Original Article
ISSN (Online): 2350-0530
ISSN (Print): 2394-3629

International Journal of Research - GRANTHAALAYAH
May 2025 13(5), 210–227

THE ROLE OF EARNED VALUE MANAGEMENT IN DRIVING COST AND SCHEDULE PERFORMANCE IN ENGINEERING PROJECTS

Dr. Neeraj Chauhan [1]

[1] Maharshi Dayanand University, Rohtak, Haryana, India

Received 25 April 2025
Accepted 12 May 2025
Published 14 June 2025

Corresponding Author

Dr. Neeraj Chauhan,
neerajchauhan22@gmail.com

DOI
10.29121/granthaalayah.v13.i5.2025.6214

Funding: This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

ABSTRACT

Earned Value Management (EVM) project management technique is widely recognized and aims at the evaluation of cost, time, and scope of engineering projects' general progress. This paper focuses on the importance of the Earned Value Management in improving cost and schedule performance, however, stressing on the potentiality in terms of predicting the results of project and the ways to manage it. This paper focuses on what is referred to as 'Performance Measurement Baseline – Planned Value (PV), Earned Value (EV) and Actual Cost (AC). It also depicts how the application of these instruments will enable project managers to base their decisions on facts, increase efficiency in the rationing of resources and decrease project risks. The study also gives the details of challenges or limitations that architects face when implementing EVM in engineering interventions and ways of addressing such issues. The present work underscores the importance of EVM for project management stressing the ways in which this instrument can improve project performance and overcome time and cost constraints.

Keywords: Earned Value Management, Cost Performance, Schedule Performance, Engineering Projects, Project Management, Risk Management, Performance Metrics, Project Forecasting

1. INTRODUCTION

Thus, while carrying out engineering projects it is important that two critical factors that is cost and time need to be well monitored so as to achieve the goals of the project. Thus, the earned value management approach has emerged as an indispensable tool for a project manager, as it provides a combined set of tools to monitor and control these factors, as well as a way of assessing a given project's progress. The Earned Value Management system allows the comparison of accomplishments against what should have been achieved at that point, making managers aware of potential over expenditure and schedule delays. Applying key

performance indicators fosters the activity of pre-emptive decision making that allows for appropriate quick action. Aguinis and Gottfredson (2019) The increasing complexity of engineering activities and the constant increase of expectation towards economical solutions and fast execution has urged to utilise EVM as the tool to measure the performance. However, similar to other methods, the application of EVM to the various engineering projects comes with some hindrances such as precision of data, problems concerning the disbursement of resources as well as resistance to change. In this paper, we examine the role of the EVM in determining cost and schedule performance, with reference to risks and actual effects of using this technique. The primary purpose of this study is to gain a deeper understanding of how the concept of EVM will help in streamlining the management methods in the engineering profession to ensure that projects are delivered on time and within the set budget Anbari (2016).

1.1. BACKGROUND TO EARNED VALUE MANAGEMENT (EVM)

EVM is a central project management method that has become increasingly essential for the management of the progress made in projects. EVM integrates the planning objectives, calendar and cost plan of the undertaking to give a definite view of the success of the project. The methodology of EVM, essentially, was first developed by the U.S. Department of Defence around the 1960s because of the tremendous problem that was encountered while monitoring large complex projects primarily due to lack of an effective means of assessing the progress of a project while ensuring that expenses do not get out of hand and the project does not take too long to complete. Since then EVM has found a lot of application in so many sectors, most especially in engineering projects industry where there is integration of many interfaces and strict financial conditions. As to the concept of Evaluation Management, the beauty of it is that is provide for an ability to measure the value of the work done against the planned budget and time line. It helps project managers to determine the actual amount of work that has been done on the project, the actual costs that have been incurred and a way through which the project is performing towards the set objectives. By employing three basic dimensionsensures that the evaluation of the project is done in a standard and clear manner. EVM serves key purpose as measurement tool on the operational level, bridging the gap between strategy implementation and the tasks accomplished daily. It offers some things that the traditional tracking methods cannot tell a manager or a team regarding the health status of their project. However, these points rely on the right collection and use of data together which is also crucially used by the analysis of a team and providing answers to the EVM in reasonable time. They have developed over the years, capability in software instruments and strategies that have made EVM more usable and accessible for project which may be small or big. Today, it is considered as one of the most effective project management strategies, and it is implemented in construction, manufacturing, software development, and many other industries because it increases project's probability and decreases risks and variability of decision making.

