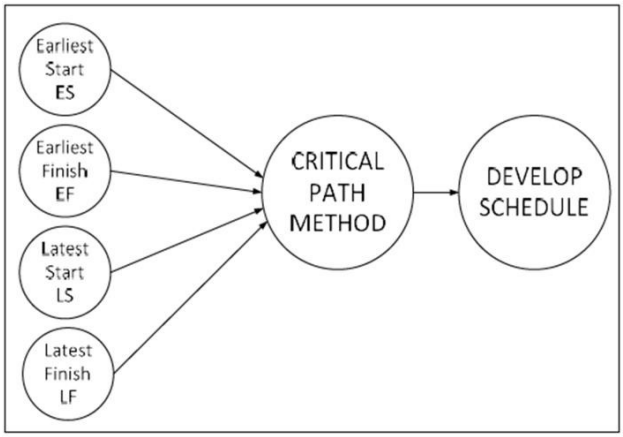

Fig. 1 - Conceptual model

In the develop schedule process using the critical path method (CPM). CPM is a method used to estimate the minimum project duration and determine the amount of flexible scheduling on a logical network path in the schedule model. This schedule network analysis technique calculates starting, ending, ending, and ending for all activities regardless of resource limitations by analyzing forwards and backward through a schedule network [2,11].

4. Result and Discussion

The forward and backward pass calculations for each activity provide several values of activity time including the earliest start time, the last start time, the earliest completion time and the final finish time directly. In addition, the results of forward and backward pass calculations indirectly result in a time of activity allowance, namely the difference between the earliest and last time of the activity without slowing down the completion of the project. The term float can be defined as the amount of time available in an activity so as to allow for a deliberate delay or delay in activity, but the delay time does not cause the project to be late. The float is divided into two types, namely free float (FF) and total float (TF). Free float is the time available for delays or slowing down of activities without affecting the start of activities afterward or successors. To calculate the free floats use the following formula:

$$FF = ES\ (successor) - EF\ (predecessor) - 1 \quad (1)$$

While, the total float is the time available for delays or slowing down of activities without affecting the overall project time. To calculate the total floats use the following formula:

$$TF = LS - ES \text{ or } LF - EF \quad (2)$$

The following are examples of total float calculations for material delivery activities that have the latest value start = 1, and have the earliest start value = 1:

$$TF = LS - ES$$
$$TF = 1 - 1 \quad (3)$$
$$TF = 0$$

Based on the total float calculation using the CPM method, the material delivery activity has a total float value of 0. Total float calculations using the CPM method for all project activities are shown in Fig 2 - (a). After performing the total float calculation, it can be seen that the activity that has its total float value = 0 is the activity of A - B - C - D - E - F - G - H - L - M - N - O - P - Q - R - S - T. This indicates that sixteen of these activities do not have a grace period for late so-called critical activities. The path that connects the critical activity is called the critical path. In scheduling above the critical path is A - B - C - D - E - F - G - H - L - M - N - O - P - Q - R - S - T. The critical path can be seen in Fig 2 - (b).

