

TEFA Development Analysis using the Critical Path Method at SMK Taruna Persada Dumai

Trisna Mesra¹, Melliana², Fitra³, Azmi⁴, Dini Febriyanti⁵

Program Studi Teknik Industri, Sekolah Tinggi Teknologi Dumai
Jl. Utama Karya Bukit Batrem II
E-mail: trisnamesra74@gmail.com

Abstrak

Proyek merupakan sebuah rangkaian aktifitas unik yang saling terkait untuk mencapai suatu hasil tertentu dan dilakukan dalam periode waktu tertentu pula. Oleh karena itulah, guna mencapai sebuah hasil proyek yang bagus menyangkut waktu dan biaya, Sudah seharusnya dalam sebuah proyek mengimplementasikan manajemen proyek agar tercapainya hasil yang sesuai. Berdasarkan dari permasalahan tersebut, penulis melakukan penelitian dengan menggunakan metode CPM (Critical Path Method) guna mencari waktu optimal dalam pelaksanaan proyek dan untuk mendapatkan biaya anggaran yang optimal dalam pelaksanaan proyek pembangunan Teaching Factory di SMKS Taruna Persada Dumai. selain itu, dalam penelitian ini juga menggunakan CV (Cost Variance) dan SV (Schedule Variance) untuk mengetahui indeks kinerja dan performansi proyek. Berdasarkan perhitungan melalui metode CPM (Critical Path Method), Waktu yang optimal dalam pelaksanaan proyek ini adalah 65 hari kerja, dengan biaya yang optimal berdasarkan perhitungan metode CPM (Critical Path Method) diperoleh biaya sebesar Rp. 188.044.781. Berdasarkan perhitungan performansi melalui metode CV (Cost Variance) dan SV (Schedule Variance), proyek Teaching Factory diperoleh nilai CV sebesar -Rp. 4.949.624 dan nilai SV sebesar Rp.7.398.376. Hal ini menyatakan bahwa proyek pembanguna Teaching Factory dari segi pelaksanaan pekerjaan lebih cepat dari yang direncanakan dengan biaya yang dihabiskan lebih besar daripada yang dianggarkan.

Kata kunci: Manajemen proyek, CPM, NPV, CV, SV

Abstract

A project is a unique series of interrelated activities to achieve a certain result and carried out within a certain period of time. However, most projects are implemented not using proper and appropriate management, so that it has an impact on wasting time and project budget costs which causes low profits for contractor companies. Based on these problems, the authors conducted research using the CPM (Critical Path Method) method in order to find the optimal time in project implementation and to obtain optimal budget costs in implementing the Teaching Factory development project at SMKS Taruna Persada Dumai. In addition, this study also uses CV (Cost Variance) and SV (Schedule Variance) to determine the performance index and project performance. Based on calculations through the CPM (Critical Path Method) method, the optimal time for the implementation of this project is 65 working days, with the optimal cost based on the CPM (Critical Path Method) calculation obtained a cost of Rp. 188,044,781. Based on the calculation of performance through the CV (Cost Variance) and SV (Schedule Variance) methods, the Teaching Factory project obtained a CV value of -Rp. 4,949,624 and the SV value of Rp. 7.398.376. This states that the Teaching Factory development project in terms of work implementation is faster than planned with the costs spent being greater than budgeted.

Keywords: Project management, CPM, NPV, CV, SV

1. Introduction

Project activities can be interpreted as a temporary activity that lasts for a limited period of time, with the allocation of certain resources and is intended to produce products or deliverables whose quality criteria have been clearly outlined (Soeharto, 1999). Project activities in the process of achieving their final results are limited by time and cost. The implementation of projects within the organization is generally carried out to achieve specific objectives, the activities are clearly defined when it starts and when it ends, and there are restrictions on funds

to carry out these project activities. In addition to the accuracy of time estimates, confirmation of the relationship between the activities of a project is also needed for planning a project.

SMKS Taruna Persada is one of the implementing elements of the teaching factory project development. This teaching factory development project was carried out for the learning needs of entrepreneurship for SMKS Taruna Persada Dumai students. In working on the project, workers have not used the CPM method in determining the time and costs required. So far, workers in determining time and costs are only based on experience. SMKS Taruna Persada Dumai often have problems in the completion time of development projects because the completion time does not match the time agreed with the previous workers. This will have a negative impact because the school will incur more costs with the inaccurate time of project completion.