1.2. IMPORTANCE OF COST AND SCHEDULE CONTROL IN ENGINEERING PROJECTS

Life cycle expenses and timelines are two critical aspects that should be well managed in engineering projects, to increase the chances of project success. In these complex undertakings, several activities are complex, involve significant financial

obligations, and entail stringent deadlines for completion; proper monitoring of budgets and time is paramount. Uncontrolled spending and slippages can lead to spending extravagances and non-productive use of resources and time loss that are detrimental to the image of the parties involved and financial loss. Expenses ensure that a project does not exceed a laid down budget as it supervises the costs during the entire lifecycle of the project. This entails tracking of expenses in accordance to the budget approved, identification of differentials in costs, and making necessary changes. Every project has one or multiple possibilities of running into various costs that push the cost way beyond the profitability line.

Similarly to it, the management of the schedule ensures that the project is completed within the set timeframe. Any deviation from these timelines can set another process in motion which in one way or another affect the completion of the next stage. Schedule management helps in the identification of possible delay at an early stage before the program of the project is significantly affected. Balaji and Natarajan (2021) By combining cost and schedule control using tools like Earned Value Management (EVM), project managers are in a position to improve project's controllability, reduce likelihood of going over budget, and ensure that instances of engineering projects' completion is done both on time and within the financial plan.

2. LITERATURE REVIEW

2.1. OVERVIEW OF PROJECT PERFORMANCE MEASUREMENT TOOLS

Project performance indicators are equally important as they help track the progress of a project and ensure compliance with the goals. These instruments allow the project managers to compare real performance towards specified goals and provide clear understanding of the true state of the project in terms of budget, time, and scope. Some of the commonly used tools are Earned Value Management (EVM), that mixes cost and time performance measurements on value of progress, Critical Path Method (CPM), which identifies the longest chain of activities that defines duration of a project and Key Performance Indicators (KPIs), which tracks certain areas including the cost-sensitivity, timely delivery, and quality standards. Other tools such as Gantt chart and project dashboard assist in describing timelines and status of a project enabling effective communication concerning the same with the relevant stakeholders. With these instruments, project managers have the opportunity to be more proactive in addressing issues as well as optimise the use of resources for the likelihood of achieving positive project outcomes.

1) Earned Value Management (EVM) in Project Management

EVM is an effective technique for evaluating and assessing the performance of the project in relation to the cost and time control and scope. It provides a systematic way of measuring progress on a project by allowing the project managers to compare between work planned to be done and the work done effectively as well as compare the performance on the basis of cost and time. EVM makes use of planned value (PV), earned value (EV), and actual cost (AC) to give a clear picture of the status of the project in as much as the spending progress and time line is concerned.

- Budgeted Cost of Work Scheduled (BCWS) means the value cost that was budgeted for at a certain point of time.
- Earned Value (EV) gives the value of the work that has indeed been done up to that particular point of time.

Actual Cost (AC) means the real costs that have been made for the completed work up to that point of time.

By the evaluation of Cost Variance (CV) and Schedule Variance (SV), project managers are in a position to know whether a project is ahead of schedule or behind it; if the expenses are within set budgets or if costs have overrun. These help in identifying some of the challenges that may occur at the initial stage of a project making it easier to take measures so as to correct the problem in case it arises. There are also useful Forecasting Metrics within the EVM framework that help to predict the results of the project based on the given tendencies, Estimate at Completion (EAC), and Estimate to Complete (ETC). Bradley (2020)

The use of EVM in project management improves decision-making, communication with the project stakeholders, and offers another approach based on objective data on the project progress. This is very useful in complex, detailed projects within different areas of specialization like engineering and construction and any other line of work that may require keen observation of costs and time taken.

