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Project Performance Analysis using Earned Value Management Method in Telecommunication

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Abstract: One of telecommunication project in Indonesia is shut downing the obsolete telecommunication infrastructure such as Sentral Telephone Otomate in Tanjungsari Bandung. This project is a modernization project of fiber optic network for 334 locations in Tanjungsari Sub-district. To compare actual performance of the scope, schedule and cost with planning for making right decisions in project's status and performance, required controlling by using Earned Value Management method since it can integrate these three things at the same time. Status and index of project performance on the 22nd day indicate that project was behind schedule that caused loss revenue of Rp 2,600,000.00 with 98% of delays from planning and project get 94% of overruns budget from issued value with amount of Rp 7,410,000.00. In addition, forecasting is done as a corrective action of past project status and performance. It is estimated that the project duration to complete work is 31 days with total cost for the remaining work (EAC) of Rp. 140,170,00.00 from previous project performance. It is also estimated that cost for remaining work until the project is completed or ETC is Rp. 7,770,000.00 with size of the project's forecasting status is a deficit from VAC value that calculated about (Rp 7,410,000.00) and the project will complete based on the TCPI forecasting calculation.

Keywords: Infrastructure project, project control, Earned Value Management, project performance, forecasting.

1. Introduction

The infrastructure project is a complex and large project involving the public and private sectors. One of the infrastructure projects is Shutdown STO Tanjungsari Project. Shutdown STO Project in Tanjungsari is a project that focuses in cable modernization project to replace copper cable into fiber optic cable. There is a company engaged in telecommunications realized that internet users in Indonesia from year to year is increasing. Survey by Statistika [1] showed that the number of Indonesian Internet user will be doubled in 2023. This number means the biggest task in the future is waiting especially the infrastructure of telecommunication project. Whitout this project, the upcoming user will not satisfy the service well particularly the high-speed issue. Replacing the oldest network to the newest network technology will help Indonesian internet subscribers to use the internet. The most ambitious project that had the largest subscriber is located in Java which is one of the provinces in Indonesia. Java is divided into three areas including West Java, Middle Java and East Java. Shutdown STO Project in Tanjungsari is done in West Java that replacing the former network to advance network.

There are 334 locations in Sumedang Regency need to replace in fiber optic cable. According to the project manager of Project Shutdown STO Tanjungsari, this project should increase the company revenue, customer satisfaction, and achieving the goal of the organization or the project owner. This project used Fix price or Lump Sum contract which has been awarded to one of the Telecommunication project vendors in Bandung. This type of contract is very risky based on vendor point of view. They need to monitor all the cost incurred and maintain good performance

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while completing project task. Any cost which has been spent higher than the ceiling price is very difficult to be reimbursed. Then, vendor should control the whole task and keep the budget on the line.

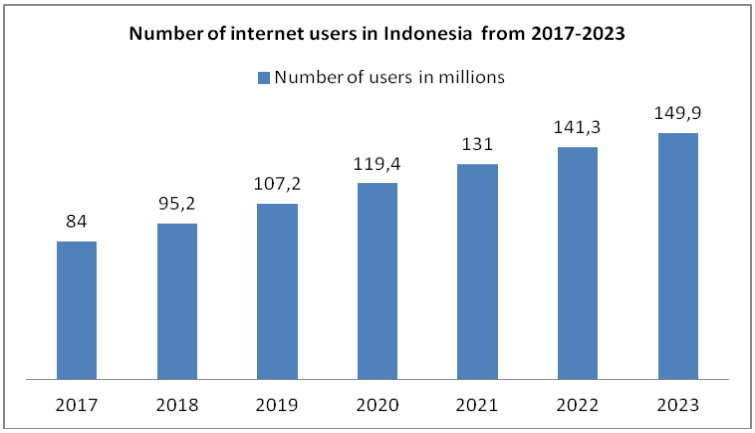

Fig. 1 - Internet user from Indonesia [1]

