International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056
Volume: 06 Issue: 05 | May 2019 www.irjet.net p-ISSN: 2395-0072

CONTROLLING AND MONITORING THE CONSTRUCTION PROJECTS BY USING EARNED VALUE METHOD

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Abstract - *Controlling and Monitoring are important task in construction projects This information is confined to study of project cost, time control and varience using earned value for monitoring the project. In this, we come to know how Earned Value is applied on any project. It plays an important role throughout the paper. Earned value will not work unless you obtain the accurate actual costs for your project. A limitation of cost systems is that they show only actual costs for invoices received and/or paid. Any work that is contracted and any purchased items will typically have invoices that lag by a month or more from when the work was actually done. Therefore, using this information from your cost system, earned value calculations can be very misleading. Earned value is considered as a 'quantitative technique' for evaluating project performance. However, it really hinges on how progress is reported. Earned value works best when the progressing techniques are quantitative, such as units completed or incremental milestones.*

***Key Words*: Cost control, Cost overrun, Cost management, Time control, Earned value, Varience.**

1. INTRODUCTION

Every country whether in the developing stage or already developed stage has the need for infrastructure development to further the economic, social, technical growth of the country. Similarly India in the growth stage or being a developing country has need for a huge amount of infrastructure development. There are large no of infrastructure projects being undertaken in India.

Project management is the application of knowledge, skills, tools, and techniques to project activities in order to meet or exceed stakeholder needs and expectations from a project. Meeting or exceeding stakeholder needs and expectations invariably involves balancing competing demands among scope, time, cost, and quality. Stakeholders are with differing needs and expectations.

Construction is everlasting activity across the world construction profitability fluctuates according to the law of demand and supply. Construction activity contributes to economic development of the country. Construction process needs resources in the form of men, material, machinery and money. Manpower in construction includes Architect, Engineers, technical and non-technical staff. Construction activity requires wide variety of materials which form substantial part of entire construction cost & lastly money is at the core of business activities & construction being a capital intensive business generally operates under money constraints. India is the second fastest growing economy in the world. The Indian construction industry is an integral part of the economy and a conduit for a substantial part of its development investment, is poised for growth on account of industrialization, urbanization, economic development and people's rising expectations for improved quality of living.

While construction we have to concentrate on core part .The successful completion of project is so largely depend on time & cost and sometimes critical in both the planning and control phase. Good project management in construction must vigorously pursue the efficient utilization of resources. Improvement of labor productivity should be a major and continual concern of those who are responsible for cost control of construction facilities. Material handling, which includes procurement, inventory, shop fabrication and field servicing, requires special attention for cost reduction. The use of new equipment and innovative methods has made possible important changes in construction Technologies in recent decades. Organizations which do not recognize the impact of various innovations and have not adapted to changing environments have justifiably been forced out of the mainstream of construction activities.

Construction is today's most important part of nation development. Generally depends on three most important part that are time, cost and schedule they are interdependent we can't neglect any of these three from the project.

2. LITERATURE REVIEW

Saad H. Al-Jibouri:

This paper describes the monitoring systems; their characteristics, the measures are used and their effectiveness for assessing performance. The systems are first evaluated on a theoretical basis and then on the basis of results from investigations carried using simulation approach. A project model has been developed which realistically simulates the progress of the project and which generates information relevant to these monitoring systems. Factors affecting the project cost and performance are represented by changes in the project plan and inflation rates. It has been found that some of the earlier monitoring systems have more response to changes than the others. The research has also shown that the Activity based ratio's technique gives a clearer and simpler indication of the overall progress of the project than the other two techniques. Also, paper reports on a research to investigate the effectiveness of some commonly used monitoring systems, in detecting deviations from the planned cost and performance. The monitoring systems used in this work are: Leading parameter technique, Variances method and Activity based ratios technique.

Salah Eldin Adam Hamza:

This paper tells about monitoring and controlling design process using control charts. Control charts have been used to monitor design progress and for auditing business processes, process adjustments and to alert for action to rectify a schedule risk. Management has benefited from control charts to fine-tune operations ranging from bid proposal processing to final design delivery stages and to identify and prevent employee time waste in addition to tracking and forecasting design performance for efficient resource allocation. These techniques helps in controlling development of engineering deliverables on budget and in detecting areas of low performance early enough for suitable corrective actions. This paper demonstrates means to control design process in organizations dealing with construction projects like oil and gas, petrochemicals and power projects. Delays in the design process may cause adverse impact in downstream projects phases including construction, procurement, start-up, production, and further affects business strategies and plans. Control charts helps to delivering design projects within constraints.