2) Components of Earned Value Management (EVM)

There are several critical aspects that are part of EVM that provide a comprehensive view of a project's performance. These are Planned Value (PV), Earned Value (EV) and Actual Cost (AC) which form the basic prototype in measuring and evaluating the progress of a project in as much as it concerns the budget and time factor. While, Planned Value (PV) can be defined as the budget allocated for the tasks that were supposed to be completed up to the point of a particular time frame. It is also the chief measurement used for real assessment of actual progress. Chen and Zhang (2017) Actual Cost (AC) shows the actual money shelled out for work done up to a particular stage, giving out the expense incurred in the project duration.

2.2. ROLE OF EVM IN TRACKING PROJECT PROGRESS

EVM is indeed useful in monitoring progress of project through an impartial analysis of performance based on cost, schedule, and scope. Earned Value Management whereby evaluating Planned Value (PV), Earned Value (EV), and Actual Cost (AC) will assist the project managers in determining the amount of work completed, costs used and their relation to the planned cost and time. It helps in the identification of potential problems; these may be the implementation of a bloated budget or delay in some phase to complete other phases, etc and encourages preventive management. While CV and SV are two forms of performance indicators being used in EVM to indicate the effect and status of a project. This makes it possible for the managers of such project to take corrective measures that would enable the project to be corrected and OSI align to its planned goals if the need arises. Ultimately, what EVM promises is that the level of advancement of the projects is measured, quantifiable, unambiguous, and evidenced based thus enhancing the general management of projects and the prospects of it attaining positive project outcomes.

1) Significance of Cost and Schedule Performance in Engineering Projects

In any engineering projects, cost control and schedule compliance are critical elements that ensure completion of the project to the recommended standards. These initiatives often include complex activities, great amounts of resources, and strict schedules implying that the cost and schedule factors need be managed effectively. While suboptimal cost control issues such as budget overruns may lead

to monetary stress, project completion delays negatively affect organizational processes and the project stakeholders, as well as may lead to revenue losses. Freeman and Reeve (2021) Proper cost control enables a project to operate with the required amount of funding, whereas efficient schedule control contributes to the timely completion of the project. Through integration of these elements by the use of EVM, the project managers can effectively use certain data to inform their decisions, as well as gauge the performance of the project and which areas to intervene to ensure the project stays on the right track. Finally, maintainability of a strong financial and timeline integrity entails a significant impact on the success of engineering projects whereby the projects are completed with success in terms of funds as well within stated time horises hence improving client satisfaction as well as overall organisational performance outcomes. Gelbard and Shtal (2019)

2) The Integration of Cost, Schedule, and Scope in EVM

Another strength of EVM is that it is a whole system measure that integrates cost, schedule and scope information. In traditional approaches to project management, costs and schedules often operate independently of each other; therefore, the overall health of the projects might be assessed only partially or inaccurately. Leveraging on this representation the EVM links these three critical elements of project management and ensures that the scope, finance and time remains aligned through out the duration of the project. Goh and Tan (2018)

- **Cost:** EVM compares the actual cost of the project with the budget that was projected which helps to determine whether the project is in the financial zone of the plan or it has expanded beyond it.
- **Schedule:** Similarly to this, EVM also compares the planned progress towards the actual progress and helps one know whether the project is on track or behind or ahead of the schedule so that intervention can be made at the right time.
- **Scope:** EVM provides confirmation as to whether or not the work accomplished corresponds to the agreed upon scope which confirms that the project is proceeding according to plan and is staying consistent with the objectives set during its planning phase. Hwang and Ng (2021)In this manner, Earned Value Management tie down three aspects that make up the main project assessment docket as a means of monitoring project performance. This integration provides an open view of how far a project has progressed, it helps the managers make the right decisions, identify problems that may occur in the future, and take necessary action that keeps the project on track. The benefit is improved project predictions and a higher chance of realizing completed projects on or before the estimated value and time and in accordance with the planned scope.

