RESEARCH ARTICLE OPEN ACCESS

Analysis of Cost Controlling In Construction Industries by Earned Value Method Using Primavera

T. Subramani[1], D. S. Stephan Jabasingh[2], J. Jayalakshmi[3]
[1]Professor & Dean, Department of Civil Engineering, VMKV Engg. College, Vinayaka Missions University, Salem, India.
[2]PG Student of Construction Engineering and Management, Department of Civil Engineering, VMKV Engg. College , Vinayaka Missions University, Salem, India.
[3]PG Student of Structural Engineering, Department of Civil Engineering, VMKV Engg. College, Vinayaka Missions University, Salem, India.

ABSTRACT
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 is developed in Visual studio 2008, SQL Server 2005, .Net (C# language). Next Comparison of selected parameters between M.S Project 2007, Primavera P6 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
KEYWORDS: Analysis, Cost Controlling, Construction Industries, Earned Value Method, Primavera

I. INTRODUCTION

1.1 What is earned value management (EVM)?

The basic concept of EVM is more than a unique project management process or technique. It is an umbrella term for 32 guidelines that define a set of requirements that a contractor's management system must meet. The objectives of an EVMS are to:

- Relate time phased budgets to specific contract tasks and/or statements of work.
- Provide the basis to capture work progress assessments against the baseline plan.
- Relate technical, schedule, and cost performance.
- Provide valid, timely, and auditable data/information for proactive management action.
- Supply managers with a practical level of summarization for effective decision making.

Once the contractor's EVM System is designed and implemented on a project, there are significant benefits to the contractor and to the customer. Contractor benefits include increased visibility and control to quickly and proactively respond to issues which makes it easier to meet project schedule, cost, and technical objectives. Customer benefits include confidence in the contractor's ability to manage the project, identify problems early, and provide objective, rather than subjective, contract cost and schedule status.

- Earned value management does introduce a few new terms. Contractors' internal systems must be able to provide:
- Budgeted cost for work scheduled (BCWS), sometimes called the planned value.
- Budgeted cost for work performed (BCWP) or earned value.
- Actual cost of work performed (ACWP).
- Budget at completion (BAC).
- Estimate at completion (EAC) which is comprised of the cumulative to date actual cost of work performed plus the estimate to complete the remaining work.
- Cost variance (CV) which is calculated as BCWP minus ACWP. A result greater than 0 is favorable (an underrun), a result less than 0 is unfavorable (an overrun).
- Schedule variance (SV) which is calculated as BCWP minus BCWS. A result greater than 0 is favorable (ahead of schedule), a result less than 0 is unfavorable (behind schedule).
- Variance at completion (VAC) which is calculated as BAC minus EAC. A result greater than 0 is favorable, a result less than 0 is unfavorable.

The Analysis and Management Reports section below illustrates using the variances to track trends over time as a management tool.

1.1.1 About the 32 Guidelines

The 32 guidelines in the ANSI-748 Standard for EVMS are divided into five sections which are discussed below.

1. Organization
2. Planning, Scheduling and Budgeting
3. Accounting Considerations
4. Analysis and Management Reports
5. Revisions and Data Maintenance

1.2 Organization

This first section includes 5 guidelines that focus on organizing the work. One of the most fundamental is that the contractor must establish a work breakdown structure (WBS) extended down to a level that describes the tasks that will be performed as well as their relationship to product deliverables. Also critical is the organization breakdown structure (OBS) that identifies who is responsible for the work effort defined in the WBS. It is at this level where the WBS (what) and OBS (who) intersect that defines a control account, a key management control point. The person responsible for the work effort (scope, schedule, and budget) is the control account manager (CAM). This is the foundation for ensuring the contractor's planning, scheduling, budgeting, work authorization, and cost accumulation processes are fully integrated. Establishing the control accounts is illustrated inFig 1.1.