According to Levin and Kirkpatrick (1972), the Critical Path Method (CPM), which is a method for planning and monitoring projects, is the most widely used system among all other systems that use the principle of network formation. With CPM, the amount of time required to complete the various stages of a project is considered to be known with certainty, as is the relationship between the resources used and the time required to complete the project. CPM is a project management model that prioritizes cost as the object being analyzed (Siswanto, 2007). CPM is a network analysis that seeks to optimize the total project cost by reducing or accelerating the total completion time of the project in question.

The objectives and benefits of the Critical Path Method (CPM) are as follows:

1. To map out all the steps required to complete the project and identify a schedule for each priority and sequence involved.
2. Shows the relationship of each activity to the whole project.
3. Identify the relationship that should take precedence between activities.
4. Show realistic cost and time estimates for each activity.
5. Assist in the use of manpower, money and other resources by observing critical issues in the project.

The project scheduling that has been discussed previously does not include the company's stock of resources. Consideration of the available resources can change the life of the project because limited resources for an activity or activity can make the time to work on the activity or activity can make the execution time of the activity longer, and vice versa. we will use the critical path method Critical Path Method (CPM), reduction of project life and resource planning in the next sub-chapter (Santosa, 2009).

The first crisis trajectory method was used on construction projects at the Du Pont company in 1957. This method put more emphasis on project costs. This is different from PERT which places more emphasis on time uncertainty, and for research and development (R&D) projects. In CPM there is no application of statistical methods to accommodate the uncertainty. The CPM also discusses the existence of a bargain or trade-off between the time schedule and project costs (Santosa, 2009).

CPM assumes that the project life can be shortened by adding labor, equipment, and capital resources for certain activities. If there are no other provisions, then the time for carrying out the activity is considered to be in "Normal" conditions, the execution time under normal conditions is called normal time (T_n). The cost of carrying out an activity under normal conditions is called the normal cost (C_n). Additional manpower or overtime work can reduce normal time. The addition of the workforce means additional costs. The normal time T_n is usually the longest time for an activity while the normal cost C_n is the cheapest cost. If all the resources owned by the company are mobilized so that an activity can be completed as quickly as possible, then the activity is said to be Crashed. The crashed condition is not only related to the fastest time, but also to the biggest cost. In the crashed condition, the time for carrying out the activities is the C_c fee.

2. Research Method

The research was conducted at the Taruna Persada Dumai Vocational School, which is located on Jalan Abdul Rab Khan KM 05, Bukit Timah Village, Dumai Selatan District, Dumai

City, Riau. This research was conducted on the teaching factory building construction project. This research will take place in March 2021.

The types of data used in this study are secondary data and primary data. Secondary data are books, journals and data obtained directly from SMKS Taruna Persada Dumai related to the discussion. Then, primary data is data obtained by researchers directly from the first party related to time data in project implementation, costs incurred in project implementation, as well as tools and materials used in project implementation.

In the implementation of data collection can be done in several ways or tools used to obtain research data called the term data collection techniques, namely observation, interviews, and documentation. The stages of data analysis used in this study are as follows:

1. Descriptive statistics, namely analyzing data by describing the data that has been collected.
2. Data processing using the CPM (Critical Path Method) method, with the following steps:
 - a. Assess and identify project scope
 - b. Describe, break it down into activities or groups of activities that are components of the project.
 - c. Rearrange the components in point 1, into a chain in the appropriate order of dependency logic, providing an estimate of the timeframe for each activity that results from the description of the project scope.
 - d. Identify the critical path (critical path) and float on the network.
3. Draw conclusions from the results of research and processing with the methods used.

3. Results and Analysis

The data taken to conduct research on the Teaching Factory construction project for SMK Taruna Persada Dumai which was carried out in March, namely schedule data, description of project implementation activities, work time, pessimistic time, most likely time, optimistic time and budget plan. Data obtained from SMK Taruna Persada Dumai.

3.1. Data Description of Teaching Factory Project Implementation Activities

Calculation of project implementation time using the CPM method. Data description of activities as well as the time of each activity of the project implementation is required. Data description of project activities for the construction of teaching factory SMKS Taruna Persada Dumai can be seen in Table 1.

