International Journal of Applied Engineering Research ISSN 0973-4562 Volume 10, Number 17 (2015) pp 37619-37623

Risk Mitigation Delay Design of Natural Gas Pipeline Project

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Abstract
One of the natural gas pipeline project delay impact are team's lack of discipline in carrying out the project management. The purpose of this study is to provide a mitigation project delays by integrating methods Earned Value Management and Risk Management. By doing comparison Planned Value, Earned Value, Actual Cost and monte carlo simulation results in three gas pipeline project had occured same events. In practice, three projects in accordance with its original destination. At the beginning of project, both SPI and CPI value in the three projects experienced significant deviation values to one another, SPI value at the beginning of the project 1 above the value of two (2), as well as SPI values in the above value of two (2) on second project, it indicates that the material procurement activities could not be met because the production process, transport, and distribution of materials that are not planned. It is also experienced by third project, although not as big as SPI value other than before, but the risk of project delays have appeared since the beginning of the project. Best action to take is to separate the procurement of materials of construction activities.

Keywords— Earned Value Management, Project Performance, Project Evaluation, Critical Path Method, Monte Carlo Simulation, Risk Management

I. Introduction

Successful Execution of Project Management can be measured from achievement of company's objective, that is project on schedule, finance, and accordance with technical specifications, with using the resources effectively, efficiently, accepted by customer [13]. Based on the United States experiences as reported by Standish Group's Chaos Chronicles record the percentage of projects are late and can not be resolved in accordance with a target of 18% [11]. In 2010, it was mentioned that within 15 years there were more than 90% of the gas pipeline project National Iranian Gas Company (NIGC) has been delayed [9]. Project delay can be defined as the slow implementation of planning process in a given period on all parties concerned agreed to the construction project [5]. Natural gas pipeline development became a good concrete steps that can be performed in a limited capacity of its distribution and transmission infrastructure. Therefore, it should be a risk mitigation plan of gas pipeline project delays by integrating several methods of project control.

II. Literature Review

A. Project Monitoring and Evaluation

Monitoring and controlling project executions are a series of activities of tracking, reviewing, and progress report to obtain performance objectives that it defined in the project management plan [18]. The main advantage of this process is that it allows stakeholder to understand about current implementation status of project, actions plan and taken, cost, schedule, and scope forecasting. Monitoring includes collecting, measuring, and distributing performance information, test measurement and trends on the impact of process changes. While the control includes determining corrective or preventive action or re-planning and follow-up on the action plan to determine whether the actions taken to resolve performance issues.

Performance measurement involves progress monitoring of project, which has two processes and results. First part is to see actual performance data compilation. Seconds part involves foresight and projected attainment based on project plan. The analysis techniques have an important role in project management success [4]. Some of the techniques used are regression analysis, causal analusis, forecasting method (sequence time activities, building scenarios, simulation, etc.), failure mode and effect analysis (FMEA), fault tree analysis (FTA), earned value management (EVM), and others.

B. Earned Value Management

Earned Value (EV) widely accepted and began a well documented application that will bring value added to the project control scheme [1], [2], [3], [6], [10], [12]. Some writers has made improvement to a traditional EV by improving its ability to contol and to monitor the project progress [15], [20]. Thus, it is not surprising that EV can be applied in many fields of education and project. EVM constructed and monitored by three element in every work packages and control records, among others are Planned Value (PV); Earned Value (EV); and Actual Cost (AC). While variance from basic budgeting has been approved and always monitored are Schedule Variance (SV), Cost Variance (CV), Schedule Performance Index (SPI), and Cost Performance Index (CPI).

C. Risk Management

The positive impact or consequences of any project is usually being challenged and confronted with certain risks. Interaction between risk and impact is crucial of overall project feasibility. If there is no risks has been monitored, yet not identificated nor mitigated, it likely that the project became failed. If, on the other hand, risks impact and consequences are reviewed in advance then the project is likely to be succeed. Because the nature of subjective risk impact analysis, the quantitative methodology is needed to translate risk impact in measurable quantities. These results can be used to assess the validity and project effectiveness success [8]. Risk assessment has calculation stage, there are the validation of

project scope, duration, and costs; including identification, quantification, and risk models. Then assign a risk ranking list based on contribution of total project budget and time variances. [19]. Risk assessment had stages calculation, there are validation of project scope, costs, and duration; including identification, quantification, and risk models. Then assign risk ranking list based on contribution of total project budget and time variance [19]. Sources of risk that affect project performance including time, cost, and quality of positive and negative sides. Sources of these risk which are classified based on their physical properties, environmental, planning, logistics, financial, legal, political, construction, and operational risk [7].