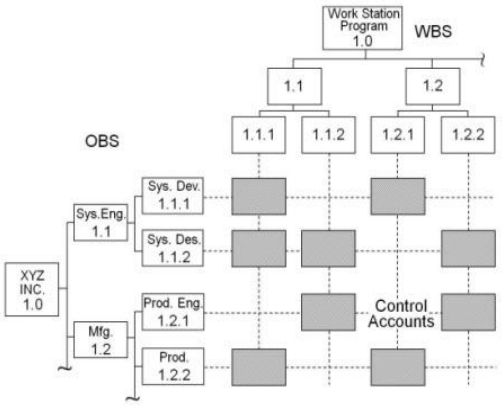


Fig 1.1 Intersection of the WBS and OBS establishes the control accounts

1.3 Planning, Scheduling, and Budgeting

The second section includes 10 guidelines that cover the basic requirements for planning, scheduling, and establishing the time phased budgets for the tasks. The integrated master schedule is the project's road map to meet contract objectives. This schedule must be resource loaded to determine the budget for the work as scheduled. The resource loaded schedule is the basis for the monthly budget, or BCWS, for each task and thus the project. This time phased budget is the performance measurement baseline (PMB). The total budget for each task, control account, or the entire project is defined as the budget at complete (BAC).

Because most projects are initiated with some level of uncertainty; i.e. risk, project managers typically set aside a portion of the total project value as a management reserve (MR). MR added to the BAC equals the total project budgeted value, defined as the contract budget base (CBB). This is illustrated in Fig 1.2

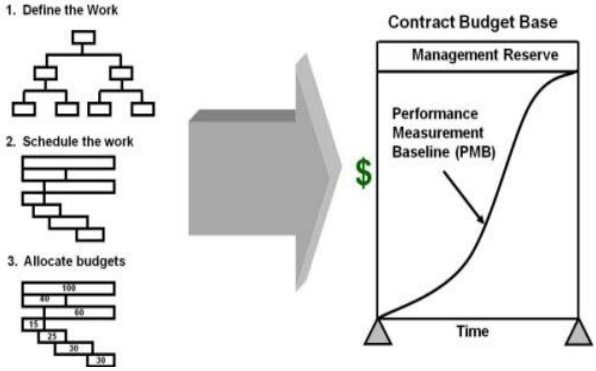


Fig 1.2 Establishing the baseline – an Iterative, three step process

All of the budgets on any project should be logged for successful baseline control. Occasionally contracted tasks may be temporarily held in abeyance, not yet authorized to a manager. When the project manager has yet to assign tasks and budgets to the CAMs, such as an authorized, not yet negotiated additional work, the task and its budget can be retained in undistributed budget (UB). These budget assignments, the WBS, and the functional organizational identity of the managers can be captured in a matrix as illustrated in Fig.1.3..

Work Breakdown Structure / Functional Organizations			Total Project								Organization Budgets
			1.1			1.2			1.3		
			1.1.1	1.1.2	1.1.3	1.2.1	1.2.2	1.2.3	1.3.1	1.3.2	
Top Level Organization	Org. A	Organization A1	1			5			14		20
		Organization A2			12			7		14	33
		Organization A3		4							4
	Org. B	Organization B1				3	12				15
		Organization B2	4		2			3			9
	Org. C	Organization C1	3						1	4	4
WBS Element Budgets			8	4	14	8	12	10	14	15	85
Undistributed Budget (UB)											5
Performance Measurement Baseline (PMB)											90
Management Reserve (MR)											10
Contract Budget Base (CBB)											100

Fig 1.3 Budget summary matrix

A very important aspect of the planning and budgeting process is to determine how BCWP will be assessed. This determination begins with classifying work tasks as one of three types: discrete, apportioned effort, or level of effort (LOE). From this initial classification, for each discrete work effort work package, the CAM selects an earned value technique such as milestones, 50/50, 0/100, or percent complete.

It must be stressed that work only begins when there is formal work authorization to proceed. This requirement is a disciplined approach to clearly define work, schedule, and budget before work commences and actual costs begin to accrue. How can someone be expected to manage the work effort when it is unclear what is to be done? The ad-hoc approach to managing, "Give me a charge number and I'll tell you when I'm done with whatever I think I am supposed to do" does not work. The principles of EVM are quite clear in this regard.

1.3.1 Accounting Considerations

This section is a very straightforward, long standing project management set of 6 guidelines for capturing actual costs (ACWP) expended for project work effort. Actual costs must be captured in a manner consistent with the way work is planned and budgeted. The section outlines the need to select the appropriate time to schedule an important project resource, material, and to accrue performance data correctly. The section also stipulates a common sense practice to accrue the costs for the material in the same month as the BCWP was taken (earned) to avoid a very misleading cost variance, also known as "booking lag."

1.3.2 Analysis and Management Reports

The fourth section of 6 guidelines is very important, inasmuch as it requires human attention to cost and schedule variances, documenting cause, impact, and correction action, and determining a new estimate at complete (EAC), if warranted. The variance calculations are typically done at the control account level which provides the ability to summarize the data up through the WBS and/or the OBS. This is illustrated in Fig 1.4.