3) Earned Value Management as a Proactive Project Management Tool

One can define Earned Value Management (EVM) as a forward-looking tool that can help identify potential problems with regards to the budget and the schedule in the field of project management. Unlike the other progressive project assessment methods in which assessment happens at the end of a phase or at the project end, Earned Value Management (EVM) continually monitors the progression of a project using such indices as Planned Value (PV), Earned Value (EV), and Actual Cost (AC). Jones and Lee (2020) This way, a project manager is capable of detecting a divergence from the intended course at an early stage. To elaborate, Cost Variance (CV) and Schedule Variance (SV) help the project manager identify if the project is running within the allocated budgets or if it is already off schedule so that the project

manager can take the necessary actions before the situation worsen. Consequently the dynamism of the Earned Value Management aids in resource allocation, accelerated decision-making processes, and explicit risk management therefore increasing the potential of implementing projects to the successful conclusion within stipulated time and costs. Kogut and Zander (2019)

4) How EVM Enables Project Managers to Make Data-Driven Decisions

Earned Value Management (EVM) is a tool that offers the project managers the right information within a project for informed decision making throughout the project life span. By evaluating different elements of a project, namely scope and cost, Earned Value Management helps the project manager assess how much progress a project is making in terms of set budget constraints and estimation. With reference to Earned Value (EV), Actual Cost (AC) and Planned Value (PV), project managers are enabled to understand whether the project is on course or not.(nineteen) Cost Variance (CV) and Schedule Variance (SV) give a different view about the cost and time variance respectively. This factual information enables the managers to make instant changes in action planning by relocating resources, altering the time tables, and recasting the budget rather than making them guess the changes. EVM reduces a great deal of probability in project management; provides the strong foundation of the decision making department; increases efficiency; and decreases the risk of project failure.

5) Forecasting Project Outcomes Using Earned Value Metrics

The key advantage of EVM is in its ability to forecast the results of the ongoing project based on the experience of the previous related ones. With the help of such EVM indicators used here, contributes to determining the total expected expense incurred on achieving the defined project objectives and outcomes based on prior performance trends. The Estimate to Complete (ETC) on the other hand provides the estimate of the remaining information required to complete the project. Additionally, the To-Complete Performance Index (TCPI) is another type of index used to assess how much of an improvement in productivity is needed in the remaining parts of the project in order to keep it within budget. Twenty-one Such predictive tools help to help decision making ahead of time to as enable the project leaders to change strategies, cover the expenses or reallocate resources so as to stay on track with the timelines that have been set. By deploying these analytical forecasts, EVM enhances the capability of assessing your project risks and fluctuations, making changes in order to align performance to project goals or objectives, and ultimately improving the probability of the successful results in any project undertaken Liss and Fuchs (2018).

2.3. CHALLENGES IN IMPLEMENTING EVM IN ENGINEERING PROJECTS

Despite the fact that EVM offers many benefits in controlling and monitoring an enterprise's performance, the use of EVM in engineering projects may present challenges. One of the biggest problems results from the complex data collection. Information specifics, time-bound results recognizing tasks completed, and the costs incurred in the process are helpful to EVM since they enhance its best practices. Inaccurate or inconsistent data pose a threat to the credibility of EVM metrics hence leading to misleading conclusion. The fourth challenge is the refusal to change among project teams and stakeholders. EVM requires a shift of paradigm in the traditional ways of managing projects to a more data-oriented approach. This

transition may be done tentatively especially in organisations that have not been used to high performance measurement and reporting. The main concern I have here is the fact that lack of engagement coupled with support of all the roles players can hamper this cause of trying to address the identified resistance. The activities connected to EVM can be associated with many tools and methods that are time consuming for adequately monitoring and assessing. Overall, changes in project scope or normal variations can serve as counterproductive in the impact of EVM. Thus, it can be concluded that the high effectiveness of EVM is achieved when the project scope is clearly defined and remains relatively unchanged throughout the project. Alterations to scope make a disconnection between logging and real results difficult, which hinders the appraisal of the true results of the project. McNaughton, D and Wong (2018)