D. CPM and PERT

Critical Path Method (CPM) and Project Evaluation and Review Technique (PERT) focus on identifying the Longest time Consuming path through a networks of tasks as a basic for planning and Controlling a project [16]. Three time estimates were subsequently used to calculate the expected time. Estimated time were obtained from people who are experts or people who will perform these activities.

E. Monte Carlo Simulation

Monte Carlo Method is a useful technique for modeling and analyzing real-world systems and situations and can be used to calculate cost of project completion or amount of project completion duration. Each calculation is iterative process. Activity costs uncertain inserted into a probability distribution function [14]. Costs for all activities of project were selected by random variable sampling.

III. Research Methodology

There are two major approaches to gathering information about situation, personally, problem or phenomenon. Based on this approach to collect a lot of information, data can be categorized as primary and secondary data [5]. The data used in this research project is natural gas pipeline installation located in Tangerang, Banten (246 days); Palembang, South Sumatera (266 days); and Jakarta (105 days). Historical data obtained in the activity report and S-curve then included in earned value management calculation. Furthermore, to obtain mitigation or to reducing the risk level, it could be done with monte carlo simulation. Deterministic calculation results compared with probabilistic results of activities project uncertain.

IV. Results

Some of performed steps in achieving project objectives, both in terms of cost efficiency and time effectiveness. Tabulated results and simulation data obtained in previous chapters are used to mitigate risk project delay. EVM is used to monitoring project performance of project historical data, CPM/PERT is used to evaluate project duration and cost, then monte carlo simulation used in probabilistic estimation of duration and cost.

From simulation results obtained activities that effect project performance, among others, material procurement, licensing, mobilization and demobilization, shop drawing, hottaping, pipe connection work, and project reports. Based on activities that affected project performance above, then risk analysis can be done in terms of project cost and project completion time.

TABLE I. **Project Performance Test for Project No. 1**

EV Metrics	Project no. 1		
	Week 3	**Week 17**	**Week 30**
CV (m.u)	843,793	838,506	(449,049)
SV (m.u)	757,113	490,374	630,282
CPI	5.73	1.27	0.97
SPI	3.86	1.14	1.05
EAC (m.u)	2,357	10,615	13,967
VAC (m.u)	13,511,692	13,503,435	13,500,083
ETC (m.u)	(175,984)	(3,059,793)	(13,828,305)
TCPI	0.94	0.92	(0.37)
Duration (days)	246		

From total project duration of two hundred and forty six (246) days on project no. 1, it can be seen that the project has been delayed at week three (3), this is caused by limited availability of primary material. Index values has been change start at week seventeen (17), due to insufficient labor capacities ranging and field material.

TABLE II. **Project Performance Test for Project No. 2**

EV Metrics	Project no. 2		
	Week 3	**Week 19**	**Week 30**
CV (m.u)	1,565,793	1,317,234	1,035,066
SV (m.u)	770,814	(1,764,467)	(781,172)
CPI	4.01	1.45	1.22
SPI	1.59	0.71	0.88
EAC (m.u)	1,738	4,798	5,718
VAC (m.u)	6,964,387	6,961,327	6,960,407
ETC (m.u)	(519,007)	(2,910,566)	(4,738,728)
TCPI	0.76	0.67	0.53
Duration (days)	266		

From total project duration two hundred and sixty six (266) days on project no. 2, that can be seen on table 4.2. At week three (3), as well as on project no. 1, there is a potential delay. This can be due to availability of primary material also caused land supply process. Due to natural gas pipeline project linkage with many government agencies and other underground utility owners institutions, then in the beginning of project there is a delay.