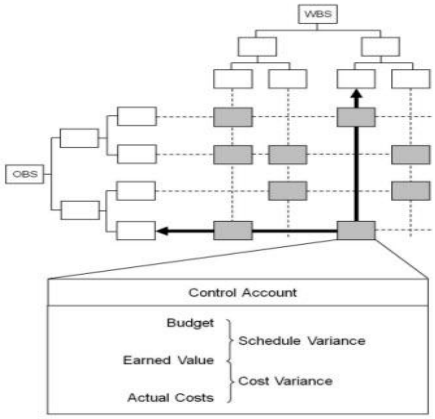


Fig 1.4 Summarizing data by WBS or OBS

As needed, the CAM or others can drill down from the control account level into the detail data to identify the root cause of a variance, determine the impact of the variance on future work effort, and identify correction actions. The use of the EVM data analysis indices is a common practice to help managers consider their past performance and their future performance to complete the work within the approved EAC and estimated completion date (ECD). This is illustrated in Fig 1.5.

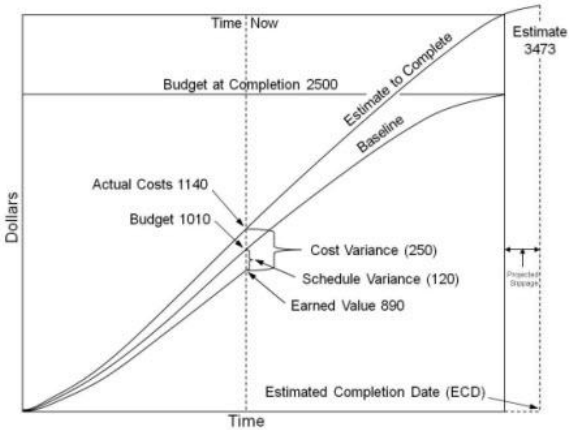


Fig 1.5 Estimate based on combined cost and schedule performance

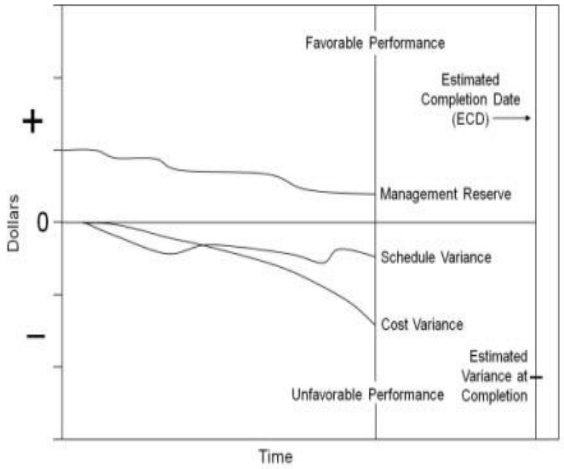


Fig 1.6 Cost and schedule variance trends

The cost and schedule indices are featured in commercial off the shelf project management toolsets and should be carefully reviewed during each reporting cycle. They serve as a valuable validity test to the estimate at completion.(Fig.1.6)

1.3.3 Revisions and Data Maintenance

The final section is a set of 5 baseline control guidelines that emphasizes disciplined and timely incorporation of customer directed changes, including stop work orders. The rules also apply to internal replanning. Lack of baseline control can doom a project. Establishing and maintaining a schedule and budget baseline is essential to be able to assess work accomplished for each reporting period. The Revision and Data Maintenance section is a must for proactive, meaningful earned value

management when there is a constantly changing baseline.

1.3.4 Contractor and Customer Benefits

An earned value management system is an aid to both the contractor and customer. The benefits of implementing an EVMS can be summarized as follows. An EVMS:

- Improves the planning process,
- Fosters a clear definition of the work scope,
- Establishes clear responsibility for work effort,
- Integrates technical, schedule, and cost performance,
- Provides early warning of potential problems,
- Identifies problem areas for immediate and proactive management attention,
- Enables more accurate reporting of cost and schedule impacts of known problems,
- Enhances the ability to assess and integrate technical, schedule, cost, and risk factors,
- Provides consistent and clear communication of progress at all management levels, and
- Improves project visibility and accountability.