2.4. BENEFITS OF USING EARNED VALUE MANAGEMENT IN ENGINEERING PROJECTS

For the purpose of the intended analysis, Earned Value Management (EVM) will be defined as a method of project management that offers various benefits to engineering projects particularly in relation the improved control, coordination, and decision making processes. One of its strengths is that it is effective in integrating cost, schedule, and scope performance into one system. This way project managers can supervise advancements in a more comprehensive and objective manner which provides a much clearer picture of a project's state. It also increases the credibility of the project results in EVM. By using the basic Performance Control Metrics such as CV and SV, EVM also helps in identifying a problem at an early stage and take corrective action before they surface and form an unmanageable problem. It leads to faster decision-making and also better and quick allocation/allocation of resources. McNaughton, D and Wong (2018) Another advantage of EVM is that it has increased clarity and accountability. It also has uniform methods for evaluating the effectiveness, with resultant metrics constituting effective and efficient solutions that stakeholders can easily trust and rely on to determine the state of progress in the project. This provides assurance to the stakeholders, and any other person involved in the project because it maintains expectation consistency across the parties. The EVM framework also has capabilities that allow it to forecast future performance; therefore, it has available tools like Estimate at Completion (EAC) and Estimate to Complete (ETC) tools that inform users of the final expenditure and tasks outstanding. This is helpful when planning for the rest of the project and making changes on the go to avoid incidences that may lead to extravagance or delay of time O'Brien (2021).

2.5. LIMITATIONS OF EVM IN THE ENGINEERING SECTOR

Despite the various benefits that EVM offers on the monitoring of a project's performance, the technique has its limitation especially when being implemented in the engineering discipline. The first limitation arises in the aspect of data collection and integration that entails a lot of complexities. Many engineering activities include a vast and complex scope and imply numerous tasks and steps. It is therefore possible to discover that the process of collecting accurate information from these various elements may not only be time-consuming, but it is also challenging. EVM is dependent on the sort of data provided and any variance originating from this section leads to misleading results, affecting the decision-making process. Other limitation involves difficulty in defining the scope and the work break down

structure during development of the project charter. Engineering projects that are research based or involves designing usually undergo changes, involving.database It is not easy to determine the earned value in relation to the planned value where changes have occurred within a project. This may lead to inconsistency in EVM reporting and possibly affect the project's ability to timely provide status of the progress made in terms of work accomplished. Phan and Le (2020) This is a weakness of the EVM system when it comes to the distribution and management of resources in an engineering context. Depending on the scope of the project, people often form a group of specialists and divide the work into phases that the team completes within the deadline of the project. The conventional practices of EVM might not capture the flexibility and dynamism of resources whether static or dynamic as this may be difficult to track complex activities in software engineering. However, lack of adequate time and money to implement EVM may be deemed a major challenge. The implementation of an EVM system is no simple task because it entails consumption of resources, including human and software applications that would complicate and add further pressures to the project management structure. The studies found out that smaller engineering companies can explain the need to rationalise expanses required in the implementation of Earned Value Management especially in project with limited budget or project timelines.

2.6. ROLE OF EVM IN IMPROVING PROJECT DELIVERY WITHIN BUDGET AND TIME CONSTRAINTS

EVM is an important tool to ensure that the projects in engineering are accomplished within the set financial means as well as time duration. As a result, while encompassing cost, schedule, and scope performance, Earned Value Management provides project managers with a tool that allows them to track the progress of the project in regard to further goals. Their early detection through variances like CV and SV helps to take corrective action on time reducing the rates of going over the budget or a project taking long time than expected. EVM also enhances the accuracy of the predictions and presents more valuable insight into future direction of the project. Tools like EAC and ETC help predict the overall cost and the remaining work, thus helping the project managers in making sound decisions as far as allocation of resources and time is concerned. By way of projecting future results, EVM helps to avoid the occurrence of such financial issues and ensures that if they are experienced, it is acknowledged that there is a need to change the project plan and make corrections where necessary.