TABLE III. **Project Performance Test for Project No. 3**

EV Metrics	Project no. 3		
	Week 3	Week 7	Week 12
CV (m.u)	(5,771.55)	20,291	200,044
SV (m.u)	(101,673)	(67,770)	182,221
CPI	0.74	1.07	1.35
SPI	0.14	0.83	1.31
EAC (m.u)	1,177,056	937,159	1.30
VAC (m.u)	(448,680)	(208,783)	(61,767)
ETC (m.u)	1,155,059	627,746	(519,007)
TCPI	1.01	1.16	0.76
Duration (days)	105		

From total project duration of a hundred and five (105) days, project no. 3 has a potential delay in accordance with project objectives, the project on time. From three samples of project time calculation, week three (3) until week twelve (12), the time and cost performance index pointed to index value number one (1). This indicates that labor allocation and primary project material in accordance with main project's initial plan.

In mitigating risk factor of cost, a step that can be done is to monitor cost variance (CV) and schedule variance (SV), in addition to comparing historical data and result of monte carlo simulation, as shown in figure 1 up to figure 3 below.

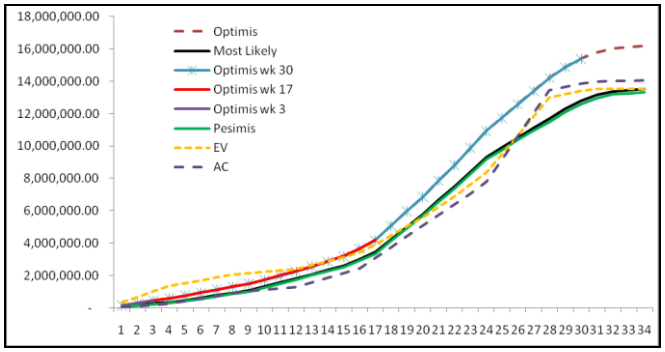

Fig. 1. **S-curve for Total Project no. 1 Budgeting Simulation at Week 3, 17 and 30.**

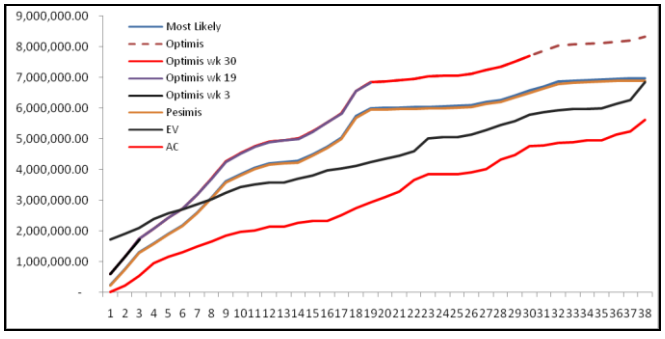

Fig. 2. **S-curve for Total Project no. 2 Budgeting Simulation at Week 3, 19 and 30.**

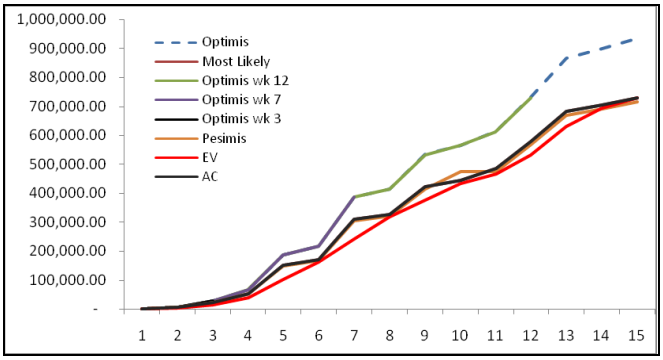

Fig. 3. **S-curve for Total Project no. 3 Budgeting Simulation at Week 3, 7 and 12.**

After depiction and time calculation of project execution by set project time, then obtained :