Earned Value analysis is a method of performance measurement. Earned Value is a program management technique that uses "work in progress" to indicate what will happen to work in the future. Earned Value is an enhancement over traditional accounting progress measures. Traditional methods focus on planned accomplishment (expenditure) and actual costs. Earned Value goes one step further and examines actual accomplishment. This gives managers greater insight into potential risk areas. With clearer picture, managers can create risk mitigation plans based on actual cost, schedule and technical progress of the work. It is an "early warning" program/project management tool that enables managers to identify and control problems before they become insurmountable.

It allows projects to be managed better – on time, on budget. Earned Value Management System is not a specific system or tool set, but rather, a set of guidelines that guide a company's management control system. In the case of cost overrun, project management team may execute a value engineering program for cost reduction either reducing scope and quality in some sections of project or providing additional budget to cover overrun cost.

Similarly, for time overrun case, the may plan some program such as fast tracking or time crashing for time reduction. Therefore, the role of EVM as well as correct and on time forecasting is very important to achieve project goals. This research includes implementation and improvement on EV to achieve a forecasting EAC based on statistical and econometrics techniques and traditional EV indexes as well. This paper discusses effectiveness of developed software of Earned Value Analysis with MS Project and Primavera P6.

Earned value management (EVM), or Earned value project/performance management (EVPM) is a project management technique for measuring project performance and progress in an objective manner. Earned value management is a project management technique for measuring project performance and progress. It has the ability to combine measurements of:

- Scope
- Schedule, and
- Costs

In a single integrated system, Earned Value Management is able to provide accurate forecasts of project performance problems, which is an important contribution for project management.

Early EVM research showed that the areas of planning and control are significantly impacted by its use; and similarly, using the methodology improves both scope definition as well as the analysis of overall project performance. More recent research studies have shown that the principles of EVM are positive predictors of project success. Popularity of EVM has grown significantly in recent years beyond government contracting, in which sector its importance continues to rise (e.g., recent new DFARS rules[3]), in part because EVM can also surface in and help substantiate contract dsputes.

1.4 Essential features of any EVM implementation include

- a project plan that identifies work to be accomplished,
- a valuation of planned work, called Planned Value (**PV**) or Budgeted Cost of Work Scheduled (**BCWS**), and
- pre-defined "earning rules" (also called metrics) to quantify the accomplishment of work, called Earned Value (**EV**) or Budgeted Cost of Work Performed (**BCWP**).

EVM implementations for large or complex projects include many more features, such as indicators and forecasts of cost performance (over budget or under budget) and schedule performance (behind schedule or ahead of schedule). However, the most basic requirement of an EVM system is that it quantifies progress using PV and EV.

As a short illustration of one of the applications of the **EVM** consider the following example. Project A has been approved for duration of 1 year and with the budget of X. It was also planned, that after 6 months project will spend 50% of the approved budget. If now 6 months after the start of the project a Project Manager would report that he has spent 50% of the budget, one can initially think, that the

project is perfectly on plan. However in reality the provided information is not sufficient to come to such conclusion, as from one side within this time project can spend 50% of the budget, whilst finishing only 25% of the work (which would mean project is not doing well), similarly a project can spend 50% of the budget, whilst completing 75% of the work (which would mean, that project is doing better, than planned). **EVM'** is meant to address such and similar issues.

EVM emerged as a financial analysis specialty in United States Government programs in the 1960s, but it has since become a significant branch of project management and cost engineering. Project management research investigating the contribution of EVM to project success suggests a moderately strong positive relationship.[6] Implementations of EVM can be scaled to fit projects of all sizes and complexities.

The genesis of EVM occurred in industrial manufacturing at the turn of the 20th century, based largely on the principle of "earned time" popularized by Frank and Lillian Gilbreth, but the concept took root in the United States Department of Defense in the 1960s. The original concept was called PERT/COST, but it was considered overly burdensome (not very adaptable) by contractors who were mandated to use it, and many variations of it began to proliferate among various procurement programs. In 1967, the DoD established a criterion-based approach, using a set of 35 criteria, called the Cost/Schedule Control Systems Criteria (C/SCSC). In 1970s and early 1980s, a subculture of C/SCSC analysis grew, but the technique was often ignored or even actively resisted by project managers in both government and industry. C/SCSC was often considered a financial control tool that could be delegated to analytical specialists.

In 1979, EVM was introduced to the architecture and engineering industry in a "Public Works Magazine" article by David Burstein, a project manager with a national engineering firm. This technique has been taught ever since as part of the project management training program presented by PSMJ Resources, an international training and consulting firm that specializes in the engineering and architecture industry.