During executing phase, a project required a comprehensive and very tight monitoring [10-11]. According to PMBOK, as the most popular guided book for project management, the project manager should check the project performance against the project planning [2]. There are some constraints while executing the project which is commonly known as the triple constraints. The triple constraint in the project comprises the scope, schedule, and cost. These project constraints are important for controlling the project in order to provide the right decision on the project [3]. Earned Value Management is a method of controlling project that integrates project scope, schedule and cost to measure project performance [4]. It produces numerical ratio and index which can be comprehended by qualitative result. EVM used to calculate the variance between schedule and cost. It also calculates the efficiency of project progress against the project planning (baseline). In addition, EVM can estimate or forecast the actual schedule and cost based on remaining work to achieve project success [5]. Therefore, EVM is very suitable for controlling this project especially when carry out fix price project because it can minimize risk the overrun schedule and over budget.

2. Literature Study

In 1967 project controls were used in projects in the US Government that integrated the schedule and cost control system called Cost/Schedule Control System Criteria (C/SCSC) [6]. For the next 5 years in 1972, first C/SCSC is used to ensure consistency among military department. After two decades, EVM used for DOD instruction 5000.2 in defense actuation management policies and procedures issued. Over time, the implementation of project control over schedules and costs becomes a necessity in organizations for internal organizational control and financial reporting [7].

Controls that integrate project scope, schedule, and cost are used by the federal government called the Earned Value Management System. In 1989 the American National Standards Institute (ANSI) published guidelines on the use of EVM [6]. In 2000, the Project Management Institute issued a simpler and more detailed terminology about EVM in his book PMBOK Guide [4]. Moreover, in the 2005, Project Management Institute publishes the Practice Standard for Earned Value Management. This methodology become important tool for control project because can make the project effective and efficient and help the project manager and project team for corrective action for the status and performance the project.

2.1 EVM Concept

In EVM there are three important components of Plan Value (PV), Earned Value (EV), and Actual Cost (AC). Plan Value can be defined as how much work can be accomplished in the planned time function. Earned Value is the value of project progress based on project cost. While Actual Cost represents the cost incurred to complete the task. These three components are periodically evaluated. It can be concluded that the main concept of earned value management relates to budget, actual cost, and progress task performance. On project performance measurement, EVM is used in measuring project cost based on the time period. The performance indicates how much under budget occur or over budget and also measure how many dates that the project is behind schedule or ahead schedule. A delay within the project can be seen by finding the status project using Earned Value Management. This is also the reason for deciding schedule compression to accelerate the duration of the project [8]. The difference of the three components EVM will result some variances. Cost variance is determined from the difference between earned value and actual cost. While the variance schedule means the difference between earned value and plan value.

EVM calculation is usually determined by the ratio between the three important components. For identifying cost performance can be calculated by the ratio between earned value and actual cost. In the other hand, Schedule Performance Index (SPI) calculated from the earned value ratio with the plan value. The earned value management concept also provides a quantitative measure for project performance and help for calculating forecasts for remaining work in cost and schedule status. EVM is integrated with scope management including change control, predictive and reliable budget, and more realistic schedule. EVM integrates these three management aspects into a system that can be used as a project control tool. Despite the unique nature of the project, EVM can help control the project accurately, periodically, and consistently with project performance measurement since the calculation is based on the real project performance.

2.2 Forecasting for Remaining Work

EVM yang can integrate management control methodology of scope, schedule, and cost performance and it provides forecasting of the real budget and schedule. Forecast for remaining work can be such a sign of an early warning of what actually occur in the project. It also provide for the cost of remaining work, expected total cost, expected status of the project, and expected efficiency cost. The functions of forecasting are also to predict the final project performance. When it is used in conjunction with the Critical Path Method (CPM), EVM can also provide the forecast of the total project duration. When significant variances occur, it must be analyzed to identify the source of problem for corrective action.