1. There are nine (9) critical path of project no. 1. As for number of activities on critical path is fourteen (14), namely 'project material procurement'; 'licensing'; 'shop drawing'; 'hotmix layer demoliliton'; 'paving block layer demolition'; 'concrete layer demolition'; 'line pine stringing'; 'pipeline welding'; 'lowering'; 'coating joint'; 'holiday test'; 'NDT work'; 'project documentation'; 'commisionning'; to 'project management'.
2. There are four (4) critical path of project no. 2. As for number of activities on critical path is sixteen (16), namely 'project material procurement'; 'material handling'; 'mobilization'; 'temporary road'; 'stringing'; 'line-up connection'; 'tie-in connection'; 'hottaping connection'; 'project documentation'; 'lowering'; 'pipeline crossing'; 'excavation retaining wall'; 'hotmix layer repairing'; 'excavated soil removal'; 'pipeline cutting'; to 'line pipe beveling'.
3. There are two (2) critical path of project no. 3. As for number of activities on critical path is twenty two (22), namely 'project material procurement'; 'safety tools and devices'; 'supporting tools'; 'pipeline coat cleaning'; 'cleanup location'; 'pipeline layer cleaning'; 'paint cleaning'; 'H-beam layer cleaning'; 'first and second linepipe layer painting'; 'third linepipe layer painting'; 'fourth and fifth linepipe layer painting'; 'sixth linepipe layer painting'; 'seventh linepipe layer painting'; 'sixth H-beam layer painting'; 'pipeline double wrapping'; 'casting concrete pipe'; 'safety guard installation'; 'marker post fabrication'; 'marker post installation'; 'location cleanly'; 'demobilization'; to 'project documentation'.

In the first project implementation, it situation occurs with aforementioned actual cost by plan costs (cost overruns), but at week twenty (20) until twenty six (26) project cost approaching ideal value. At the same time, it cost overruns had cost impact of 706,827.73 m.u below the nominal project cost limit. Start at week twenty seven (27) until project time completion, it activities approaching to the ideal value of zero

(0). This situations can be anticipated with additional resources of labor and tools.

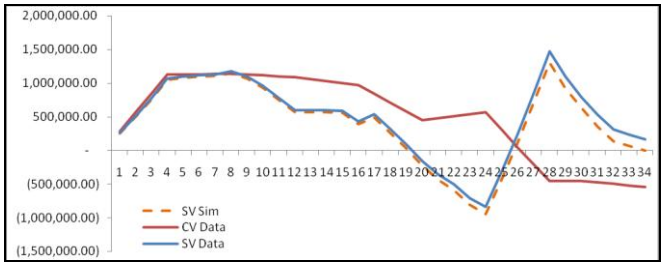

Fig. 4. **Project no. 1 SV and CV Analysis**

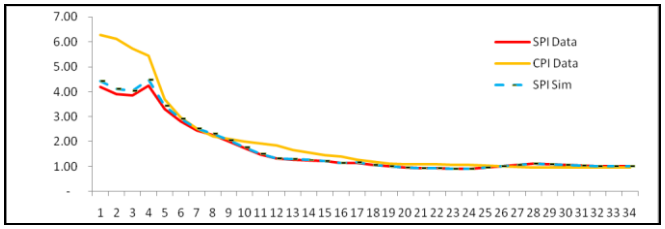

Fig. 5. **Project no. 1 SPI and CPI Analysis**

Value of one (1) shown in figure above indicates that ongoing project is in accordance with project schedule set plan. In project no. 1, both historical data and simulation results, the SPI index shown a value above two (2). At week twenty (20) until twenty five (25), activity completion time is lagging compared to activity time plan, especially on pipe connection and pipe repairing activities. At week twenty six (26) until project completion, the project are on schedule as shown in figure 5.

In project no. 2, cost overruns has occured at week seventeen (17) until twenty third (23), as shown in figure 6 below. This situation may results from manpower and equipment mobilization process until project completion phase. Project cost impact incurred in these activities reached 1,600,000 m.u below the nominal project cost limit. Start at week thirty seven until project completion, it activities approaching to the ideal value of zero (0). This situation can be anticipated with additional manpower and equipments.

