European Online Journal of Natural and Social Sciences 2013;
vol.2, No. 3(s), pp. 709-716 ISSN 1805-3602

Optimization of cost and scheduling parameters through Earned Value Management in construction projects: A case study on the project of telecommunication buildings construction and installation and implementation of equipment in Bandar-Emam Khomeyni

Ehsan Lorghaba[1], Ali Narimani[2]

[1]Department of Civil Engineering, Science and Research Branch, Islamic Azad University, Khouzestan, Iran; [2]Isfahan University of Technology Mechanical Department, Iran

Abstract

Project managers normally seek strategies to help them certify that projects are accurately implemented and that productivity is increased. Considering this premise, Earned Value Management (EVM) is regarded as an effective technique for analyzing and controlling the performance of projects. EVM is the process of analyzing project variances (problematic points). Recognizing problems as fast as possible, this technique provides strategies and procedures to balance cost/scheduling of projects against plans and to minimize the risk of increased costs and time. Developing an efficient model in this regard entails using theoretical and academic concepts and merging them with practical capacities and experiences in performing projects. Additionally, this process tries to overcome executive limitations through providing practical feedback based on scientific concepts. Applying the technique of EVM for a civil project, this study is an attempt to reveal the real effects of EVM on optimizing the management parameters costand scheduling on enhancing management capacity.

Keywords: updating, Earned Value, control, cost, scheduling

Introduction

Nowadays, despite the fact that high-ranking managers as well as the project management team spend a considerable wealth of time, energy and resources on planning and defining basic project strategies, most of the managers admit that are not optimally implemented. To increase project managers' satisfaction with the implementation of managerial factors, recognizing points of strength and weakness as well as problems and discrepancies existing in projects can serve as a preliminary but most effective step. As a result, lack of sufficient knowledge of such existing problems and their degree of importance and priority will definitely hinder the process of solving these problems. Unfortunately, there are numerous cases in which projects are primarily planned and launched, although despite scheduling and resource allocation, they end up with failure at their final stages or are finalized after a dilatory course. Any delay in doing projects will leave a large wealth of capital unexploited for a long period of time.

Yet, losing the returns from project utilization will impose huge losses on national and economical projects of a society. One the most important factors of success in civil projects it to adjust cost/scheduling performance of projects to original plans. Obviously, applying a uniform and efficient technique with a constantly controlling and forward-looking approach can play a significant role in bringing success to a project.

Relying on EVM, as a most effective management technique for managing cost and schedule, is crucial to direct the progressive course of projects and maximize the possibility of obtaining goals of a project. EVM is a systematic method for consolidating, measuring and comparing the progress of costs,

Corresponding author: Ehsan Lorghaba, Department of Civil Engineering, Science and Research Branch, Islamic Azad University, Khouzestan, Iran. Email: E_lorghaba@yahoo.com

scheduling and scope in a project. Of course, this technique is more concentrated on cost management in such a way that its scheduling parameters are calculated according to costs (Savoji and Kheir Khah,2008).

The system or technique of EVM encompasses an effective and efficient project mechanism, which warns high-ranking managers and the project management team when there is a discrepancy between primary plans and the real development of a project. Receiving such warning signals, managers will take necessary measures in response to the observed ineffectual performance of the project, and consequently use the current performance as a parameter for future performance to successfully finalize the project.

The postulates of EVM have been seriously taken into account in such countries as the United States and England over the past decades (from late 1960s). In Iran, too, experts, policy-makers, researchers, and project managers found the system or technique of EVM interesting, particularly after the Plan and Budget Organization of Iran declared the use of EVM obligatory for projects under construction in 2003. Since then, conscious attempt has been made to apply this modern management technique to such an extent that it is now one of the main topics of Iranian domestic conferences on management.