In the late 1980s and early 1990s, EVM emerged as a project management methodology to be understood and used by managers and executives, not just EVM specialists. In 1989, EVM leadership was elevated to the Undersecretary of Defense for Acquisition, thus making EVM an essential element of program management and procurement. In 1991,Secretary of Defense Dick Cheney canceled the Navy A-12 Avenger II Program because of performance problems detected by EVM.

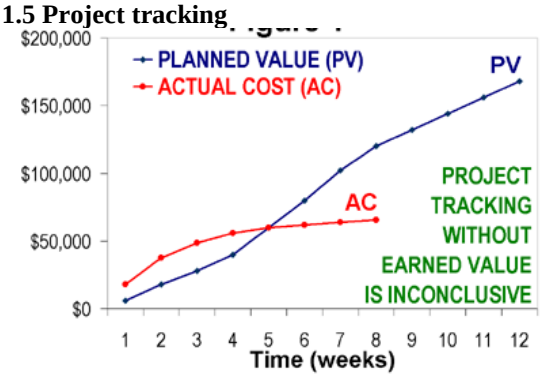
This demonstrated conclusively that EVM mattered to secretary-level leadership. In the 1990s, many U.S. Government regulations were eliminated or streamlined. However, EVM not only survived the acquisition reform movement, but became strongly associated with the acquisition reform movement itself. Most notably, from 1995 to 1998, ownership of EVM criteria (reduced to 32) was transferred to industry by adoption of ANSI EIA 748-A standard.[7]

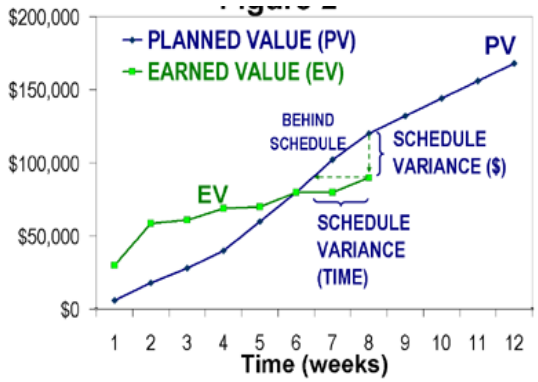
The use of EVM quickly expanded beyond the U.S. Department of Defense. It was adopted by the National Aeronautics and Space Administration, United States Department of Energy and other technology-related agencies. Many industrialized nations also began to utilize EVM in their own procurement programs.

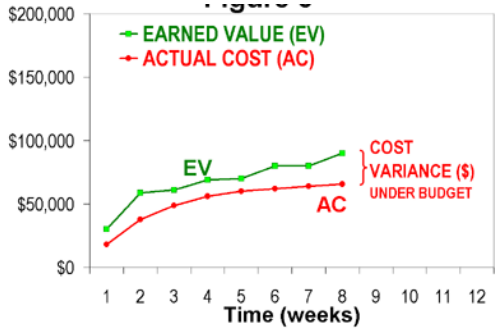
An overview of EVM was included in the Project Management Institute's first PMBOK Guide in 1987 and was expanded in subsequent editions. In the most recent edition of the PMBOK guide, EVM is listed among the general tools and techniques for processes to control project costs.[8]

The construction industry was an early commercial adopter of EVM. Closer integration of EVM with the practice of project management accelerated in the 1990s. In 1999, the Performance Management Association merged with the Project Management Institute (**PMI**) to become PMI's first college, the College of Performance Management. The United States Office of Management and Budget began to mandate the use of EVM across all government agencies, and, for the first time, for certain internally managed projects (not just for contractors). EVM also received greater attention by publicly traded companies in response to the Sarbanes-Oxley Act of 2002. In Australia EVM has been codified as standards AS 4817-2003 and AS 4817-2006.

1.5 Project tracking







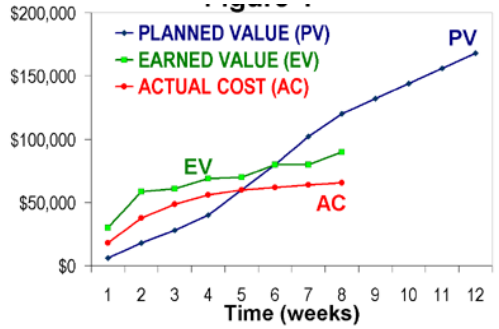


Figure 1.7 shows the cumulative budget

It is helpful to see an example of project tracking that does not include earned value performance management. Consider a project that has been planned in detail, including a time-phased spend plan for all elements of work. Figure1.7 shows the cumulative budget (cost) for this project as a function of time (the blue line, labeled PV). It also shows the cumulative actual cost of the project (red line) through week 8.