The earned value management concept provides a quantitative measure of project performance and necessary mathematical formulation for forecasting final project cost and schedule status. As the project progresses, forecasts can be developed for cost and schedule performance. Schedule forecast is calculating the duration for remaining work until the project done. Schedule forecast used time estimate which usually use date the project starts plus time remaining. But in this research, the time estimate for remaining work will be calculated with a ratio in between the percentage of remaining work and project progress in a certain period. Estimate at Completion (EAC) is the expected total cost for the project when work will be completed. EAC can be analyzed based on project conditions. In instance, if the future cost performance will be performed at the budgeted rate, future cost performance will be the same as all past cost performance, and the future cost performance will be influenced additionally by past schedule performance. Basically, the EAC can be calculated based on budgeted rate and the project performance. In this research, EAC calculated by using Budget at Completion plus Actual Cost minus Earned Value. The value of EAC show the condition of the project whether future work will be accomplished at the planned rate and the value of daily CPI has different status and performance.

The estimate to complete (ETC) is the expected cost for complete all the remaining work [5]. The formal EAC can be estimated by the project team, however EAC may also be calculated based on EAC. Typically, the EAC based on EAC minus the actual cost for the work. Forecasts the amount of budget deficit or surplus at the end of the project is variance at completion (VAC) [5]. The VAC shows the project team if the project forecasted to finish under or over budget. VAC calculated by different between Budget at Completion and Estimate at Completion that will estimate the different in cost at the completion of the project. The last forecast is for performance efficacy needed to complete the project is called To-Complete Performance Index (TCPI) [5]. TCPI used ration of remaining work to remaining budget. In this research the value of TCPI used that the efficiency that have to be maintained in order to complete the current EAC.

2.3 Research Methodology

As shown in Fig.2, EVM method as a tool to measure project performance in economic way. EVM has a basic principle of performance patterns and trends that integrate project scope, schedule, and cost at the baseline to generate project performance [5]. EVM also still has the best description to analysis the project performance.

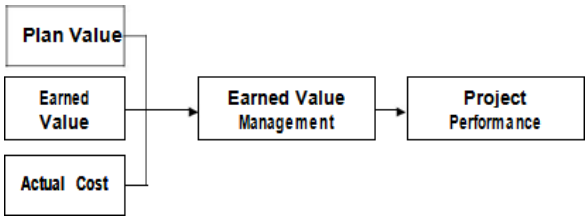

Fig. 2 - Research data relationship

The basic data for EVM such as plan value, earned value, and actual cost. These three components are processed by using variance analysis for schedule variance and cost variance. Schedule variance will be calculated by finding the differences in between earned value and plan value. For cost variance, earned value and actual cost will be calculated for finding the difference between two of them. Hence, EVM is also used to calculate the project performance

efficiency for schedule and cost. In schedule, the performance efficiency called Schedule Performance Index that will calculate the ratio between earned value and plan value. Then the cost called Cost Performance Index that will calculate the ratio between earned value and actual cost.

From data processing using EVM, it will be produced project performance that may help the project manager aware the status and performance efficiency of the project. The past status and performance efficiency EVM are also made for calculating the actual schedule and budget which is called the schedule and budget forecast. The forecasting usually calculated the estimate duration, expected total cost, total cost for the reaming work, expected variance, and expected cost efficiency.

3. Result and Analysis

Scope baseline is approved of scope statement, work breakdown structure (WBS) and WBS dictionary by project stakeholder. Scope statement in STO Tanjungsari Shutdown Project is the project function is for cable modernization access in STO Tanjungsari. The project executor is PT. DCM for 30 days and the project value written in the contract. The project deliverables are project charter for formal project initiator, progress report for project performance report, and commissioning test for the project closing.

The success criteria of the project are on time and on budget especially not over budget from the planning, and project should gain more revenue. The limitation are the project just conduct modernization cable in STO, the budget is not more than planning cost, if any change request is occur, the change should be confirmed as soon as possible, the duration for project execution is 30 days exclude day off, and contract price based on fix price contract which has been agreed upon both parties (contractor and project owner). The Work Breakdown Structure (WBS) of the project can be seen in Fig. 3 Work Breakdown Structure.