Considering the existing resources and the findings of previous research on this topic, in this study we relied on theoretical concepts of EVM and investigated the effects of the technique by applying it to the Project of Telecommunication Buildings Construction and Installation and Implementation of Equipment in *Bandar-e Emam*Khomeyni, Iran. In doing so, primarily the basic concepts of EVM will be explained, and then the applied dimensions of implementing EVM will be reviewed. Following that, the performance of EVM will be investigated and evaluated, and managerial strategies will be presented to enhance the efficiency of the technique under study.

A review on the definitions of EVM can provide an illuminating insight into the concept of *earned value*. In its various forms, EVM is a method used for evaluating performance. Evaluating costs, scheduling and scope will help the management team to measure and assess the progress and performance of a project. This management technique is dependent upon forming a unified baseline based on which the performance of a project is evaluated.

Analyzing the earned value of a project and comparing it with the planned and actual progress of the project in question, as well as considering the time and the costs spent on the project will help develop a new approach to project management that can accelerate the fulfillment of goals. Thus, performing accurate analysis and obtaining authentic and scientific data require accurate information about calculating the percentage of planned and actual project progress in terms of both physical and monetary aspects. After this stage, techniques and parameters recognized in EVM will provide strategies and procedures to harmonize the costs/scheduling course of the project with what was forecasted and planned. It should be noted that in projects which miss the deadline, as long as *re-plan* (i.e. extending contract or increasing value) has not been formulated according to approvals, the parameters of costs and scheduling cannot be relied on.

The process of establishing EVM

The following figure indicates the processes used to establish EVM.

The specifications of the project under study

General information

Subject of project: Constructing telecommunication buildings and installing and implementing equipment in *Bandar*-e*Emam*Khomeyni, Iran.

Project duration: 14 months

The value of installation contract 15/020/000/000 IRR.

The value of purchase contract: 6/980/000/000 IRR.

Total contract value: 22/000/000/000 IRR.

Now, Table 1 illustrates the components of EVM, the general aspects of the project under study have been introduced, and the significance of physical and planned progress of the project (the work that must have been done according to plan prior to valuation) has been explained. Following this stage, after calculating the percentage of actual physical progress (work done at the time of valuation) and actual monetary progress which is equal to the percentage of the value verified and paid by employer divided by total project value, other components of EVM will be calculated and related figures will be provided to further clarify the technique.

Components of EVM

Table 1 illustrates the components of EVM.

Table 1.Components of EVM

Abbreviations and relations	Description	EVM	
BAC	Sum of total planned value for completing a work scope. In civil projects, this parameter is the final value of the contract including additions if applicable.	Budget At Completion	Basic Data
PV	The budget given to the scheduling process to perform an activity or part of the work breakdown structure. Planned value is the monetary amount of a work that should be performed according to the plan before reporting.	Planned Value	
AC	The *real* costs spent and registered for an activity or part of the work breakdown structure. In civil projects, this parameter is equal to the last cumulative expense account certified by employer.	Actual Costs	
EV	The value of the work performed as approved and allocated budget for scheduling. In other words, it refers to the financial value of work performed before valuation. It represents the monetary value of a work actually performed before it is reported.	Earned Value	
CV=EV-AC CV > 0 Project was more cost-effective that estimates CV=0 Project was completed according to estimates CV< 0 Project was costlier than estimates	The valuation of cost performance in a project, and it represents the difference between EV and AC.	Cost Variance	Variance
SV=EV-PV SV > 0 Project was completed ahead of schedule SV = 0 Project was completed according to schedule SV < 0 Project was completed behind schedule	The valuation of time performance in a project. It represents the difference between EV and PV.	Schedule Variance	
CPI=EV/AC CPI >1 Completed project was more cost-effective than estimates CPI = 1 Completed project was as costly as forecasted in estimates CPI < 1 Completed project was costlier than estimates	The valuation of completed work against progress of AC of the project. This is the most vital parameter in EVM and it measures cost efficiency for completed works.	Cost Performance	Parameters
SPI=EV/PV SPI >1 Project was completed ahead of schedule SPI = 1 Project was completed according to schedule SPI < 1 Project was completed behind schedule	It refers to the valuation of the progress obtained compared to planned progress. This parameter is normally used in a combination of CP to forecast project estimates at completion, and it evaluates the effectiveness of scheduling.	Schedule Performance	

