



Integrated Earned Value Management and Risk Management Approach in Construction Projects

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ABSTRACT

It is very important and crucial in the current critical business and economical environment to improve the quality of the monitoring and controlling of a project, especially in the construction projects which is well known to be a very risky and expensive type of projects, which need to be monitored and controlled from cost, time, quality and scope aspects, to establish a reliable performance measurement baseline, monitor and control the baseline and conduct forecasting and taking decision accordingly.

The Earned Value Management and Risk Management are two well known and popular techniques those are used to implement the project monitoring and controlling throughout all project stages.

Keywords— techniques, performance, comparing

I. INTRODUCTION

Cost monitoring and controlling of a project is very important and crucial factor for project success, as one of the main objectives of project management is to finish the project at a point that is not far away from the allocated budget, after establishing the project budget and the commencement date of the project starts, normally deviations start to appear between the allocated budget and the actual incurred costs, these deviations may be above the allocated budget (overrun), and may be under the allocated budget (under-run), the probability of the overrun is usually higher than the probability of the under-run, prices of the construction materials raise due to economical inflation and many other risks occur that affect the project cost performance, project stakeholders start to investigate the reasons of the cost overrun, highlight and monitor those reasons, to figure out whether these new impacts will continue affecting the cost performance till end of the project or not. Forecasting of the project cost at completion is a challenging issue, as the project may go into overrun, under-run and according to the allocated budget, but the

issue is whether the current cost performance trend will remain the same, enhanced or worsen for the remaining life cycle of the project. There are two major parts at any time of the project progress, the first is the works executed to date (work done) which is represented through the Actual Cost, and the future remaining works which will be carried on to achieve the project which is represented through the Estimate to Complete, the summation of the Actual Cost and the Estimate to Complete at any point is the total expected project Cost at Completion, the cost performance till a certain time of a project life cycle can be easily determined and monitored because it is a fact, the challenging part is to know what is coming on - the uncertainty.

Various techniques are used to figure out the cost performance to date, one of these techniques is the Earned Value Management that can be effectively used to monitor and control the project actual costs to date by simply comparing the budgeted cost of work performed against the actual cost of work performed, reasons of the cost performance can be then figured out. On the other hand, there is nothing else but the Risk Management can be used to predict the future issues whether threats or opportunities, Earned Value Management system is only fed by the data extrapolated from the past performance and hardly any way to use the Earned Value Management to predict the future, the Risk Management on the other hand is the specialized tool in this regard.

Many organizations use both techniques actually, but the issue is that The Earned Value Management and Risk Management can and should be implemented in an integrated way, not only during the project execution phase, but also from the project initiation phase till project completion.

II. LITERATURE REVIEW

The benefits of EVM and RM have been all around described elsewhere, as the user and fans of both tools seek to encourage getting better utilization. Each of both tools has a minimum of one disadvantage which is

risky and unreliable to those depend on the output of only one of them to support decision making (Hillson, 2004), according to (Pajares and Lopez, 2008), project Risk Management is a key factor for project success. However, Earned Value Management does not take into account project risk. EVM and RM are two such project management tools those have proved their value independently in supporting the project monitoring and control process. However, there are areas where they are both integral that if utilized shall result in much more benefits to both disciplines, project monitoring and controlling and therefore to project management in general (APM, 2008). The integration of risk analysis under the Earned Value Management framework demonstrates an important step forward in the development of the methodology. Earned Value Management measures what happened in the past, whereas Risk Management is looking forward to the unknown future – the uncertainty, (Pajares et al, 2011) proposed to integrate both tools under the same framework.

Generally, both tools are concerned about the project performance, Earned Value Management does this by looking to the past performance while Risk Management does this by looking forward to the future risks those are the motivators of the future performance, both have the same objective of implementing effective actions and decisions to avoid or prevent undesired trends to enhance the likelihood of effectively achieving the project objectives (Hillson, 2004).

(Bower and Finnegan, 2009; Harbor, 2009) suggested that Earned Value Management is to be integrated with different techniques such as Risk Management to adjust for this shortcoming aspect of the Earned Value Management technique. Project leaders can see Earned Value Management and Risk Management as corresponding project management tools. Risk Management recognizes risks those shall have a major effect of the project future trends. In this manner the Integration of Earned Value Management with Risk Management techniques can be a very useful tactic to obtain a much better and accurate measurements of project status at completion (PMI, 2011a).

(Pajares and Lopez, 2008) suggested to integrate both techniques as well. Earned Value Management focuses on the history of the project which is the performance to date, whereas Risk Management looks ahead. An integrated methodology can help to forecast and control the future performance of the project taking into account lessons learned from the past. Earned Value Management and Risk Management techniques are in harmony and related. Indeed, their shared features entail a powerful integration, that can be accessed through utilizing the strong aspects of each of them and use the information extracted from one to feed the application of the other (Hillson, 2004).