Sagar K. Bhosekar and Gayatri Vyas:

Most of the construction projects suffer from cost and time overruns due to a multiplicity of factors. Earned value management (EVM) is a project performance evaluation technique that has origins in industrial engineering, but which has been adapted for application in project management. The earned value analysis gives early indications of project performance to highlight the need for eventual corrective action. This study is to present and discuss the main parameters involved in the calculation of Earned Value Analysis (EVA) in the cost management of civil construction projects. The purpose of this dissertation is in 3-fold. Firstly, Earned Value Analysis software, SQL Server 2005. Comparison of selected parameters between M.S Project 2007, Primavera and developed software is done. Therefore, it can be concluded that the software could be used in a wide range of projects for Earned Value Analysis calculation.

Mark Gershon:

This paper describes the usage of Earned Value Analysis by project managers. While Earned Value is the most important tool for monitoring and controlling project performance, and it is also included in any set of best practices in project management, we discover a very low usage rate of this valuable tool. Also, we identify barriers to the use of Earned Value, reasons why it is not used. Finally, we prescribe a set of practices that will overcome these barriers and facilitate the use of this tool. If followed, these steps will help this best practice tool to really be put into practice.

2. ILLUSTRATION

Control of the project

Project is temporary Endeavour which is undertaken to create a unique product. Each project has its own constraint in terms of time and available funds. Thus such temporary endeavor needs to be managed with unusual effort. Project management is a comprehensive concept about managing nine knowledge areas that are project integration, project scope and project time, project cost, project quality, project human resource, project risk, project procurement. Construction is very complex in nature to manage due to its unique nature. A good project management in construction must vigorously pursue the efficient utilization of labor productivity should be major.

Due to versatile nature of construction, project manager needs strict monitoring and control over the project. Monitoring is the most important component in project management. It deals with measuring performance of project at certain time interval and reports that performance to organization for process control. After getting such monitored information, the concerned authority decided further action that is called controlling. Thus monitoring and controlling is a persistent process throughout entire duration of project.

Throughout the implementation of a project, procedures for project control and record keeping becomes crucial tools to managers and other participants in the construction process. These tools gives out dual purpose of recording the financial dealings that occur as well as giving manager as indication of the improvement and problems linked with a project.

The basic control process in any industrial activity is a three step function of: Establishing performance standard then measuring the performance against the standards and correcting deviation, if any from the standards. A system approach for application of project performance is shown in fig-1.

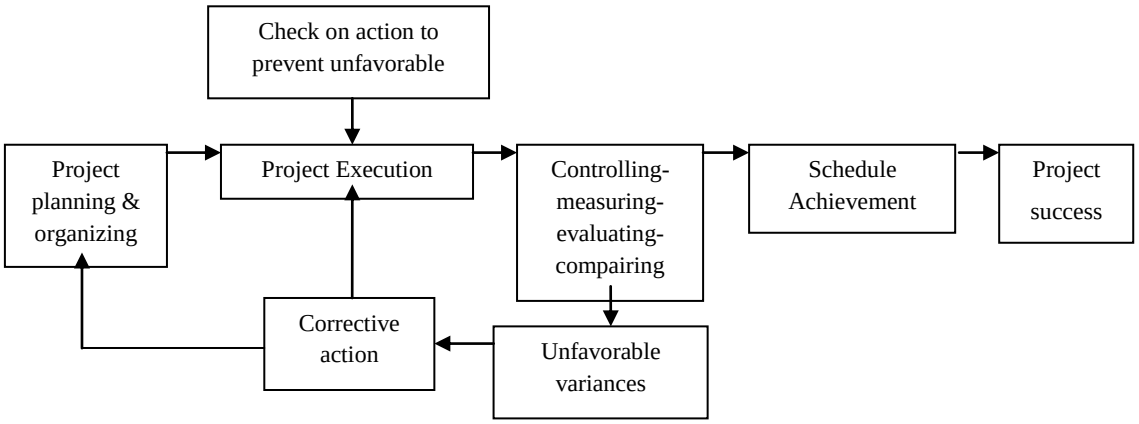

Fig -1: **Checking and Control Functions in Project Management**

Controlling the time, cost and quality leading to project success, calls for a great deal of seriousness on the part of management. As project time and cost control are interdependent we will discuss it together.

Project cost

Project cost is cumulative addition of engineering cost includes installment accomplished for transfer of technology, Material cost & construction cost.