$ETC = \frac{BAC - EV}{CPI}$	The cost expected to complete the remaining work of the project. The estimate of the remaining cost of the difference between BAC and EV at the time of valuation compared with CPI.	Estimate to Complete (the remaining work)	
EAC = AC + ETC $EAC = AC + \frac{BAC - EV}{CPI}$	Total of cost expected from a scheduling activity or of a project at the time of a scope completion. EAC is the result of AC (paid costs) added to ETC.	Cost Estimate At Completion	Estimates
$EAC(t) = AD + \frac{PD - ES}{PF}$ $ES = N + \frac{EV - PV}{PV_{N+1} - PV_N}$	The final time expected from an activity in a project. In recent years, new concepts have been proposed to enhance the accuracy of time estimate at completion. Practically, however, this parameter is difficult to be implemented.	Time Estimate At Completion	
TCPI = (BAC – EV)/ (BAC-AC)	The prior performance of the project that should be taken into account so that the budget does not exceed final contract value or BAC.	Cost Performance Coefficient	Performance Coefficient

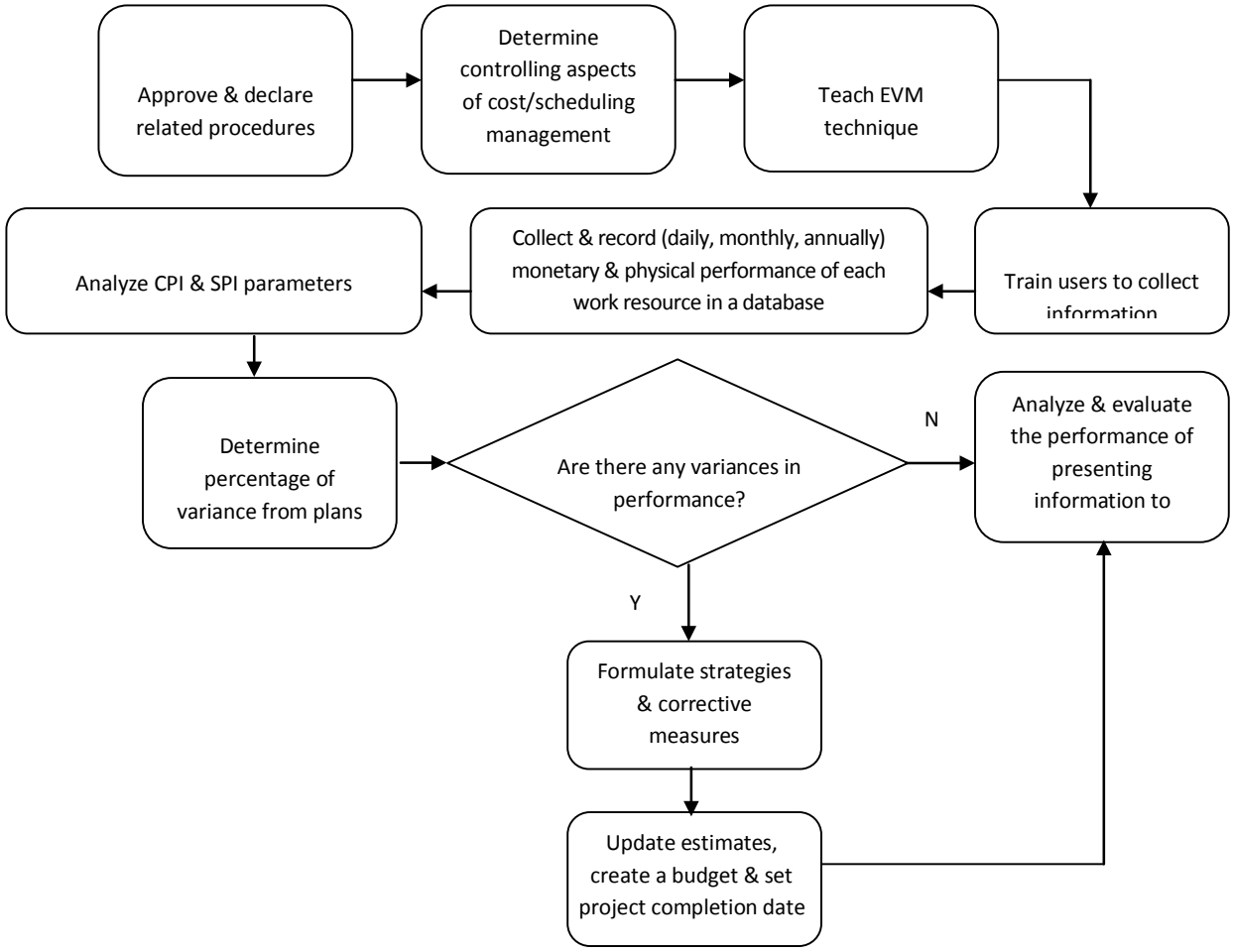

Figure 1.The process of establishing EVM