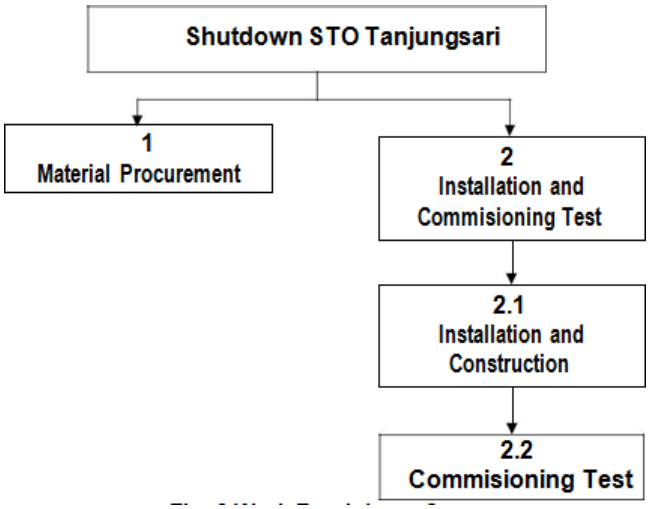

Fig. 3 - Work breakdown structure

The Work Breakdown Structure is divided into 3 levels. First level is the project, Shutdown STO Tanjungsari. Second level is sub-project material procurement and installation and commissioning test. The last level or third level is installation and construction and commissioning test. The WBS divide into three levels because of the project work decomposed into small work in order to help project manager and project team for execute the project.

Plan value, earned value, and actual cost are the most basic and mainly important data for EVM method. Plan value, earned value, and actual cost are basic data that should be included in EVM calculation. Plan value is a budgeted plan to complete the project task. Earned value is the value of work performed. Actual cost is the real actual cost incurred during a specific period to complete the project task. Those three components used for calculating the status variance and performance project. Project can be separated from S curve. S curve is the best used in controlling the project. The S curve depicts 3 curves correspond the project status such as earn value, planned value and actual value. The actual and earn value curve should be in lined with planned value curve if the gap occur then it may indicates something good or bad news. The good news such as the project is ahead schedule and under budget. The bad news such as the project is behind schedule and over budget. The unit measurement of this project is day as a consequence the S curve will be produce using “day” measurement. The S curved is illustrated in the Fig. 4.

This project took 30 days to be finished. The observation took the day-21. At this point, the project performance will be analyzed. From the S curve can be seen at the beginning of the project period, earned value and actual cost is zero because there is no task done in that period. But in the next period 3th - 12th, it is clear that the project's plan value is below earned value and actual cost. This may indicate that project schedule is overrun and over budget.

From the 13th to 16th the earned value line is below actual cost line. The actual cost line is below the plan value line. That means the project is behind schedule and over budget. In 17th the project status produces the same value as the planning (baseline) because the plan value, earned value, and actual cost stay in the same point. From 18th to 22nd, the project status is behind schedule and over budget from baseline. Form S curve, some corrective action should be taking over soon in order to minimize the huge gaps between actual and baseline.

Table 1 - Project Performance Summary

Period	PV	AC	EV	SPI	CPI
1	Rp6,913,150.21	Rp-	Rp-	0	-
2	Rp13,826,300.43	Rp-	Rp-	0	-
3	Rp20,739,450.64	Rp15,378,239.10	Rp23,369,683.08	1.13	1.52
4	Rp27,652,600.86	Rp27,065,700.82	Rp35,845,153.96	1.30	1.32
5	Rp34,565,751.07	Rp37,112,817.03	Rp45,204,176.72	1.31	1.22
6	Rp41,478,901.29	Rp46,442,282.09	Rp53,682,464.14	1.29	1.16
7	Rp48,392,051.50	Rp55,464,182.36	Rp59,982,141.40	1.24	1.08
8	Rp55,305,201.71	Rp62,948,258.72	Rp68,499,142.47	1.24	1.09
9	Rp62,218,351.93	Rp69,817,205.52	Rp73,919,052.23	1.19	1.06
10	Rp69,131,502.14	Rp76,378,587.54	Rp79,561,565.44	1.15	1.04
11	Rp76,044,652.36	Rp82,324,839.99	Rp82,658,656.74	1.09	1.00
12	Rp82,957,802.57	Rp87,758,484.47	Rp86,299,674.69	1.04	0.98
13	Rp89,870,952.79	Rp92,576,999.39	Rp90,375,253.27	1.01	0.98
14	Rp96,784,103.00	Rp96,780,384.75	Rp93,266,968.70	0.96	0.96
15	Rp102,375,307.67	Rp100,368,640.54	Rp95,719,477.87	0.93	0.95
16	Rp107,966,512.33	Rp102,521,594.01	Rp96,784,103.00	0.90	0.94
17	Rp113,557,717.00	Rp107,318,947.60	Rp109,364,313.50	0.96	1.02
18	Rp113,589,354.50	Rp120,289,570.27	Rp113,557,717.00	1.00	0.94
19	Rp113,620,992.00	Rp120,323,083.29	Rp113,588,658.48	1.00	0.94
20	Rp114,434,522.13	Rp120,342,520.83	Rp113,603,825.49	0.99	0.94
21	Rp115,248,052.25	Rp120,351,904.48	Rp113,616,961.38	0.99	0.94
22	Rp116,061,582.38	Rp120,356,596.30	Rp113,620,992.00	0.98	0.94