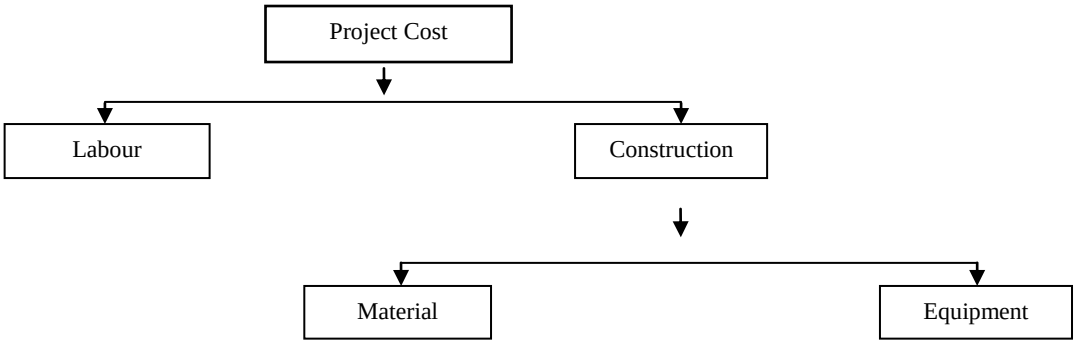

Fig -2: **Project Cost**

Generally there are two types of project cost: -

i) Fixed Cost: These are costs that do not increase or decrease as output fluctuates. For example, salaries or employees, rent for premises and advertising cost.

ii) Variable Cost: Variable cost is that cost which changes with level of activity available resources exactly in the same proportion as changes in the output. Therefore as output is increased total variable cost is also increased and as output

decreased total variable cost also decreased but per unit it remains constant. For example, indirect material cost per unit quantity.

Project Cost Overrun:

Project cost overrun is defined as excess of actual cost over budget. Cost overrun sometimes also called as "cost escalation", "cost increase", "budget overrun".

When overrun occurs, the project manager looks for ways of reducing costs. The simplest way is to reduce scope is begins with a search for items that easy to cut out. The items that are easy to cutout are those items which are poorly understood during the estimating process and therefore underestimated.

If easy cut items do not provide sufficient cost reductions, then a seperate search begins among hard to cut items. Hard to cut items include:-

- Direct labor hours
- Material
- Equipment
- Facilities
- Others

If the cost reduction are unacceptable to management, then management must decide whether or not to pull the plug and cancel the project.

Time control:

Construction projects are time bound and all project activities are directed towards the achievement of project time objectives. In complex project where large number of activities are performed at different places by different agencies or task forces with each having its own schedule target, a small delay in a critical activity can affect many schedule. Delay can alter the planned level of resources and their mobilization. Time overrun increase overhead it reduces planned level of resources and their mobilization, it also reduces planned revenues from sales and create cash inflow problem. Delay in contracted projects can result in penalties and adversely affect the reputation of company it causes confusion and conflicts.

Project time control aim at the timely execution of work according to the project plan schedule and applies corrective measures in case of time deviations. In its broader sense time control implies the control on entire planning systems as time is directly or indirectly related with all activities and project functions. Time control monitoring starts with measuring time status of completetion in progress and nonstarted balance activities. It uses time plan updating techniques and depicts process pictorial. Time related plan more commonly called schedule. It should be created as early as possible in the life of project. This could be possible at the conceptual stage, but should not later than outline design stage. The accuracy and completeness of a time schedule is directly proportional to time elapsed since the project kick off. In other words, time schedules prepare in the early stage are likely to be less accurate and less definitive than the same time schedule model at later stage in project life cycle.

Fig -3: Traditional Cost Analysis

3. EARNED VALUE

When we speak of Earned Value we generally are speaking of a methodology. While Earned Value is just one element of this methodology it is the key element. The simplest way to think of Earned Value is to equate it with physical progress. As the name implies it is something that is gained through some effort. In project management this value is earned as activities are completed consequently; Earned Value is also a measure of progress. As we shall see later there is a direct relationship between Earned Value and per cent complete. The attributes of Earned Value are threefold. First it is a uniform unit of measure for total project progress or for any sub-element of the project. Second it is a consistent method for analysis of project progress and performance. Third it is a basis for cost performance analysis of a project.

If set up properly Earned Value provides a uniform unit of measure for reporting progress of a project. The traditional units that are used include work hours and dollars. For labor intensive efforts work hours are often considered adequate in such instances the financial details of the remaining project cost are controlled by the accounting system. These costs include subcontractors, overheads and other direct costs. When the entire project cost is to be controlled from the project control system, then it is more effective to use dollars as the unit of measure for Earned Value. Since each labour hour has a price and dollars can be used to control labour. However when using dollars, additional factors enter into the performance evaluation. This includes salary rate differences, escalation, overhead adjustments and differences.