The cumulative and periodical charts of planned and actual progress illustrate the difference between the percentage of planned progress and actual progress. In these calculations, the percentage of planned progress and actual progress is depicted cumulatively. This chart illustrates the circumstances under which the project is, indicating the stage of the project in terms of planned progress versus actual progress. Such a chart can most clearly show the degree of setback in proportion to what was primarily planned.

Figure 2. The plan for constructing telecommunication buildings and installing and implementing equipment in Bandar-eEmamKhomeyni

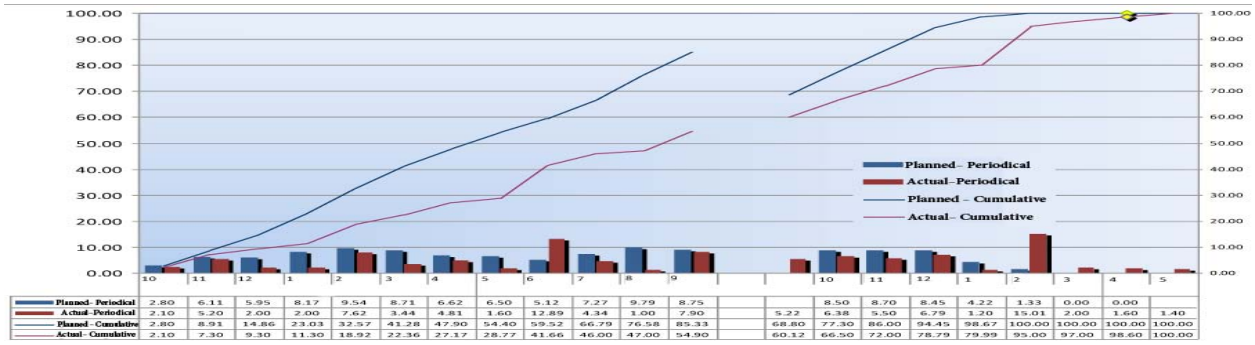

Figure 3. Cumulative and periodical chart of planned and actual progress

As figure 4 depicts, if project planning is not updated, the planning stage of the project has been finalized, although in actuality the project has considerably fallen behind, an issue that will engender certain problems in the project.

The PV chart (project baseline) has been plotted to depict the two conditions before and after introducing updates. After the PV chart is updated, this chart will be used as a criterion for project performance. The project under study was updated in July 2011, causing a breakdown in the chart. When the planned progress of a project approaches its final stage and actual progress is behind set plans, the schedule should be updated so that the PV chart can be optimized by the project performance baseline.