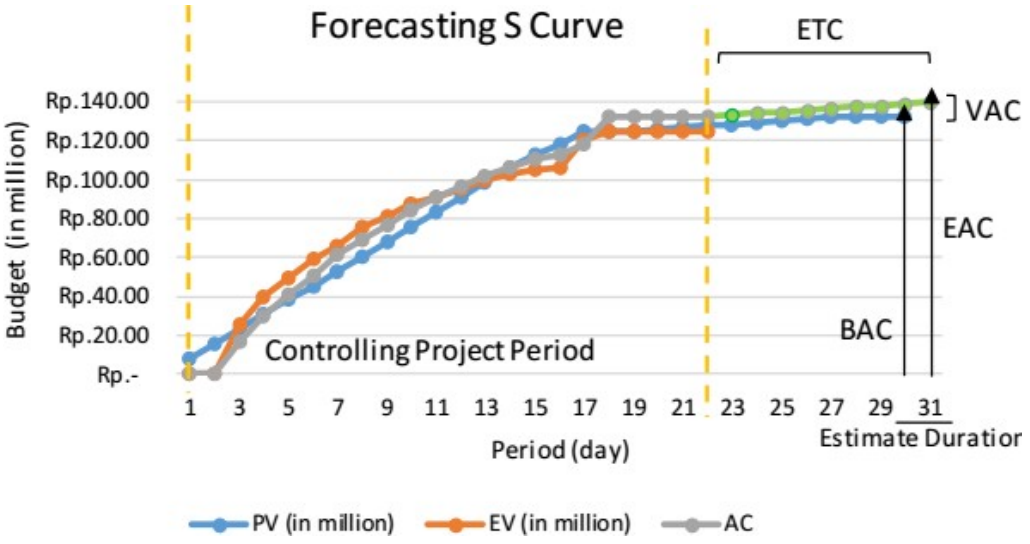

Fig. 4 - Forecasting S curve

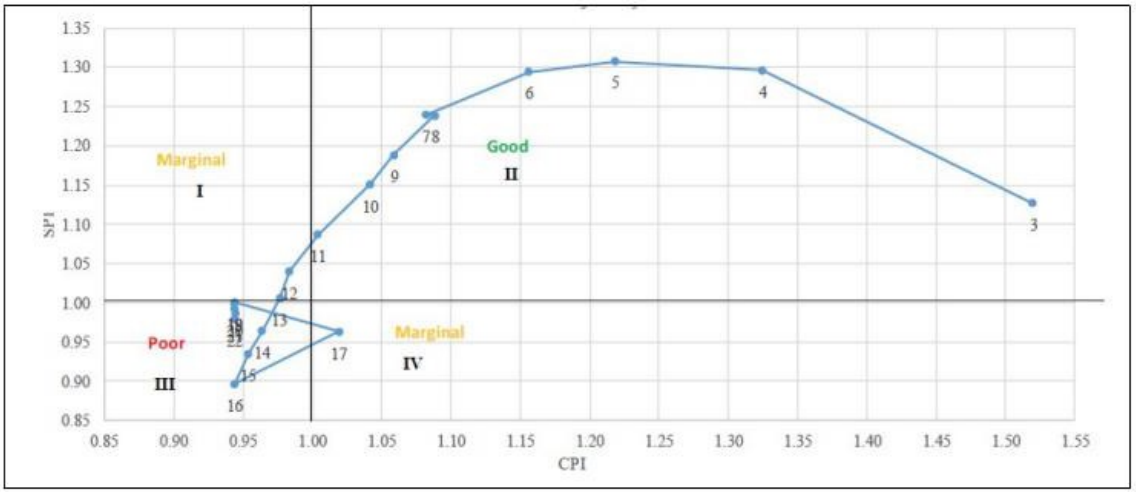

Fig. 5 - Project performance quadrant

Form the last observation, schedule progress produces only 98% form the planning baseline, it equals with the the loss of Rp. 2.680.000,00. In addition, the project also experienced an over budget of Rp. 7.410.000,00. This is because every Rp. 1 incurred by the project is only worth Rp. 0.94. After getting the last status the project manager can forecast for the rest of the work for the project to finish and succeed. Forecasting is done by calculating EAC, ETC, VAC, and TCPI. The results are illustrated in the S curve of project forecasting in the Fig. 5. Below is the calculation of project forecast both schedule and cost.

Cost Performance Index:
CPI= EV/AC
CPI= Rp 113,620,992,00/Rp 120,356,596,30
CPI=0,94

Schedule Performance Index:
SPI= Rp 113,620,992,00/Rp 116,061,583,38
SPI= 0,98

Cost Forecast (Upcoming actual cost):
Estimate at Completion (EAC)= Budgeted at Completion (BAC) + Actual Cost- Earn Value
EAC= Rp 120,688,169 + Rp 120,356,596,30- Rp 113,620,992,00
EAC= Rp. 127,423, 773,30

Cost Estimation to complete the remaining task:
ETC= EAC-AC
ETC= Rp 127, 423, 773,30 - Rp 120,356,596,30
ETC= Rp 7,067,177,00

Schedule Forecast:
Schedule Forecast = Current date of observation/ SPI = 30/0.94 = 31 Days
Variance between upcoming actual cost and baseline:
VAC= BAC-EAC
VAC= Rp 120,688,169- Rp. 127,423, 773,30
VAC= -Rp 6,735,604,30

To Complete Performance Index:
TCPI= (BAC-EV)/(EAC-AC)
TCPI= (Rp 120,688,169- Rp 127, 423, 773,30)/(Rp. 127,423, 773,30- Rp 120,356,596,30)
TCPI= 1

All The final project duration is 31 days indicating the project increase up to 1 day to complete the remaining work. The actual spending of this project or EAC is Rp. 140.170.000,00. The cost for the remaining work (ETC) of Rp. 7.7700.000,00. From the Fig. 5, the EAC is above the BAC that means the project cost turn to high up to Rp.

7.410.000,00. All the CPI and SPI form 22 data were plotted by Cartesian diagram. The Cartesian shows the three project conditions which are good, marginal and poor. As shown in Fig.6, at the early start until day 11, the project stay in good position. Nevertheless, the projects start to marginal and poor status at day 12 to 22. This visual diagram will help the project manager especially the main stakeholder to understand about what the project is going on.

The EVM calculation will not end until finding the "To-Complete-Performance-Index". This value indicates the comparison between remaining works toward the remaining budget. If the value produces more than "1", then project condition seems terrible. However, if the value produces less than 1 then the project condition seems fine. According to TCPI calculation, this project has approximately produced more than 1, then it may show the project still need to be done but the budget may run out gradually. To investigate the deviation, Root cause analysis or Ishikawa diagram is used as a tool for finding the problem. Root cause analysis can be seen on Fig. 6. Project Manager held meeting and invited some project team to investigate the problem within the project. From root-cause analysis, the over budget is caused by implementing the change request directly without some proper change request procedure. In the material aspect, the volume of actual material is not the TCPI same as planning one. There are so many changes in the project which are not documented well. According to PMBOK [5] any change request should be evaluated first based on the scope, time, and schedule and quality impact.