Table 1. Data Description of Teaching Factory Project Implementation Activities

| No | Description of activities |
|------------|--|
| I | Preliminary Work |
| 1 | Preparation of tools and materials |
| 2 | Location Cleaning |
| 3 | Install bouwplank/measurement |
| II | Teaching Factory Building |
| 1 | Foundation work |
| 2 | Foundation excavation work |
| 3 | Mobile Trench Excavation Works |
| 4 | Foundation sand fill work |
| 5 | P1 Reinforced Concrete Foundation Works |
| 6 | Rib work 1 brick |
| III | Bata Foundation Raben Jobs |
| 1 | Concrete And Structure Works |
| 2 | Column Work K1 Reinforced Concrete 20/20 cm |
| 3 | RB1 Concrete Beam Ring Work 15 x 20 Cm |
| IV | Wall work |
| 1 | Brick Wall Installation 1: 2 |
| 2 | Wall Plaster Installation 1: 2 |
| V | Door And Glass Works |
| 1 | Iron Panel Door Installation Work |
| 3 | The Job of Installing Door Frames and Rear Door Leaves |
| 2 | Installation of window frames and shutters |

| | |
|-------------|--|
| VI | Floor job |
| 1 | Soil embankment work under the ground floor Thickness 30 cm |
| 2 | 8 cm thick floor slab casting work |
| 3 | 40 x 40 . Floor Ceramic Installation Work |
| 4 | Acian job |
| VII | Ceiling Works |
| 1 | Plywood Ceiling + Frame Work |
| 2 | Ceiling List Job |
| VIII | Roof Frame Work |
| 1 | Light Steel Easel Installation |
| IX | Roof Covering Works |
| 1 | Metal tile roof installation work |
| X | Electrical Installation Work |
| 1 | Light installation work |
| 2 | Power outlet installation work |
| 3 | MCB box work |
| XI | Air compression installation |
| 1 | Air compression installation |
| XII | Painting Job |
| 1 | wall paint job |
| 2 | ceiling paint job |
| B | Doorsmeer Building |
| XIII | Foundation work and sanitation |
| 1 | Doormeer building foundation excavation work |
| 2 | Sanitation work |
| XIV | Pole and roof steel work |
| 1 | Pole construction installation |
| 2 | Installation of roof construction |
| XV | Floor job |
| 1 | Floor casting 13.4 x 20 M |
| 2 | Acian job |
| 3 | Installation of hydraulic equipment (single post H type hydraulic carwash) |
| XVI | Water machine installation work |
| 1 | Installation of water machine installation |
| XVII | Final Work |
| 1 | Finishing work |
| 2 | Final Cleaning |

Table 1 is a data description of the project implementation activities for the construction of the teaching factory at SMKS Taruna Persada Dumai. Detailed data on development activities and planned implementation times using the CPM method can be seen in Table 2.

Table 2. Detailed Data on Activities and Implementation Time Planned with the CPM Method

| Code | Type of activity | Work days | Worker | The Number of workers | Preliminary Activities |
|------|---|-----------|---------------------|-----------------------|------------------------|
| A | Location cleaning | 3 | Craftsman Helper | 1 2 | - |
| B | Preparation of tools and materials | 3 | Helper | 2 | A |
| C | Install bouwplank /measurement | 4 | Craftsman Helper | 1 1 | B |
| D | Teaching factory building foundation excavation work | 3 | Craftsman Helper | 1 1 | C |
| E | Mobile trench excavation work | 2 | Helper | 1 | C |
| F | P1 teaching factory reinforced concrete foundation work | 5 | Craftsman Helper | 1 1 | C |
| G | Rib work 1 brick | 4 | Craftsman Helper | 1 1 | D,E,F |
| H | Bata Foundation Raben Jobs | 4 | Helper | 2 | G |
| I | Teaching factory foundation sandfill work Concrete sloof work 20 x 20 Cm | 4 | Helper | 1 | H |
| J | Reinforced concrete K1 column work 20/20 cm | 5 | Craftsman Helper | 1 1 | I |
| K | Reinforced concrete K1 column work 20/20 cm | 4 | Craftsman Helper | 1 1 | J |
| L | Concrete ring work RB1 15 x 20 Cm | 5 | Craftsman | 1 | K |