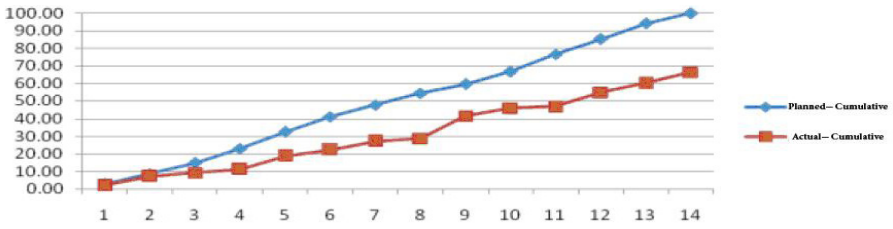

Figure 4. Cumulative chart of planned and actual progress without updating

The chart of PV, AC, and EV illustrates the overall status of the project. This chart, even at the primary stages of the project, can help analyze variances (problematic points), while it signals warnings to the managing team to take timely measures in response to the weak performance of the project and use current per-

formance as a criterion for a successful completion in the future. As figure 3 shows, there is a breakdown in the PV that occurred when updates and management strategies were introduced to control variances.

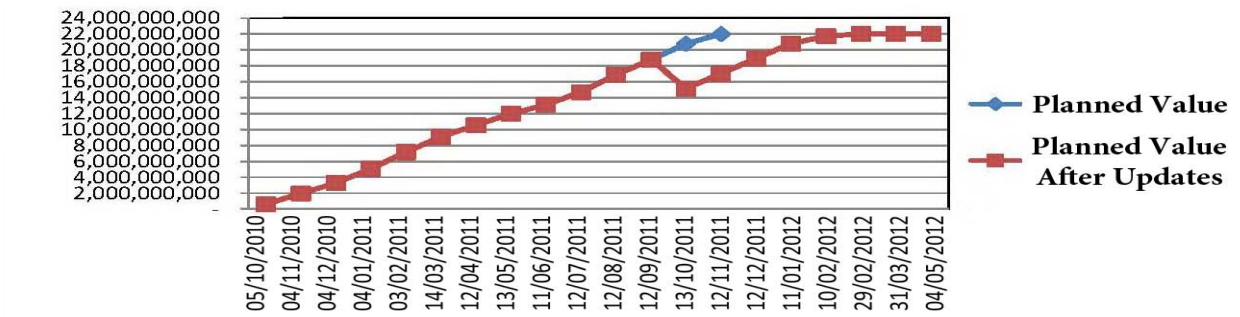

Figure 5. PV chart before and after updates

Much of the delay was of course caused by problems of supplying equipment from overseas, although these problems had not been considered serious at the time of planning. Figure 3 well depicts the effect of EVM. AC was equalized by PV and EV at the end of the project, while from the middle stages of the project EV exceeded AC. This resulted in a positive value of cost variance, suggesting desired cost-related conditions and showing the effect the delay had on the project.