To those unfamiliar with EVM, it might appear that this project was over budget through week 4 and then under budget from week 6 through week 8. However, what is missing from this chart is any understanding of how much work has been accomplished during the project. If the project was actually completed at week 8, then the project would actually be well under budget and well ahead of schedule. If, on the other hand, the project is only 10% complete at week 8, the project is significantly over budget and behind schedule. A method is needed to measure technical performance objectively and quantitatively, and that is what EVM accomplishes.

II. EARNED VALUE ANALYSIS – CONCEPT

Earned Value is a program management technique that uses "work in progress" to indicate what will happen to work in the future. EVA uses cost as the common measure of project cost and schedule performance. It allows the measurement of cost in currency, hours, worker-days, or any other similar quantity that can be used as a common measurement of the values associated with project work. EVA uses the following project parameters toevaluate project performance:

- Planned Value
- Earned Value
- Actual Value

As noted, there are many ways to calculate the EV, PV and AC of work packages that are in progress. Comparison of those figures can serve to identify specific work packages in which performance and progress is inadequate or advanced, which will hopefully lead to remedial action by the project manager and team. Cost and schedule performance should be measured and analyzed as feasible with regularity and intensity consistent with project management need including the magnitude of performance risk. Analysis should be progressive and should follow the principle of management by exception. Variance thresholds should be established in the planning phase and should be used to guide the examination of performance.

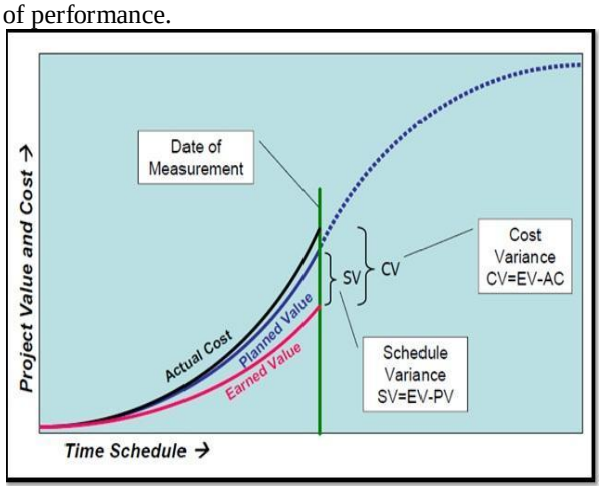


Fig: 2.1.Standard Earned Value Analysis Graph.

Earned value project management is a well-known management system that integrates cost, schedule and technical performance. It allows the calculation of cost and schedule variances and

performance indices and forecasts of project cost and schedule duration. The earned value method provides early indications of project performance to highlight the need for eventual corrective action.

III. ABOUT THE SOFTWARE

Taking lead from the literature review the present study aims at evaluating Earned Value Analysis function of three software namely Microsoft Project 07, Primavera 6 and Develop Software.

IV. CASE STUDY

The Case Study of Residential Project has been taken, using the information of an actual project its cost and scheduling. The Built-up Area of residential building is 120 sq.m. Earned Value analysis in Prima Vera is ahown in Fig4.1 to 4.11

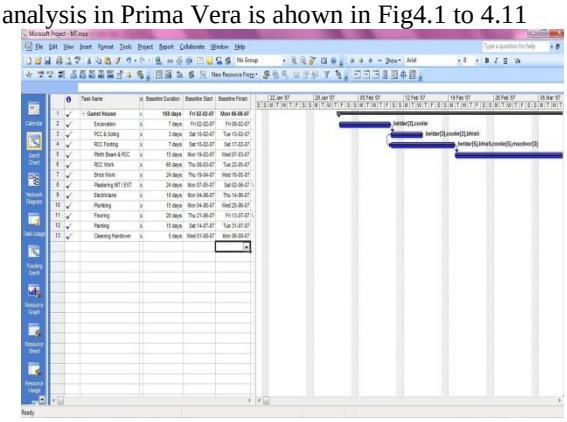


Fig 4.1 Scheduling activity, relationship SS, FS, FF, SF, Start Date, Finish Date