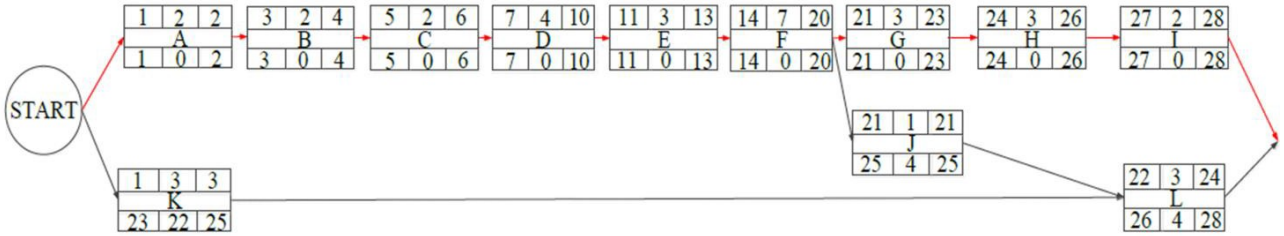

Fig. 2 - (a) Network Diagram Critical Path

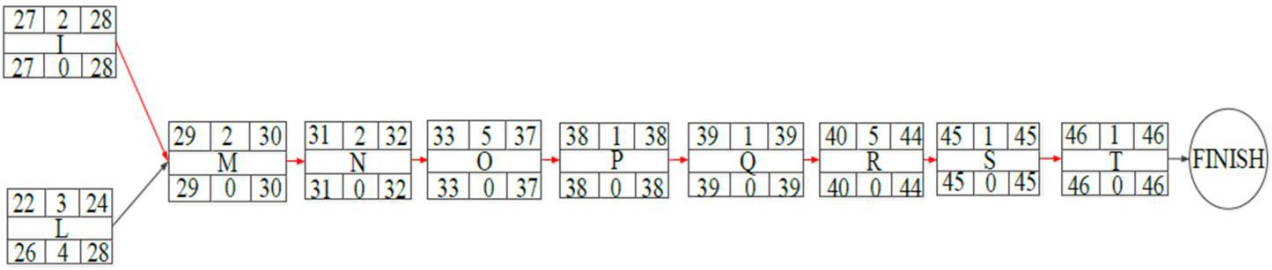

Fig 2. - (b) Network Diagram Critical Path (Cont.)

4.1 HDPE Clamping Activity

HDPE Clamping Activities obtain forward pass results with the earliest start 5 and earliest finish 6 values, while the backward pass results obtain the latest start 5 and latest finish 6 values so that the total float results in HDPE Clamping activities are 0. This indicates that HDPE Clamping activities are a critical activity that is an activity that does not have a grace period for being late. Therefore, after installing the sub-duct at STO Nanjung, the project manager must be able to ensure that the HDPE pipe clamping process is carried out within 2 days. The HDPE clamping process has two ways, namely the boring system and the open trench system. In boring systems, it is necessary to pay attention to the cable depth that has been determined which is at least 150 cm or in accordance with the applicable local government rules.

4.2 Excavation Activity

Land excavation activities are carried out as large as the land needed to install fiber optic cables. The excavation is carried out by the open trench method, which is a direct planting method by direct excavation of the fiber optic cable withdrawal grooves, especially for the cable planting grooves that are parallel to the road. This activity obtained forward pass results with the earliest start 7 and earliest finish 10 scores, while the backward pass results obtained the latest start 7 and latest finish 10 values, so that the total float results in the Soil Excavation activity were 0. This indicates that the Ground Excavation activity is critical activity is an activity that does not have a grace period for being late. At excavations that cut in the entrance of residents' houses or shopping areas, they must be immediately stockpiled or landed or temporary bridges can be installed in the form of boards because they can disturb the traffic of people or vehicles.

4.3 Hoarding Activities

Hoarding activities are carried out after the installation or installation of the cable work is completed. After the withdrawal or installation of cables carried out on the excavation has been completed, the excavation must be closed or backfilled so that the soil returns to its initial condition. This activity obtained forward pass results with the earliest start 7 and earliest finish 13 scores, while the backward pass results obtained the latest start 7 and latest finish 13 values, so that the total float results in the claim activity were 0. This indicates that the activities of deducting are a critical activity that is an activity that does not have a grace period for being late. The collecting activity requires four workers. Collating is done by dumping sand as high as approximately 10 cm each 5 cm below and above the cable.

4.4 Duct cable installation

Duct wiring is done after sub-duct installation and HDPE clamping. Duct cabling has similarities with the sub-duct installation process, but the difference between the two is the type of cable used and the place of cabling.

4.5 Duct Cable Installation activities

Duct Cabling Activities obtain forward pass results with the earliest start 14 and earliest finish 20 values, while the backward pass results obtain the latest start 14 and latest finish 20 values, so that the total float results in the Duct Cable Installation activity are 0. This indicates that the activity Duct Cabling is a critical activity. The selection of duct pipes must be considered, the duct pipe to be used must be in one road along the existing duct route.