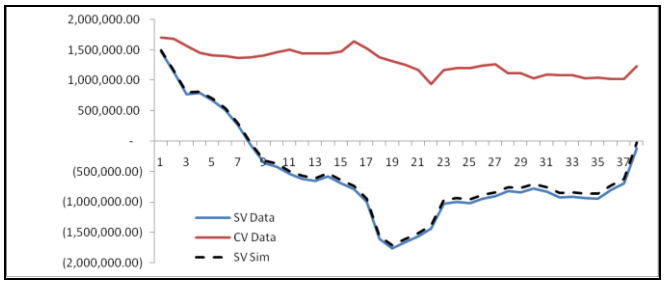

Fig. 6. **Project no. 2 SV and CV Analysis**

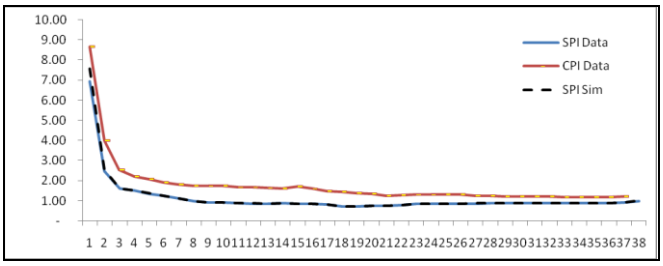

Fig. 7. **Project no. 2 SPI and CPI Analysis**

In the project no. 2, it activities in early weeks occur similar situation to the first project, there are excess material stock at warehouse. On the other hand, the project baseline needs to be reviewed because it does not achieve project cost budgeting absorption and aggressively exploiting opportunities (figure 6).

Cost overruns that occurs in project no. 3 at week five (5) until seven (7) may result from work preparation until linepipe bridge early stage. At the same time, it cost overruns had cost impact of 64,087.67 m.u below the nominal project cost limit. Start at week eight (8) until project time completion, it activities approaching to the ideal value of zero (0). This situations can be anticipated with additional resources of labor uncerand tools.

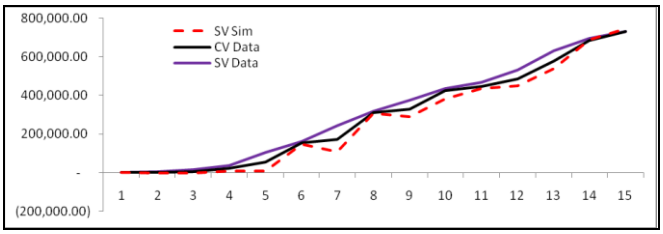

Fig. 8. **Project no. 3 SV and CV Analysis**

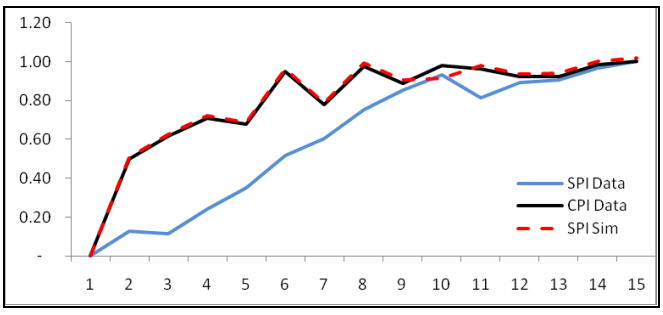

Fig. 9. **Project no. 3 SPI and CPI Analysis**

In the project no. 3, there is a delay from the initial schedule of activities planned start until week eleven (11), in addition to lack of material support and resources are limited, this situation may pose an aggresive threat reduction. This can be overcome by rescheduling, material procurement coordinated and resources additional (figure 8).

In table 4 are shown about project cost and time distribution, it value obtained from siimulation results with a confidence level of 90%, then at week 4.5, the cost distribution is

134,899.82 m.u where the mean value of cost distribution is 97,087.00 m.u at week 4.2. So, the project cost buffer with 90% confidence level is 37,821 m.u, while project time buffer with 90% confidence level is 0.3.

TABLE IV. **Project Cost and Time Distribution**

Parametric	Time	Cost
90% Probability	4.50	134,899.82
Expected	1.58	79,835.79
Mean	4.20	97,078.40
Variance	0.02	97,538.60
Buffer	0.30	37,821.42

By doing the calculation for project cost and time baseline risk to gained cost and time buffer weight value, then projet cost and time controlling index obtained to mitigate project delays risk.