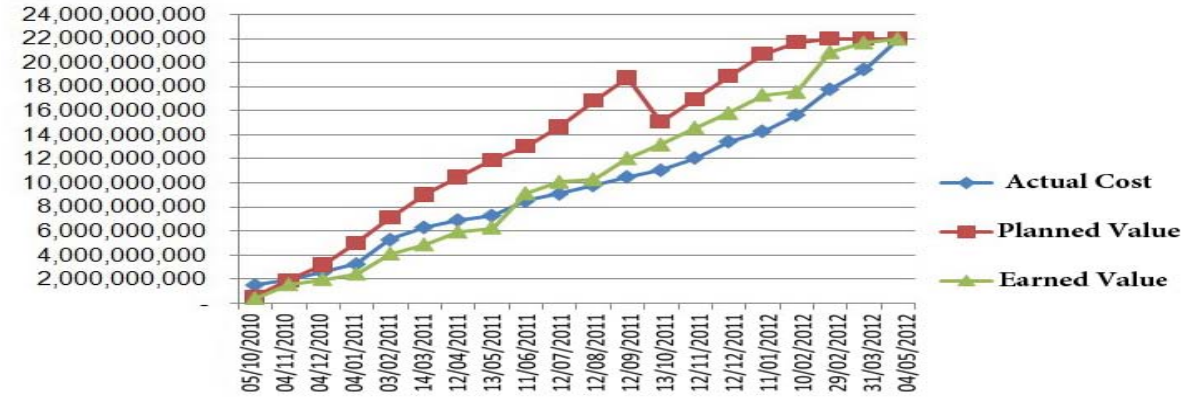

Figure 6. PV, AC, and EV

The efficiency of such parameters as costs and scheduling are used to evaluate the budgetary and chronological planning of the project. The variances in costs and scheduling bring about results compatible with the said performance parameters. As Figure 6shows, both of the parameters approach 1 at the end. In cases where costs and scheduling approach 1, the project had progressed according to plan as far as cost-related and time-related aspects are concerned. Yet, although costs of the project under study were spent according to the plan, completing the project was delayed. As Chart 4 illustrates, the parameter of scheduling finally reached 1 in month 20, although the duration of contract was 14 months. Clearly, in month 14, the parameter of scheduling was distant from 1.

The chart for EAC, considering the efficiency of budgeting and scheduling of a project, can help calculate and verify the budget necessary for completing the entire project with more accurate estimates. One of the outputs of such an analysis is a more accurate estimate of the total budget needed for future financial episodes. In the project under study, EVM helped balance total planned budget with the budget for completing the project, showing the effectiveness of this technique.

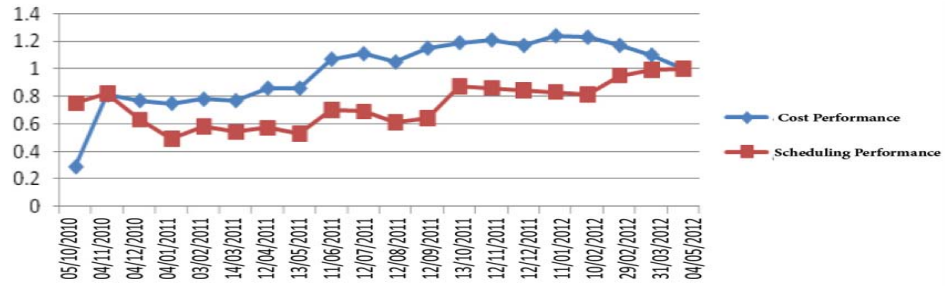

Figure 7. Cost/scheduling performance

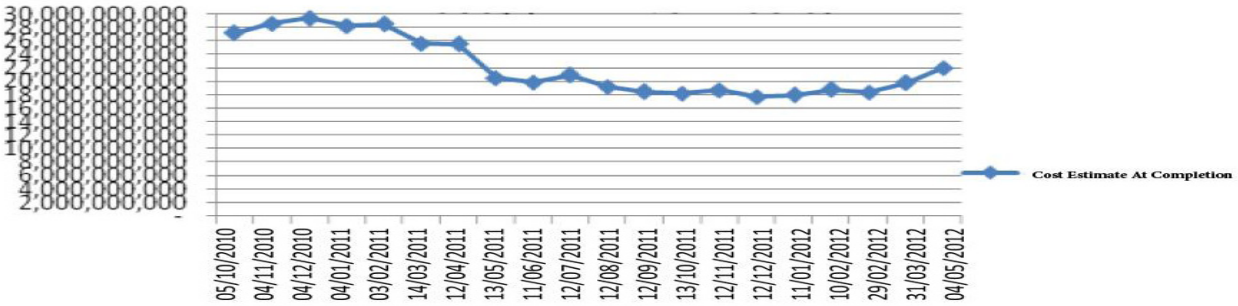

Figure 8. EAC of the project under study

Conclusions

To control projects appropriately, it is crucial to manage such parameters as cost, scheduling and scope. From among the possible ways to control these parameters, EVM is one of the most important and widely used techniques. In this study, EVM was used to deal with contractors. The technique of EVM can help compare planned value with actual costs at any given stage of the project, and in case actual costs exceed planned value, EVM can be used to discover the causes of deficiency or increases costs and provide useful strategies. At any stage of the project, the technique can clarify the course of the project and to what extent the physical/monetary progress of the project conform to primary plans. More specifically, the technique clarifies cost/scheduling variance of the project from the original plan.