4.6 Cable Connection Activities

The optical fiber connection tool used in this project is universal closure (UC). Installation of optical fiber connecting device (UC) is done after the duct cable is installed. This activity obtained forward pass results with the earliest start 14 and earliest finish 20 scores, while the backward pass results obtained the latest start 14 and latest finish 20 values, so that the total float results in the fiber optic connector installation activities were 0. This indicates that the activity installation of fiber optic connectors is a critical activity. Workers who are tasked with installing UC devices must be ensured of wearing head protection equipment or special helmets that are in accordance with the provisions or rules regarding work safety (safety rules).

4.7 Cord Installation Activity

The patch cord is a fiber optic cable of a certain length that has a connector installed at its end, used to connect between devices. Patch cord installation activities are carried out after connecting optical cables. Patch cord installation activities obtained forward pass results with the earliest start 27 and earliest finish 28, while the backward pass results obtained the latest start 27 and latest finish 28 values so that the total float results in patch cord installation activities were 0. This indicates that activity Patch cord installation is a critical activity.

4.8 Passive Splitter 1: 4 Installation Activity

Passive splitters are simple fiber optic cables that divide optical signals into several paths (multiple paths) or combination signals in one path. The installation of a 1: 4 passive splitter obtained forward pass results with the earliest start 21 and earliest finish 21 values, while the backward pass results obtained the latest start 25 and latest finish 25 values so that the total float results in patch cord installation activities are 4. This indicates that the 1: 4 passive splitter installation activities have a grace period of 4 days. Because getting a grace period does not mean workers delay the installation of a 1: 4 passive splitters, but workers must continue to carry out the activity for one day so that if there are obstacles in the process, it will not affect the overall project schedule.

4.9 SITAC ODC Land Acquisition Activities

Land acquisition is a way for companies to take over a certain amount of land that is controlled or owned by several communities (private or legal entities) to be used in property or tourism development. In this project, land acquisition is used in the construction of ODC devices. The acquisition activities of the SITAC ODC land obtained forward pass results with the earliest start 1 and earliest finish 3 values, while the backward pass results obtained the latest start 23 and latest finish 25 values so that the total float results in patch cord installation activities were 22. This indicates that 1: 4 passive splitter installation activities have a grace period of 22 days.

The SITAC team must have the ability to negotiate and understand the psychology of individuals and a community group understands population administration documents for individuals, understand land ownership administration documents, and can establish good communication with NGOs (Non-Governmental Organizations) and CSOs (Community Organizations). Because of permission from the local government has been issued, cancellation can occur at the insistence of the community, NGOs, or CSOs.

4.10 ODC Installation Activities

ODC is a passive device installed outside the STO. In this project, the installation of ODC is carried out on the ground (outdoor) so that there is a need to acquire land for the installation of ODC. ODC installation activities obtained forward pass results with the earliest start 22 and earliest finish 24 scores, while the backward pass results obtained the latest start 26 and latest finish 28 values so that the total float results in ODC installation activities are 4. This indicates that ODC installation activities have a grace period of 4 days. In the process of lifting ODC cannot be done by human power, therefore it must use tools such as pulleys, levers, or other tools.

4.11 Pole Installation Activities

Iron pole installation is the first step to be able to install an aerial cable. Installation of poles is planted 1/5 of the part that goes into the ground, for steel poles installed pole reinforcement from 30 cm cement mortar. And the distance between poles is between 40-50 meters. 14 iron pole installation activities obtained forward pass results with the earliest start 29 value and earliest finish 30, while the backward pass results obtained the latest start 29 and the latest finish 30 values, so the total float results in the iron pole installation activities were 0. This indicates that Iron pole installation activities have a grace period of 0 days. The location of the pole must not interfere with pedestrians or vehicles, even so with the placement of poles arranged in such a way as not to disturb the aesthetics of the scenery and beauty. The distance of the pole needs to be considered, for within the city approximately 40 meters and for outside the city approximately 50 meters.

4.12 Activities of Pole Accessories Installation

The installed iron pole requires the installation of accessories on the pole. Pole accessories include pole strap, stag clamps, S clamps, and stripper. The installation of pole accessories obtained the forward pass with the earliest start 31 and the earliest finish 32, while the backward pass obtained the value of the latest start 31 and the latest finish 32, so the total float result in the pole accessories installation activity was 0. The process of painting an iron pole on a pole is positioned perpendicularly. So, the work process can be completed within two days.