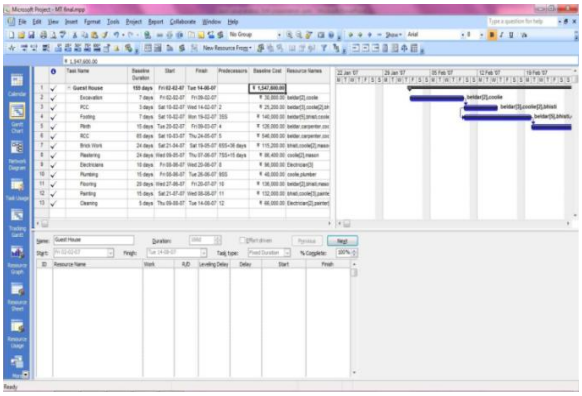


Fig 4.2 Resource sheet, Resource allocation for each activity

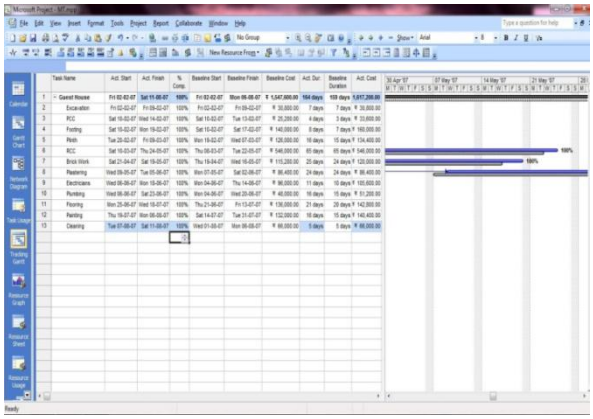


Fig 4.3 Tracking schedule

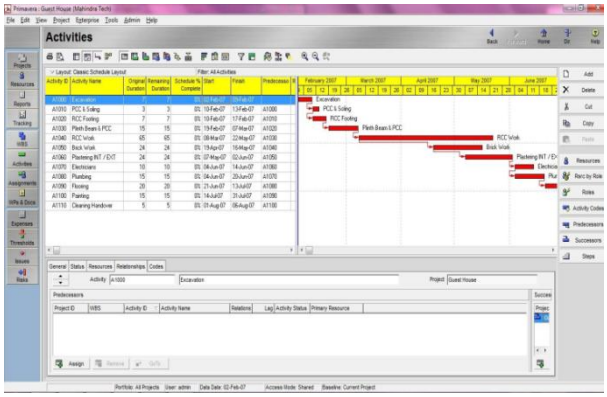


Fig 4.4 Scheduling activity

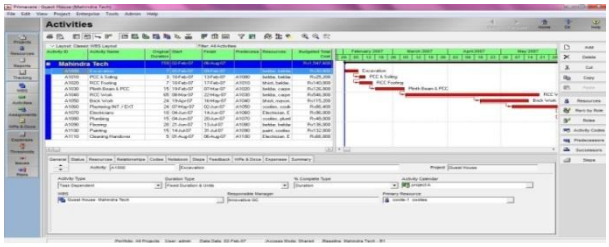


Fig 4.5 Resource allocation

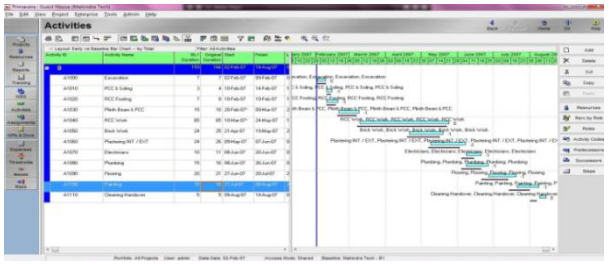


Fig 4.6 Tracking schedule

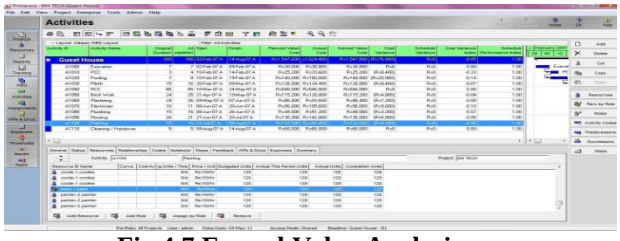


Fig 4.7 Earned Value Analysis

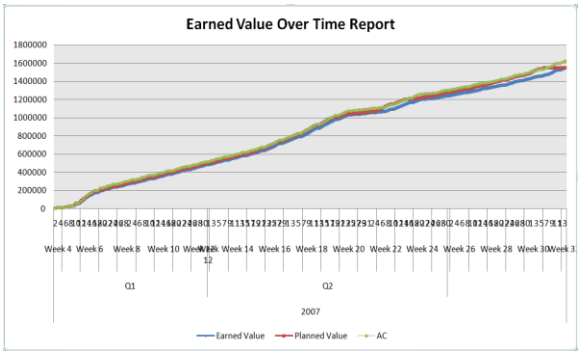


Fig 4.8 Graphical presentation of Earned Value Analysis

C. EARNED VALUE ANALYSIS IN DEVELOPED SOFTWARE

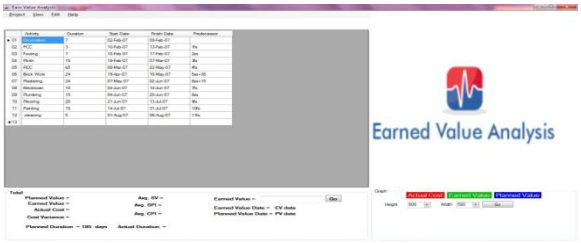


Fig 4.9Scheduling Activity, Relationship SS, FS, FF, SF, Start Date, Finish Date

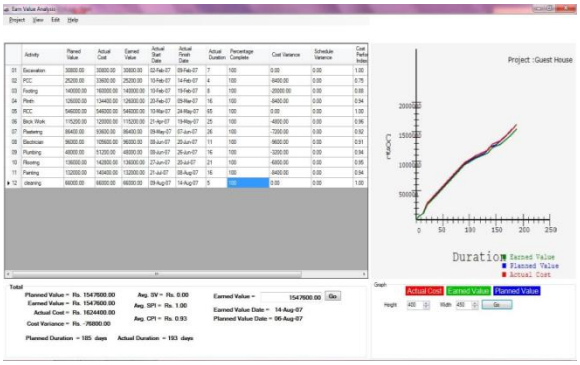


Fig 4.10 Earned Value Analysis and SV(t)

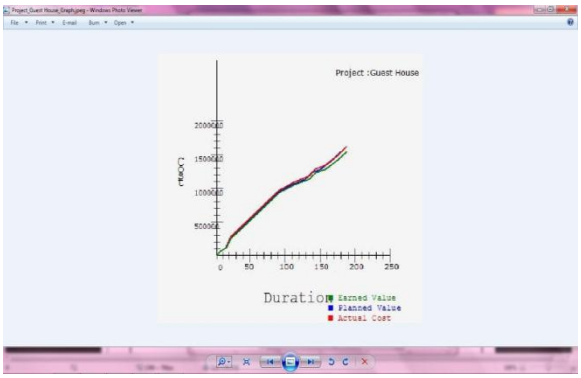


Fig 4.11 Graph generated by Developed software

V. RESULTS

Developed software.[parameters- SV(t), CV ,CPI, PV, EV, AC, PD, AD. In this study 8 parameters where consider for effectiveness of Developed Software, for this purpose comparison was done between M.S Project, Primavera [PV - Planned Value, AC - Actual Value, EV - Earned Value, CV - Cost Variance, CPI - Cost Performance Index, PD - Planned Duration, AD - Actual Duration, SV(t) - Schedule Variance respect to time.] contractors involved in the wide range of construction

VI. CONCLUSION

Although EVA(Earned Value Analysis) may be most easily associated with the monitoring and evaluation of project cost that are undertaken within an organization, it can also be readily applied, with some adjustment, to the control of project cost that are performed by contractors and vendors. In those circumstances, however, it must be recognized that the client and contractor will have differing perspectives on actual and budgeted costs.

This study also indicated that EVA has significant value and presents unique features that can benefit clients, consultants and industries. The two Projects were analysed using the developed software (in C#, .Net & SQL server) and MS Project 2007 and Primavera P6 based on Earned Value Analysis Method. CPI, PD, AD, CV, PV, AC, EV variable were selected.

The result shows a strong relation between each software. The final result gives more than 99.5% accuracy. A new parameter SV (t) (Schedule Variances respect to time) is identified and incorporated in developed software which is not in MS Project 2007 and Primavera 6. The final result gives almost 100% accuracy.

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