V. Results

Symptoms of delay in these three projects shows similarities in some activities. Material procurement and equipment & personnel mobilization at early weeks of project greatly affect it performance. In the middle of project implementation on every project sample, project delays symptoms can be suppressed indicated by value of one (1) in SPI and CPI. Monte carlo simulation of project cost and time can predict the project risk in the weeks thereafter. Risk mitigation activities carried on critical path of the project sample. SPI value are high indicating the activity of material procurement cannot be met to project objectives. The mitigation action that can be done is to separate material procurement from project construction activities, perform other activities simultaneously to determined the project activity priorities.

References

[1] Abba, W., Niel, F.A. (2010). *Integrating Technical Performance Measurement With Earned Value Management*. The Measurable News 4, 6–8.

[2] Anbari, F.T. (2003). Earned value project management method and extensions. *International Journal of Project Management* 34 (4), 12–23.

[3] Blanco, V.D. (2003). *Earned Value Management: A Predictive Analysis Tool*. Navy Supply Corps Newsletter: 66 (2), 24–27.

[4] Burati, J., M. Mattews, S. Kalidindi. (1994). Quality Management In Construction Industry. *Journal Of Construction Engineering And* Management. Vol. 117-2. Pp. 341359.

[5] Chan, D.W.M., M.M. Kumaraswamy. (1995, 1997). A Study Of Causes Of The Factors Affecting Construction Durations In Hong Kong. *Construction Management And Economics*. Vol. 13 (1995, 97), P. 319-3.

[6] Cioffi, D.F. (2006). Designing Project Management: A Scientific Notation And An Improved Formalism For Earned Value Calculations. *International Journal of Project Management* 24, 136–144.

[7] Dachyar, M., & Novandra, RP. (2014). Performance Evaluation of a Drilling Project in Oil and Gas Service Company in Indonesia by MACBETH Method, Journal of Physics: Conference Series 495 012012

[8] Elkarmi, F. N. (2011). A Novel Methodology for Project Assessment and Evaluation. *Journal of Service Science and Management*, 261-267.

[9] Fallahnejad, M. H. (2011). Delay Causes in Iran Gas Pipeline Projects. *Journal of Service Science and Management*, 261-267. *International Journal of Project Management*, 136-146.

[10] Fleming, Q.W., Koppelman, J.M. (2005). *Earned Value Project Management, 3rd ed*. Project Management Institute.

[11] Harper, Jerry. (2004). *Earned Value Management*, Presentation, Department of Commerce, United States of America.

[12] Kim, E., Wells Jr., W.G., Duffey, M.R. (2003). A Model For Effective Implementation Of Earned Value Management Methodology. *International Journal of Project Management* 21 (5), 375–382.

[13] Kerzner, H. (2006). *Project Management: A System to Planning, Scheduling and Controlling*, Ninth Edition , John Wiley & Sons.

[14] Kwak, Young Hoon., & Lisa Ingall. (2007). Exploring Monte Carlo Simulation Applications For Project Management. *Risk Management*: *Palgrave Macmilan Journals*. 9 (1), 44 – 57 (Feb.).

[15] Moslemi Naeni, L., Shadrokh, S.H., Salehipour, A. (2011). A Fuzzy Approach For The Earned Value Management. *International Journal of Project Management* 29 (6), 764–772.

[16] Davis, Mark M., Nicholas J, Aquilano and Richard B, Chase. (2003). Fundamental of Operation Management, 4th, McGraw–Hill, Irwin, P. 94.

[17] Pajares, J. A.-P. (2009). An extension of the EVM analysis for project monitoring: The Cost Control Index and the Schedule Control Index. *International Journal of Project Management*, 615-621.

[18] PMBOK(R). (2013). *Project Management Body of Knowledge*. PMI. Project Management Body Of Knowledge.

[19] U.S. Departement Of Transportation. Federal Transit Administration. (2004).

[20] Vandevoorde, S., Vanhoucke, M. (2006). A comparison of different project duration forecasting methods using earned value metrics. *International Journal of Project Management*. 24 (4), 289–302 (May).