The benefits from integrating the Earned Value Management and Risk Management were stated by (APM, 2008) as per the following:

- The Performance Measurement Baseline incorporates the entire agreed scope of the project.
 - The work is scheduled to meet the projects objectives.
 - Risks are identified and managed effectively into agreed scope as required.
 - Project level comparison of Risk Management based and Earned Value based forecasts will expose potential anomalies and inform better decision making at a strategic level.
 - Integrated management control processes are being maintained/implemented and developed where necessary.
- While (Teixeira, 2001) stated the benefits from the integration process as per the following:
- Providing the right level of secure information to the right levels of management at the right time.
 - Improved communication and visibility within an organization and related organization regarding potential problems and who is doing what about them.
 - Improvement of the overall levels of management and control through better informed decision making.
 - Implementation of cost effective mitigating actions and controls and controlled risk increases the possibility of achieving the project requirements in accordance with the planned cost, time and performance target.

(APM, 2003) stated that “Risk Management and Earned Value Management share common frameworks. Earned Value Management requires a work breakdown structure, containing costs, timescales, budgets, and product definitions. When combined with an organization breakdown structure, one has a logical framework for identifying risks to program objectives, deciding ownership, and formulating and managing mitigation plans. Typically, the Earned Value Management system will be used to monitor progress to date and based on this and consideration of the forward plan, make predictions of actual spend and schedule completion. The Risk Management system on the other hand is forward looking and bases its predictions on potential risk and opportunity impacts and the anticipated affects of mitigation actions. Integration information provided by the Risk Management and Earned Value Management processes in a structured manner can lead to a far broader and more robust approach to running a program”.

III. METHODOLOGY

The methodology of applying the integration between Earned Value Management and Risk Management in practice can be carried out through the following stages:

1. Allocating the Project Budget.
2. Budget Change Management Process.
3. Analysis and Forecasting
4. Decision making.

3.1 Allocating the Project budget

Allocating the project budget is one of the most important stages ever in the integration technique, the allocated budget shall be the measurement baseline which shall be the base for the project monitoring and controlling throughout the project life cycle, from the business perspective, it is very crucial to establish as much as possible an accurate budget baseline, as some projects alike to real estate projects are sold and contracted during the early stages of the execution phase, depending on the market, some even sold and contracted before the project execution takes place, the selling rates are based on the construction budget plus other expenses such as land cost, in case of future major cost overrun, the profit is reduced or in the worst case scenarios turns into loss, which sometimes have a catastrophic consequences on the organization business.

The first step to create the project budget is to figure out the scope of work and the project work breakdown structure including deliverables for the project, then creating detailed budgets and schedules and control accounts, the work breakdown structure is the base to establish a high level - top down budget. At this stage these outputs doesn't include risk identification. Next stage is to identify potential risks to the project objectives, the point is to set up a high-level perspective of the risks that might occur, and identify procedures for how these risks to be handled. Procedures shall be based and affected by the project risk appetite and priorities of stakeholders' objectives.

Cost and schedule risk identification shall be carried out to understand the certainty of accomplishing the allocated top down budget and schedule targets. This analysis aims to incorporate both the uncertainty estimates and the effect of risk events through the risk management qualitative and quantitative analysis. This procedure will help recognizing the most sensitive regions of the schedule and budget.

The risk response actions to handle the high-level risks will affect the top down budget and top down schedule preliminary estimates which may lead to a change to the scope of work and the underlying work breakdown structure. The top down budget and top down schedule will be adjusted to reflect the implemented adjustments, which aims to trigger a further review of the risk register and a rerun of the cost and schedule risk analysis. Now the budget estimates and schedule are still at a high level, and have not been created to the control account level.

The project risk register is currently extended to include noteworthy control account risks. Project stakeholders aims to iteratively review this project risk register and approve any further risk response actions to minimize or mitigate risks or improve and seize opportunities. Approved actions ought to then be moved into control accounts, as indicated by the organization risk appetite, on the premise of suitable risk analysis and cost/benefits investigation data.

The specific risk provision is currently ascertained on the project of the post-mitigation position of the determined risks in the risk register. Risk response

actions in the risk register don't form part of the specific risk provision. At the point they are exchanged toward the Performance Measurement Baseline as they will be incorporated into the Performance Measurement Baseline, with the post-mitigation residual risk reflected in the specific risk provisions.

An estimation of potential savings could be generated through the opportunities in the risk register. This value ought not be netted off against the specific risk provision. Any savings made by seizing opportunities may permit work and budget to be expelled from the Performance Measurement Baseline and moved to the specific risk provision in case of newly identified risks or to be moved to the non specific risk provision in case that no new risks are identified.