The result of the change request evaluation is handed to important stakeholder who familiarly known as "Change Control Board". These people are responsible to decide whether the change request can be done or not. The last step of change request is updating the project management plan and project baseline as well so it will be fruitful for implementing the EVM calculation. However, in the STO Tanjungsari Shutdown project, the project management plan and baseline were not updated thus they cannot visualize the actual condition and the project performance became poor. From the method aspect, procurement activities are conducted in parallel sequence which leads to increase the warehouse cost. Warehouse costs are not listed in the cost baseline plan, so it makes the actual cost is not same as planning cost. The lesson learned from this situation is all the material should be prepared first and ready to be used rather than conduct in executing phase. This situation means the vendor management should carefully implemented and keep the best communication with them.

The man aspect shows that the team project is not proactive and aware with change request process. The project team are not educated enough about change request procedure according to the theory. Thus, the excessive change request is implemented without evaluated first. The telecommunication company has not applied the correct PMO (Project Management Office) principles in control process. From this case, the actual project performance was not achieved because the project team did not update the project management plan and baseline when change occurs. The most necessary is the Project Management Office. Project Management Office is an organization that standardizes project -related governance processes and facilitates resources, tools and techniques (PMI, 2017). The PMO has the responsibility to integrate project scope, schedule, and cost into clear standardization and methodology in each project. In addition, PMO projects can help projects that are being worked on simultaneously not interfere because they can predict the availability of resources and organizational capabilities in working on projects.

In addition, the PMO has the authority in the project control with various types of supportive, controlling, and directive. The functions of the PMO itself can also be project oversight, compliance monitoring procedures, project policy management, and project communication coordination. However, this finding is in line with study from Ullah et al [10] that shows Asian project had suffered the project management cost overrun problem that outstanding planning is a must to avoid the overbudget.

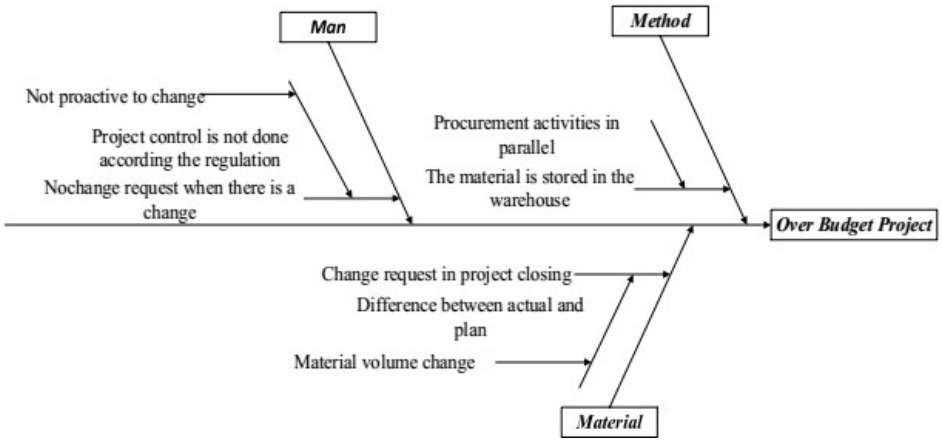

Fig. 6 - Root cause diagram

4. Summary

Telecommunication project is one of the aggressive projects held in Bandung to fulfil the internet demands. The project should start immediately since people can live without the internet now. Although the project must be done

straightaway, the tight controlling must not be neglected. Implementing EVM can instantly depict project condition in economic term which is one of the top management's concerns. Based on EVM calculation the project status experiences a little delay and 6% budget overruns from the planning. Although the result produces some problem in here but this number is fairly acceptable. However, form TCPI calculation, the project still has many to be accomplished with very limited budget. Thus, it may enter important consideration whether the project should be crashed by adding some sources or fast tracked. Form root cause analysis the source of delay or over budget can be identified by conducting a team management meeting. Over budget experienced by the project due to not updating the project management plan that makes the baseline plan measurement not updated and different from actual one. For further research it will be better to jump into alternative crashing or fast-tracking scenario to meet the desired plan.

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