| | | | | | |
|----|---|---|-----------|---|------------|
| | | | Helper | 2 | |
| M | 1:2 . brick wall installation | 4 | Craftsman | 1 | L |
| | | | Helper | 1 | |
| N | Installation of wall plaster 1: 2 | 3 | Craftsman | 1 | M |
| | | | Helper | 1 | |
| O | The job of installing the frame + iron panel door leaf and frame + back door leaf | 3 | Craftsman | 1 | M |
| P | The work of installing windows + shutters | 2 | Craftsman | 1 | M |
| U | Light Steel Easel Installation | 4 | Craftsman | 1 | M |
| V | Metal tile roof installation work | 3 | Craftsman | 1 | N,O,P,U |
| | | | Helper | 1 | |
| W | Plywood Ceiling + Frame Work | 4 | Craftsman | 1 | M |
| | | | Helper | 2 | |
| X | Ceiling List Job | 3 | Craftsman | 1 | W |
| | | | Helper | 1 | |
| Q | Soil embankment work under the ground floor Thickness 30 cm | 3 | Helper | 1 | I |
| R | 8 cm thick floor slab casting work | 4 | Craftsman | 1 | Q |
| | | | Helper | 1 | |
| S | 40 x 40 . Floor Ceramic Installation Work | 5 | Craftsman | 1 | R |
| | | | Helper | 2 | |
| T | Finishing work | 2 | Helper | 1 | S |
| Y | Install the LED light | 1 | Craftsman | 1 | M |
| Z | Install the socket | 2 | Craftsman | 1 | Y |
| AA | MCB box work | 2 | Craftsman | 1 | Z |
| AB | Doormeer building foundation excavation work | 3 | Craftsman | 1 | C |
| | | | Helper | 1 | |
| AC | Sanitation work | 3 | Craftsman | 1 | AB |
| AD | Pole construction work | 5 | Craftsman | 1 | AB |
| | | | Helper | 2 | |
| AE | Roof construction work | 4 | Craftsman | 1 | AB |
| | | | Helper | 2 | |
| AF | Floor casting | 4 | Craftsman | 1 | AC,AD,AE |
| | | | Helper | 1 | |
| AG | Finishing work | 2 | Helper | 1 | AF |
| AH | Wall Paint Job | 4 | Craftsman | 1 | T,AG |
| | | | Helper | 1 | |
| AI | Ceiling Paint Job | 3 | Craftsman | 1 | X |
| | | | Helper | 1 | |
| AJ | Install electricity | 3 | Craftsman | 1 | AA |
| AK | Installation of air installation equipment | 4 | Craftsman | 1 | AH |
| AL | Installation of hydraulic equipment (single post H type hydraulic carwash) | 5 | Craftsman | 1 | AK |
| AM | Installation of water machine installation | 4 | Craftsman | 1 | AL |
| AN | Final work (finishing) | 4 | Helper | 1 | V,AI,AJ,AM |
| AO | Cleaning | 3 | Helper | 2 | AN |

The project for the construction of the SMKS Taruna Persada Dumai teaching factory has a project price of Rp. 201,332,781,-. The price of the project includes planning a detailed price quote consisting of materials, wages, and tools used.

The desired time for the construction project of the SMKS Taruna Persada Dumai teaching factory is 90 days, to find out the time the work carried out meets the desired target can be calculated using the CPM method. The steps for processing time data using the CPM method are compiling a network diagram based on the time duration of each type of activity, calculating the earliest starting time (ES), calculating the latest starting time (LS), calculating the earliest finish time (EF), calculate the most recent finish time (LF), and slack. The activity trajectory that has a slack value of 0, then the activity is in a critical path. The steps of data processing using the CPM method are as follows.

3.2. Time Data Processing Using the CPM Method

The desired time for the construction project of the SMKS Taruna Persada Dumai teaching factory is 90 days, to find out the time the work carried out meets the desired target can be calculated using the CPM method. The steps for processing time data using the CPM method are compiling a network diagram based on the time duration of each type of activity, calculating the earliest starting time (ES), calculating the latest starting time (LS), calculating the earliest finish time (EF), calculate the most recent finish time (LF), and slack. The activity trajectory that has a slack value of 0, then the activity is in a critical path. The steps of data processing using the CPM method are as follows.