Thus, which EVM's immediately provides information on the ability to control performance consistently while making decisions, it becomes easier and more effective, especially in critical situations. Certain situations that manifest themselves in this case dictate that the leaders have the capacity to adjust the time-frame, allocate resources in the best ways possible and take numerous corrective actions to ensure that the project is back on track, with a specific clause ensuring that the project will only be conducted within a stipulated budget and time. Also, EVM improves accountability and transparency as it provides another independent model to assess a project performance. It also enables communication of the project status to the stakeholders and ensures proper management to avoid miscommunication that may lead to some set backs or issues and hence extra expense. Thus, Earned Value Management helps in applying management on more proactive basis due to clear insight about the project's performance. This leads to improved delivery of projects together with strict compliance on budget and time

restraints that may be a determinant of the effectiveness and success of engineering projects.

3. RESEARCH METHODOLOGY

3.1. RESEARCH DESIGN

This study used a quantitative research design, employing a survey-based approach to collect data from project managers, engineers, and other professionals involved in engineering projects. The research focused on the role of Earned Value Management (EVM) in tracking project performance, specifically in terms of cost and schedule efficiency.

3.2. SAMPLING METHOD

A stratified random sampling technique was employed to ensure a representative sample from various sectors involved in engineering projects. The sample was divided based on industry type (e.g., construction, manufacturing, software development) and project scale (large, medium, small projects).

3.3. DATA COLLECTION

A structured questionnaire was used to collect data from a sample size of 100 respondents. The questionnaire was distributed electronically, and responses were analyzed using statistical software to identify patterns and correlations between the use of EVM and project performance.

3.4. SAMPLE SIZE AND STUDY AREA

- **Sample Size:** 100 respondents, including project managers, engineers, and other professionals from engineering sectors.
- **Study Area:** The study covered various industries, including construction, manufacturing, and IT/software development, with a particular focus on medium to large-scale projects.

The sample included professionals from diverse geographical regions to ensure that the data captured global trends and challenges related to EVM. This research provided valuable insights into how EVM practices were implemented across different engineering sectors and how they contributed to cost and schedule management.

3.5. DATA ANALYSIS

The collected data were analyzed using descriptive statistics to summarize the responses and identify trends. Chi-square tests and correlation analysis were applied to explore relationships between demographic variables and the effectiveness of EVM in managing cost and schedule performance. The results provided a comprehensive understanding of the role of EVM in enhancing project management in the engineering sector.