The project schedule is currently established and forms the base of the approved Performance Measurement Baseline. Anything that has been recognized as potentially affecting the project yet is excluded in the Performance Measurement Baseline will be held in the risk register. The quantified amounts for these risks will be held in the management reserve. Management reserve is divided into specific risk provisions for known risks and non specific risk provision for unknown risks. Management will now estimate an amount for the non specific risk provision, to cover emergent unknown risks. This amount will be estimated based on the management's view of the development of the data in the project risk register, the setting in which the project is being attempted, existing benchmark information and historical data on past comparative projects where suitable.

3.2 Budget Change Management Process

The Performance Measurement Baseline and Management Reserve changes throughout the project life cycle to reflect scope changes, whether additional scope or scope omission, the Performance Measurement Baseline shall always include the actual scope relevant to the time schedule in order to extract reliable information from the Earned Value Management parameters and indicators.

The Performance Measurement Baseline and Management Reserve changes also when an identified risk is materialized, risk that is not going to happen, or emergent risk is materialized, this will lead to changes and a synchronizaiton between the Performance Measurement Baseline, the Specific Risk Provision and the non Specific Risk Provision, different cases have different impacts on the allocated budget elements.

A periodical review to the project risk register is carried out to recognize new risks, opportunities and to monitor or close existing risks, this does not necessarily affect the project measurement baseline, while there are newly identified risks, an amount from the non specific risk provision will be moved to the specific risk provision that will results into decreasing the non specific risk provision and increasing the specific risk provision, on the other hand if some identified risk are monitored and shall not be materialize and will be permanently closed, these risks provisions will be moved

from the specific risk provision to the non specific risk provision which results in decreasing the specific risk provision and increasing the non specific risk provision.

A synchronization to happen between the Performance Measurement Baseline and the Management Reserve (which consists of the non specific risk provision and the specific risk provision) when adding work to the baseline or removing work from the baseline when a risk response action is included in the baseline to mitigate a threat or exploit an opportunity or to recover from a threat that has materialized. The result is an increase in the project measurement baseline and a correspondent decrease in the specific risk provision, on the other hand, work may be removed from the baseline when a risk response action is discontinued or when an opportunity is realized, the result is a decrease in the project measurement baseline and an increase in either or both of the specific risk provision in case of a residual risk is introduced and the non specific risk provision.

3.3 Analysis and Forecasting

A periodical review to the estimate at completion of the project measurement baseline, the specific risk provision and the non specific risk provision is carried out to conclude and figure out the total project cost at completion in the light of the current project status, scope changes and the periodical risk review.

The Performance Measurement Baseline shall be always reflecting the actual scope additions or omissions to keep the data extracted from the Earned Value Management as reliable as possible to give the correct cost and time performance of the project, this estimate at completion shall only be calculated using the well know formula that is the summation of the estimated cost to complete the current scope and the actual cost incurred to the date of the estimation process.

The specific risk provision shall be revisited according to the revised risk register and will be updated according to the risk analysis results and the non specific risk provision shall accordingly be changed when eliminating risks from the specific risk provision or in case or omitting scope of work from the performance measurement baseline while there is no specific risk to be allocated on.

It is to be highlighted that the Earned Value

#	Budget Element	Amount
1	Performance Measurement Baseline	556,602,321
2	Specific Risk Provision	14,175,293
3	Non Specific Risk Provision	18,900,391
	Total Budget	589,678,005

The construction started progressing along with the project commencement date and no major cost variance was detected within the first few months, once the raw material prices started to rise, a remarkable deviation between the earned value and the actual cost started to appear, the deviation began to expand by time as a result of other impacts that will be demonstrated later.

Moreover and due to the continuous escalation,

Management shall be a performance measurement tool for the quantified risks and will reflect to what extent of accuracy were these risks quantified, this shall give an impression about the integrity of the risk management process and shall be a key factor to the management whether to change their risk management procedures and ideologies or keep it as it is.

3.4 Decision Making

Decision making process is iterative and based on the results of the analysis and forecasting stage when it is detected that insufficient project baseline budget or schedule to cover approved changes, or more threats/fewer opportunities materialize than originally forecast, the project may go into over target baseline and/or over target schedule position.

Decisions include but not limited to: Value engineering – cost reduction – scope changes – omitting unnecessary items – design changes – specifications changes

The timing of the decision making is somehow more important than the decision it self, because late decisions will lead to ineffective or useless results.

IV. CASE STUDY

A case study was used to demonstrate the effect of the absence of the integration between Earned Value Management and Risk Management process as a project monitoring and controlling technique.

The project objectives and success criteria are to finalize the project scope of work within the allocated budget, targeted time schedule and with the quality according to the contract technical specifications, the project main deliverables and key outputs are to construct core and shell buildings, landscape, roads, parking areas, external and internal fences, main gates, decorative water features and all public infrastructure and utilities including electrical network, sewage network, potable water network, irrigation network, gas network and telecommunication network.