Because contracts are stipulated according to financial and legal obligations, it is necessary to adopt an appropriate method for evaluating progress of a project. Thus, to determine the percentage of progress, care should be exercised and experienced civil engineers should be employed in possible. As a result, the actual progress of a project can be determined more accurately.

As the charts reveal, EVM is a not technique that merely provides diagonal samples (positive points); in the process of performance valuation, a strong reliance on diagonal sampling will not guarantee the accuracy of the results, despite the satisfactory information it provides. One of the shortcomings of this technique is the variance in behavior and the parameter of scheduling in a project and the way it may be interpreted from different angles.

The first criticism is that variance in scheduling is measured through financial units, and not time units. This problem will make more complicated to understand the behavior of the variance, bringing about misinterpretations. The second criticism on variance and the scheduling parameter used in the method is concerned with invalid interpretations of the status of the project at the end of the project. As the project reaches its completion, variance in scheduling approaches 0 and the parameter of scheduling performance constantly approaches 1, a situation which implies an optimal status even if the project was delayed (Vandevoorde and Mario, 2006).

Relying on EVM to remove these shortcomings, one can use economic engineering relations and inflation rate to calculate and compare the loss caused by delays according to costs. Because in EVM forecasting future progress is dependent upon previous progress, one can merger EVM with risk management to considerably enhance the efficiency of EVM. If the two methods are combined, they can create an increased potentiality that can offer new advantages by using the forward-looking aspect of risk management and status analysis of EVM.

Finally, it should be noted that this technique functions as a warning signal, and, as figure 1 illustrates, it constantly leads the project toward better decision-making by representing planned and actual information, and harmonizes the cost/scheduling course of the project with what was primarily planned. The importance of cost/scheduling management should be taken into account before commencing the project and during holding auctions. Without accurate and logical analysis of project activities at the time of offering prices, one will not only offer inaccurate and non-competitive prices, but will also problematize cost management during the construction phase. Presetting accurate scheduling based on analysis at the time of offering prices is an important step toward reaching an effective and efficient cost/scheduling management.

References

FarajMashayi, M.R. (2007). *Earned Value Management.*

Graham, R.(2007).Using cost risk to connect cost estimating and Earned Value Management (EVM). *IEEE Aerospace conference proceedings,* (41-53).

Haj Shir Mohammadi, A &Yaraghi, T.(2006). *Introduction, Clarification, and classification of Iran project management main challenges.* 2th project management international conference.

Khorshidi, A .(2006). *Project Management Schedule execution and budgeting control in civil Projects.*

Project Management Institute (PMI) (2004). *A guide to the project management body of knowledge (PMBOK GUIDE-2004 edition).*

Project Management Institute (PMI) (2008). *A Guide to the Project Management Body of Knowledge (PMBOK GUIDE).*

Project management institute (PMI)(2011). *Practice standard for earned value management.*

Putz, P *et al.*, (2007). Earned Value Management at NASA: An integrated, Lightweight solution. IEEE Aerospace Conference Processing, (200-209).

Savoji, H &Kheir Khah, S.(2008). *Study of new methods of project perceived value management.* 4th project management international conference.

Shabahangian, P.(2010). *Application of project management knowledge development Guide PMBOK in execution works.*

Takabi , M &Mobtadi, R.(2011). *Delay analysis techniques in construction projects.*

Vandevoorde, S & Mario, V. (2006). *A comparison of different project duration forecasting methods using earned value metrics.*

Wagner, W &Duker, W.(2006). *A Five Step method for Value –based Planning and monitoring of system engineering Projects.* Conference on Software Engineering and Advanced Application, (282-290).