1. Draw up network diagrams

Prepare a network diagram of the Teaching Factory project activities using the AOA (activity on arrow) approach based on the planned data including the duration of the working day of each type of activity in Table 4.2. CPM network diagrams can be seen in Figure 1.

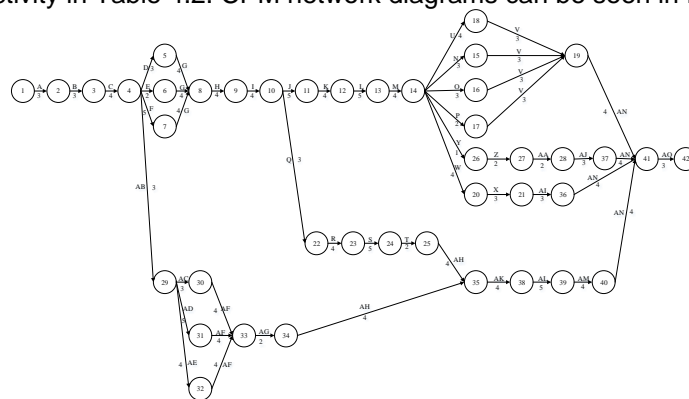


Figure 1. Network Diagram of Teaching Factory Development Project for SMK Taruna Persada Dumai

Figure 1 is a network diagram of the teaching factory project activities for the Taruna Persada Dumai Vocational High School in Dumai.

2. Determine the critical path and project completion time

The next step is to calculate the ES, EF, LS, LF, and slack from each activity time to determine the critical path. Critical trajectory on the project to determine and know the project completion time. The calculation results can be seen in Table 3.

Table 3. Calculation of ES, EF, LS, LF and Slack with the CPM Method

| Code | Processing time | ES | EF | LS | LF | Slack |
|------|-----------------|----|----|----|----|-------|
| A | 3 | 0 | 3 | 0 | 3 | 0 |
| B | 3 | 3 | 6 | 3 | 6 | 0 |
| C | 4 | 6 | 10 | 6 | 10 | 0 |
| D | 3 | 10 | 13 | 12 | 15 | 2 |
| E | 2 | 10 | 12 | 13 | 15 | 3 |
| F | 5 | 10 | 15 | 10 | 15 | 0 |
| G | 4 | 15 | 19 | 15 | 19 | 0 |
| H | 4 | 19 | 23 | 19 | 23 | 0 |
| I | 4 | 23 | 27 | 23 | 27 | 0 |
| J | 5 | 27 | 32 | 30 | 35 | 3 |
| K | 4 | 32 | 36 | 35 | 39 | 3 |
| L | 5 | 36 | 41 | 39 | 44 | 3 |
| M | 4 | 41 | 45 | 44 | 48 | 3 |
| N | 3 | 45 | 48 | 52 | 55 | 7 |
| O | 3 | 45 | 48 | 52 | 55 | 7 |
| U | 4 | 45 | 49 | 51 | 55 | 6 |
| V | 3 | 49 | 52 | 55 | 58 | 6 |
| W | 4 | 45 | 49 | 48 | 52 | 3 |
| X | 3 | 49 | 52 | 52 | 55 | 3 |
| Q | 3 | 27 | 30 | 27 | 30 | 0 |
| R | 4 | 30 | 34 | 30 | 34 | 0 |

| | | | | | | |
|----|---|----|----|----|----|----|
| S | 5 | 34 | 39 | 34 | 39 | 0 |
| T | 2 | 39 | 41 | 39 | 41 | 0 |
| Y | 2 | 45 | 47 | 49 | 51 | 4 |
| Z | 2 | 46 | 48 | 51 | 53 | 5 |
| AA | 2 | 48 | 50 | 53 | 55 | 5 |
| AB | 3 | 10 | 13 | 27 | 30 | 17 |
| AC | 3 | 13 | 16 | 32 | 35 | 19 |
| AD | 5 | 13 | 18 | 30 | 35 | 17 |
| AE | 4 | 13 | 17 | 31 | 35 | 18 |
| AF | 4 | 18 | 22 | 35 | 39 | 17 |
| AG | 2 | 22 | 24 | 39 | 41 | 17 |
| AH | 4 | 41 | 45 | 41 | 45 | 0 |
| AI | 3 | 52 | 55 | 55 | 58 | 3 |
| AJ | 3 | 50 | 53 | 55 | 58 | 5 |
| AK | 4 | 45 | 49 | 45 | 49 | 0 |
| AL | 5 | 49 | 54 | 49 | 54 | 0 |
| AM | 4 | 54 | 58 | 54 | 58 | 0 |
| AN | 4 | 58 | 62 | 58 | 62 | 0 |
| AO | 3 | 62 | 65 | 62 | 65 | 0 |