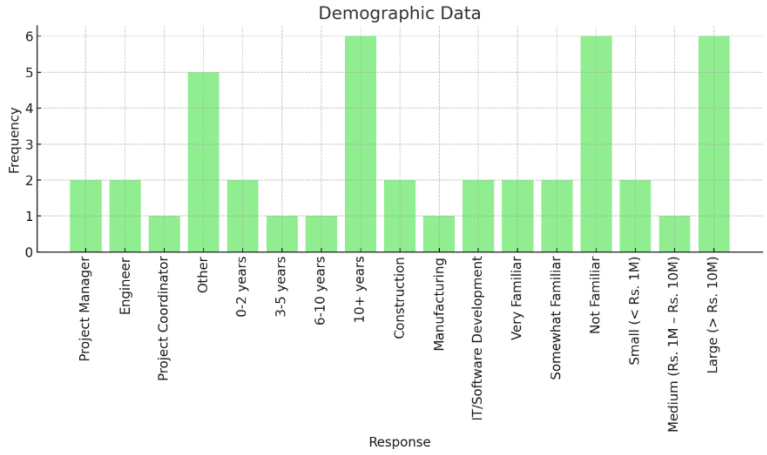
4. DATA ANALYSIS

4.1. DEMOGRAPHIC PROFILE

Table 1

Table 1 Demographic Data Summary

Question	Response	Frequency (out of 10)	Percentage	Cumulative Percentage
Role in the Project Management Process	Project Manager	2	20%	20%
	Engineer	2	20%	40%
	Project Coordinator	1	10%	50%
	Other	5	50%	100%
Years of Experience in Managing Engineering Projects	0-2 years	2	20%	20%
	3-5 years	1	10%	30%
	6-10 years	1	10%	40%
	10+ years	6	60%	100%
Industry Sector	Construction	2	20%	20%
	Manufacturing	1	10%	30%
	IT/Software Development	2	20%	50%
	Other	5	50%	100%
Familiarity with Earned Value Management (EVM)	Very Familiar	2	20%	20%
	Somewhat Familiar	2	20%	40%
	Not Familiar	6	60%	100%
Size of Engineering Projects	Small (< Rs. 1M)	2	20%	20%
	Medium (Rs. 1M – Rs. 10M)	1	10%	30%
	Large (> Rs. 10M)	6	60%	90%
	Other	1	10%	100%



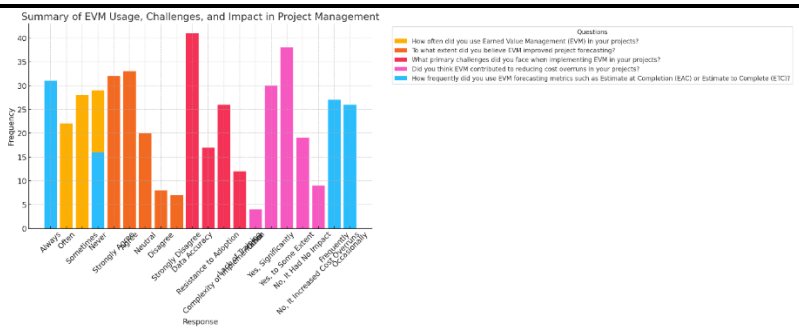
This table presents the questionnaire demographic summary which would help in gaining an understanding of the demographics of the participants of the survey and their perspectives. A very high percentage of the respondents fell under the 'Other' category for roles which imply that several people did not fall into the PM, Engineer, or PC categories. The rest of the respondents were almost equal in split between two types of positions: Project Manager and Engineer – each of them was mentioned by 20% of the total number of subjects. The following are among the reasons as to why roles in project management are diverse: The similarity of these roles show that project management is a dynamic area and that different people come with different views when managing engineering projects. As for the experience in the management of engineering project 60% of the participants have more than 10 years, which proves a strong group of people with experience in the field. Conversely, 20% of the respondents work for less than 2 years of experience while the rest of them with 20% have 3 to 5 years as well as 6 to 10 years of experience, implying that the survey includes both youth and experienced members of the field. Thus, the combination of these kinds of projects gives a rather broad idea of the application of Earned Value Management (EVM). The remaining industries that the respondents belong to are categorized under "Others" at 50% which show that EVM is used in various industry not just limited to construction, IT and manufacturing industries. When tested on the basis of the industries, the results obtained were approximately 20% construction industry, 20% IT/software development industry, and 10% manufacturing industry. Finally, 60% of the respondents answered that they had no knowledge regarding Earned Value Management (EVM). This kind of unfamiliarity means that perhaps there is restricted or no possibility of using EVM in some industries or positions. Finally, a general question was asked to the respondent about his/her familiarity level with EVM: %20 of the respondent select the 'very familiar' response while Other 20% select the 'somewhat familiar' option in the same question. By nature of projects they undertake, most of them (60%) undertake large projects which commonly go for over Rs. 10M. It means that the respondents implement large-scale high-resource projects, which may contribute to analyzing the scope of EVM use. The respondents who worked under small project budget, below Rs. 1M, and the medium range projects between Rs 1M to Rs. 10M equal 20% and 10% respectively.