4.13 Aerial Cabling Activities

Aerial cabling, namely the installation of fiber optic cables carried out in the air. Fiber optic cable installation from ODC to ODP uses aerial cable installation because of the ease in the installation process and reducing the time and cost compared to using the duct system. Air cables can be installed on new poles or existing poles. Aerial cabling activities obtained forward pass results with the value of earliest start 33 and earliest finish 37, while the results of the backward pass obtained the value of the latest start 33 and the latest finish 37, so the total float results in aerial cabling activities were 0. For the placement of fiber optic cables must be above the copper cable because the unregulated fiber optic cable is bundled together with a copper cable.

4.14 Air Cable Connection Activity

Aerial cable connection is based on withdrawal routes. On a straight route with a distance between 40-50 meters pole using a hanging method, while on a turning or curving route use a belay method. In the mooring, the process must use special tools and not cut the hanging wire (bearer). Aerial cable connecting activities obtain forward pass results with the value of earliest start 33 and earliest finish 37, while the results of backward pass obtain the value of the latest start 33 and the latest finish 37 so that the total float results in aerial cabling activities are 0. This indicates that the activity aerial cabling does not have a grace period, so after the aerial cabling activity is finished, then it is connecting the air cable.

4.15 Passive Splitter 1: 8 Installation Activity

Previous passive splitter installation activities but different ratios and system attenuation passive splitters with a ratio of 1: 8 have a system attenuation of 8.8 - 11.0 dB, 1: 8 passive splitter installation activity obtains forward pass with earliest start 39 and earliest finish 39, while for backward pass results get the value of the latest start 39 and the latest finish 39, so the total float result in the passive splitter 1: 8 installation activity is 0. This indicates that the passive splitter 1: 8 installation activities has no grace period, by therefore there needs to be more stringent supervision so that the time of implementing 1: 8 passive splitter installation activities runs for one day.

4.16 ODP Installation Activities

ODP is a successor box or internet connection divider distributed from the company and distributed back to the client. ODP has a functional equation with switch and HUB. ODP installation activities obtained forward pass results with the earliest start 40 and earliest finish 44, while the backward pass results obtained the latest start 40 and latest finish 44 values, so the total float results in ODP 1: 8 installation activities were 0. This indicates that ODP installation activities do not have a grace period, therefore it is necessary to pay attention to the input cable that goes to the ODP device generally in the form of a distribution cable, the cable must enter through the hole/path that has been provided on the ODP device.

4.17 Grounding Installation Activities

Grounding is a security system for devices that use electricity as a source of energy from electricity or lightning surges. The main purpose of the existence of grounding is to create a path that has resistance or low pressure on the earth's surface. Grounding installation activities obtain forward pass results with the earliest start 45 value and earliest finish 45, while the backward pass results obtain the latest start 45 and latest finish 45 values, so the total float results in the grounding installation activity are 0. This indicates that the grounding installation activity has no grace time. The location of the grounding road is not too far from the house, but do not damage the installation system that has been embedded and the placement between the grounding roads in a straight line, not too many turns. For the selection of materials also need to be considered, the best grounding road is a solid pipe made of copper, in addition to its strong conductivity, it is also not easily corroded.

4.18 ODP Activity Ready For Use

ODP ready for use activities obtain forward pass results with the earliest start 46 value and earliest finish 46, while the backward pass results get the latest start 46 and the latest finish 46 values, so the total float result is 0. This indicates that ODP activity is ready for use does not have a grace period, because in ODP ready for use activities only ensures that the ODP is properly installed.

5. Conclusion

By using the CPM method, the total time needed to complete the project is 46 days with 16 critical activities. There are 16 activities included in the critical activity because they have a total float value of 0, namely the activity A - B - C - D - E - F - G - H - L - M - N - O - P - Q - R - S - T. The critical activity does not have a grace period for being late, and the duration of the activity cannot be changed unless the company wants to change the overall duration of the project. Strict supervision of 16 critical activities is needed so that the project can run according to the specified time. There is a need for further research on the analysis of the cost of STO Nanjung's FO feeder installation project on monitoring and controlling so that this research becomes a lesson learned for future projects.

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