Variance:

A variance is defined as any schedule, technical performance or cost deviation from specific plan. This measures the difference between two factors by subtracting one from other to give positive or negative variance. It can be used to show differences between actual progresses and planned. Variance must be tracked and reported. They should be mitigated through corrective action and not eliminated through baseline change unless there is good reason. Variances are used on both types of measurement. In order to calculate variances we must define the three basic variances for budgeting and actual costs for work scheduled and performed using following three variables.

- Budgeted cost of work scheduled (BCWS)
- Actual cost of work performed (ACWP)
- Budgeted cost of work performed (BCWP)

4. METHODOLOGY

At this point we come to actually seeing how Earned Value is applied on any project. There are 5 steps in setting up the Earned Value system on a project, and 4 steps in using it. These steps are described generically but they are the same for all projects. Each of these steps will be discussed in detail. To set up the Earned Value system:

1. Establish the Work Breakdown Structure (WBS) to divide the project into manageable portions.

2. Identify the activities to be scheduled that represent the entire project.

3. Allocate the costs to be expended on each activity.

4. Schedule the activities over time.

5. Tabulate, plot and analyze the data to confirm that the plan is acceptable. To use the information generated by the Earned Value Calculations.

6. Update the schedule by reporting activity progress.

7. Enter the actual costs on the activities.

8. Execute the Earned Value calculations, print and plot the reports and charts.

9. Analyze the data and write the performance narrative.

Step 1: Establish the WBS: The WBS is the road map for analyzing the project progress and performance. It provides a multi-level structure for analyzing the project at varying degrees of detail. A properly defined WBS also provides that each element of the structure at each level is the responsibility of an individual who has management authority over that element and all the elements that roll up into that element. Furthermore the WBS must contain the full scope of the project. Otherwise the information generated will not represent the total project.

The bottom level of the WBS should be the activities of the project. The key that each element has a responsible individual identified with it and each element represents a part of the project that someone or more people are interested in monitoring.

Step 2: Identify the Activities: The second step is to identify the activities of the project. The WBS provides the framework for identifying the project components. Each activity should be assigned to one element in the WBS. The completion of this step will produce the project schedule of activities, typically in a CPM network.

Step 3: Allocate the Cost: The third step is to identify and allocate the costs to be expended for each activity. Since an activity represents a finite symmetrical bell shape, front loaded triangle, back loaded triangle, equal triangle, lump sum at the beginning or end of the activity. However detailed discussion of the application of resource curves is beyond the scope of this paper.

Step 4: Schedule the Activities: The fourth step is to calculate the schedule of the activities. This step generally provides the spread of the resources over the entire time duration of the project. It generates the traditional S-curve of the project plan or baseline also called the BCWS Curve.

Step 5: Tabulate, Plot and Analyze: The final step is to tabulate and plot the information that was loaded and then to analyze this information. The purpose is to assure that the allocation of resources is properly planned. This includes analysis of individual resources to see if the maximum requirement during any time period is available. It also includes review of cash flows if dollars are entered to see if the financing plan for the project supports the schedule. Third it provides a review to see that all project resources and costs that are budgeted are entered into the program.

Once these five steps are completed, the project team will have the basis for conducting periodic analysis of the project progress and performance. That process is explained in the next four steps.

Step 6: Update the Schedule: The first step in the periodic process is to update the schedule with the period progress. This is generally done whether Earned Value is used or not. The project schedule activities are reported as started, completed or with a remaining duration as appropriate. The percent complete of unfinished activities should also be reported. If 1000 cubic yards of concrete are planned to be poured and 300 yards have been done to date then the activity is 30% complete. For efforts that are not so easily measured special earning rules might have to be employed. Full discussion of earning rules is also beyond the scope of this paper. Two examples are presented to illustrate the point. For example if the activity is the creation of a design drawing progress might be reported as follows: 10% when the preliminary research and background study are completed, 20% when the drawing draft is completed and passed on to drafting, 40% when the first draft is printed, 50% when the first draft is reviewed, 60% when the second draft is completed, 75% when the client review is completed, 90% when the final draft is completed and 100% when the drawing is issued for construction. The key in defining this kind of rule is that each "milestone" is discrete and its achievement is easily recognized by such evidence as transmittal memos.