The project budget was established as per the following table:

and schedule delays caused by the project owner, the contractor claimed an addendum to the contract conditions, terms of payment and time schedule, this new agreement was signed by the contractor and the employer top management representatives of both stakeholders, the new contract addendum contained new payment terms in addition to one year extension of time with an additional indirect cost of 1,250,000 per month, also 4% increase to the contract rates and prices was

agreed, beside a currency devaluation to be calculated. Along with the fuel prices increase, the contractor claimed additional amount of 7.5% of the remaining contract scope of work cost due to the effect of the escalated fuel prices on the contract price.

It is to be highlighted that the contractor had the right to claim for such terms of payment as per the contract general and particular conditions, the claimed amounts were justified and approved by the project owner after negotiations, the impact was beyond the

#	Factor	Impact
1	Overrun item quantities	(25,640,874)
2	Construction materials price fluctuation	(44,788,480)
3	Currency devaluation	(20,000,000)
4	Contract price escalation	(23,054,832)
5	Extension of time	(15,000,00)
	Total Impact	(128,484,186)

The Earned Value Management was the monitoring and control tool for the project, cost control parameters were calculated on monthly basis to evaluate the project cost performance and efficiency.

#	Parameter	Value
1	Planned Value	402,751,925
2	Earned Value	384,697,448
3	Actual Cost	488,820,716
4	Cost Variance	(104,123,268)
5	Schedule Variance	(18,054,477)
6	Cost Performance Index	0.787
7	Schedule Performance Index	0.955

The poor cost and time performance can be justified by following factors:

- Absence of the Integration between Earned Value Management and Risk Management is the main reason for the project poor cost performance.
- The absence of the integration technique during establishing the performance measurement baseline and the management reserve resulted into unreliable budget.
- The absence of the integration technique in the budget change management stage contributed to late decision making and consequently led that the project went out of control.
- Earned Value Management process was not supplemented by identification and implementation of the risk mitigation plans.
- There was no Risk Management performance and assumptions measurement carried out during the project execution phase.
- The organization - such as many other organizations still has a cultural problem that is the Earned Value Management and Risk Management are completely separate processes and therefore cannot be seen to complement each other.
- The Earned Value Management and Risk Management processes were carried out by different sets of people, lack of communication and coordination led

allocated management reserve.

A periodical review to the project cost estimate at completion of the performance measurement baseline was applied to monitor the cost variance at completion and recommend for corrective actions if any, the latest project cost estimate at completion was approximately equal to an amount of 685,086,507 which resulted into a cost variance at completion of (128,484,186), the cost variance at completion justification is demonstrated through the following table:

The recorded earned value, actual cost, cost variance and cost performance index after 3 years of the project commencement can be demonstrated through the following table:

to such performance.

- Absence of the Integration between Earned Value Management and Risk Management led to not delivering the right information to the right levels of management at the right time and hence deprived the project from any possible early corrective actions.
- The project caused a major loss to the organization portfolio.

V. SUMMARY AND CONCLUSION

It cannot be denied that the use of the Earned Value Management in a project cost and time monitoring and controlling is very efficient regarding the past performance evaluation, and although that the Earned Value Management technique has some theoretical mechanisms for predicting the future performance and trends, it is highly recommended that this technique should and must be integrated with the Risk Management which - on the other hand is a forward looking radar that can be used to predict the future performance and trends.

The successful integration of Earned Value Management and Risk Management will provide more realistic Earned Value assessments and better estimates related to the completion of the project and an effective

mechanism for monitoring the individual performance of the risk mitigating measures that have been implemented. This integration provides leading indicators that increase response time and probability of success.

Both EVM and RM are, in their own way, validating project baseline estimates using objective and subjective data: estimating error can be reduced by comparison of data outputs from both disciplines, providing a better understanding of project progress and predicted future trends.

The benefits of bringing together the Risk Management and Earned Value Management disciplines are clear, effective and a must in both the pre- and post-contract award stages.

The integration technique between Earned Value Management and Risk Management is crucial to meet the project allocated budget and scheduled time, depending on the Earned Value Management indices in forecasting the project future performance and trends is risky as the future performance cannot be predicted using the data extracted from the Earned Value Management measures of the project past performance. The project measurement baseline is monitored and controlled by the Earned Value Management, and on the other hand the project Management Reserve is monitored and controlled by the Risk Management technique.

The integration technique will improve the change management relevant to the time and cost aspects and will keep the time and cost constraints very well monitored and controlled especially at the current worldwide economical situation.

Another important side, is the data analysis, forecasting and decision making, the integration technique between Earned Value Management and Risk Management will facilitate the forecasting issues and will give more realistic data that allow the project stakeholders to apply a preventive or corrective actions in the adequate time, it is very crucial to take the preventive or corrective actions as early as possible to avoid unwelcome future consequences.

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