Table 2 is a calculation table using the CPM method to find the critical path and project completion time. Based on the slack value 0 indicates that the activity is an activity that is on a critical trajectory. The critical paths in the calculation table are: A, B, C, F, G, H, I, Q, R, S, T, AH, AK, AL, AM, AN and AO with a completion time of 65 days. After getting the critical path and project completion time, the next step is to create a critical path on the network diagram. The calculation of wages is based on the cost of labor for each activity and then the total cost of wages for these activities. The wages that have been obtained from each activity are then multiplied by the working days of each activity. The cost of materials and tools does not depend on the calculation of the day, but based on each activity. The project cost budget for 65 days based on Table 4.7 is Rp. 188.044,781.

3.3. Determination of Performance Index

Determining the performance index can be done through evaluating the project's performance at a certain point in time. There are various variables that can be used, the variables are BCWS (Budgeted Cost Of Work Scheduled), ACWP (Actual Cost Of Work Performed) and BCWP (Budgeted Cost Of Work Performed). From the three BCWS, BCWP and ACWP quantities, other quantities can be obtained, namely CV (Cost Variance) and SV (Schedule Variance). If the CV value is negative, it means that the project's performance in terms of costs is not good because the actual costs are greater than planned. If the SV is positive, it means that the execution of the work is faster than what was done and vice versa if it is negative, it means that there has been a lag behind what was planned. The project for the construction of the Teaching Factory SMKS Taruna Persada Dumai building has a project price of Rp. 239,247,099. Implementation of the desired project for 90 days which means for 3 months. Currently, the construction project for the Teaching Factory building has been running for 52 days. The CV and SV calculation data for the Teaching Factory building project at SMKS Taruna Persada Dumai can be seen in Table 4.

Table 4. Calculation of CV and SV Data for Teaching Factory Project

| No | Information | Cost |
|----|----------------|-----------------|
| 1 | Budgeted costs | Rp. 239.247.099 |
| 2 | BCWP (52 hari) | Rp. 138.231.657 |
| 3 | ACWP (52 hari) | Rp. 143.181.281 |
| 4 | BCWS (52 hari) | Rp. 130.833.281 |

Table 4 shows CV and SV calculation data consisting of ACWP, BCWP and BCWS values for 52 days. The results of the calculation of CV and SV can be seen as follows.

$$\begin{aligned}
 CV &= BCWP - ACWP \\
 &= Rp. 138.231.657 - Rp. 143.181.281 \\
 &= -Rp.4.949.624
 \end{aligned}$$

$$\begin{aligned} \text{SV} &= \text{BCWP} - \text{BCWS} \\ &= \text{Rp. } 138.231.657 - \text{Rp. } 130.833.281 \\ &= \text{Rp. } 7.398.376 \end{aligned}$$

The calculation above shows that the results of the CV calculation are negative, namely -Rp.4.949,624 and the SV calculation is positive, which is Rp. 7,398,376. Based on the table of cost variance prices and schedule variants and their meaning means that in terms of carrying out the work faster than planned with costs spent greater than budgeted.

4. Conclusion

The conclusions in this study are as follows, the optimal time in the implementation of the Teaching Factory construction project at SMKS Taruna Persada Dumai after being calculated using the CPM method is 65 days. While the optimal cost in implementing the Teaching Factory development project at SMKS Taruna Persada Dumai for 65 days after using the CPM method is Rp. 188.044,781 of the initial cost for 90 days of Rp. 201,332,781. There is a difference in cost reduction of Rp.13,288,000. The Teaching Factory construction project at SMKS Taruna Persada Dumai has a negative CV value of -Rp.4,949,624 and a positive SV value of Rp.7,398,376. This means that in terms of the execution of the work faster than planned with the costs spent being greater than budgeted.

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