A second common rule that is quite effective when the project has several thousand activities is to use the 50-50 rule. In this rule each activity is considered 50% complete when its start date is reported and it is 100% complete when the activity finish date is reported. Reporting progress provides the basis for the Earned Value Calculations.

Step 7: Enter The Actual Costs: The second step in the periodic process is to enter the actual costs into the schedule. This information comes from the time sheets and invoices to the project. Whether the data is entered manually or electronically is a matter of choice depending on the degree of integration between the company's financial accounting system and the project control systems. In any case it is necessary to determine which costs are to be allocated to which activity. By proper integration of the financial and project Accounting systems is facilitated to the point of total automation. However human analysis of the actual data is recommended to assure that improper data doesn't inadvertently enter the system.

Step 8: Calculate, Print And Plot: The next step in the periodic process is to calculate the Earned Value and to print reports and plot charts for analysis. The Earned Value is simply the percent complete of an activity times its budget this provides the key value in the Earned Value process. Other calculations include the schedule, cost variances, performance indices, estimates at completion and percent Complete of the upper elements of the WBS. Purpose of this method is we will look at the basic impact of cost performance on the EAC. The intent is to show that Earned Value is a key forecasting tool for managing a project. The simplest Formula for arriving at the EAC at the time of the data date is:

EAC = (BAC-BCWP) / CPI + ACWP

Step 9: Analyze and Report: The final step in the Earned Value process is to analyze the data and the report. The result of that analysis is the scope of this study does not allow detailed discussion of the analysis process. However from the above the planner can recognize the significance of the various calculations discussed above.

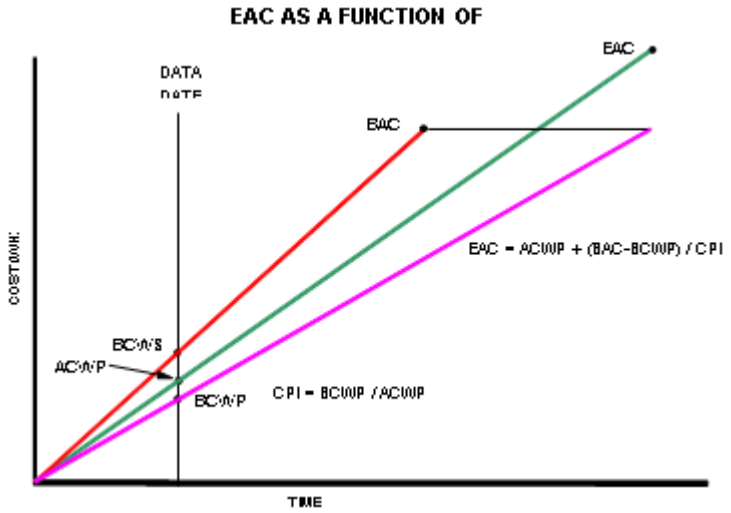

Fig -4: **Forcasting the estimate at complition**

5. CONCLUSIONS

A good project planning and budgeting along with good project management methodology can compress the gaps on time, cost and schedule. The literature review showed us how to control the cost of the project by utilizing resources of the project.

Scheduling of the activities is a important task. If the time of the project increases cost of the project also increases simultaneously, so to complete the project within budget and time we have to implement earned value management on the project. This shows the progress of the project with respect to estimated values, by calculating cost variance and schedule variance of the project.

While estimating task, cost and schedule are key elements in Earned Value Management, EVM can also assist in making these estimates more accurate. First an initial estimate is made using the best method available (expert judgment, analogy, and top-down or bottoms-up). Next as the tasks are completed, earned value and actual costs computed a cost and schedule variance can be calculated for the work package. These resultant variances then can be used to adjust cost and schedule estimates for subsequent similar tasks. Thus earned value can be used as a feedback mechanism for revising task performance estimates.

The identification of the bottom level work packages for the project is the most important step in using earned value as a part of the risk management program. The majority of these tasks should be discrete work packages for which progress can be clearly measurable. As previously mentioned the key to effective use of earned value for risk management is selecting, work packages that are clearly definable, determinable and the effort completed in a relatively short duration.

There are three primary activities which must be performed in using Earned Value Management as part of a project's risk management program. First we define the work packages for the project. Next we have to provide cost and schedule estimates for completion of each work package. Finally earned value must be computed and compared against the estimated values to determine the cost and schedule variance for each work package. Then as previously mentioned these cost and schedule variances are used for identifying areas of potential risk and in monitoring the progress of risk mitigation efforts. These are the benefits of applying earned value management on the project which will be very useful to construction and project industry.

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