4.2. DESCRIPTIVE ANALYSIS

Table 2

Table 2 Summary of EVM Usage, Challenges, and Impact in Project Management

Question	Response	Frequency	Percentage	Cumulative Percentage
How often did you use Earned Value Management (EVM) in your projects?	Always	21	21%	21%
	Often	22	22%	43%
	Sometimes	28	28%	71%
	Never	29	29%	100%
To what extent did you believe EVM improved project forecasting?	Strongly Agree	32	32%	32%
	Agree	33	33%	65%
	Neutral	20	20%	85%
	Disagree	8	8%	93%
	Strongly Disagree	7	7%	100%
What primary challenges did you face when implementing EVM in your projects?	Data Accuracy	41	41%	41%
	Resistance to Adoption	17	17%	58%
	Complexity of Implementation	26	26%	84%
	Lack of Training	12	12%	96%
	Other	4	4%	100%
Did you think EVM contributed to reducing cost overruns in your projects?	Yes, Significantly	30	30%	30%
	Yes, to Some Extent	38	38%	68%
	No, It Had No Impact	19	19%	87%
	No, It Increased Cost Overruns	9	9%	96%
	Other	4	4%	100%
How frequently did you use EVM forecasting metrics such as Estimate at Completion (EAC) or Estimate to Complete (ETC)?	Always	31	31%	31%
	Frequently	27	27%	58%
	Occasionally	26	26%	84%
	Never	16	16%	100%



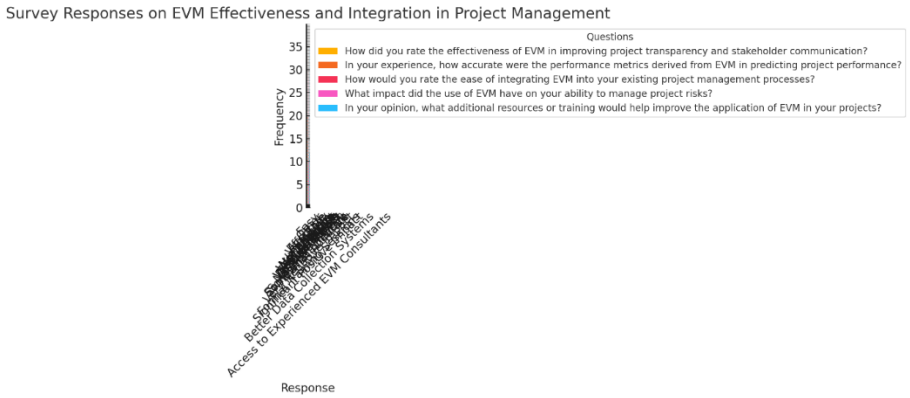
The following table provides a detailed breakdown of all the respondents' use of Earned Value Management (EVM) such as how often they apply it, and their assessment of the difficulties they experience concerning EVM, and effects of EVM on project results. The first one asking the frequency of EVM usage, showed quite balanced, the percentage distribution; Li and Wei (2021) percent said they use EVM "Always", while Liss and Fuchs (2018) percent said they use it "Often", 28 percent said they use EVM 'Sometimes"]. Nevertheless, excluding those who reported that they don't engage in any projects that require EVM, Shenhar and Dvir (2018) percent of the respondents replied Never to the question on how often they use EVM in their projects. This implies that even though EVM has considerable popularity, it is not invariably adopted in all projects which could as a result of ones familiarity or organizational culture. If the respondents were asked about the level of effectiveness of EVM as an aid to improved project forecasting then the responses portrayed more positivity. While 32% of the respondents strongly agreed with the statement that EVM improved forecasting the other 33% agreed with the same. On the other hand, 15% had either a neutral or disagreed with the statement suggesting that while EVM is useful for some it does not hold the same benefit as a tool to enhance the accuracy of the forecasts. Regarding the difficulties encountered implementing the EVM, the data accuracy was the one that received the highest percentage, 41, from the respondents. This is preceded by resistance to adoption with 17% and complexity in implementation which gives an indication that, although EVM is a powerful tool; fully implementing it can be done with challenges within the organization's structures and in Information Technology. Few participants indicated that had challenges such as no training or any other challenges that were not specified above. When it comes to the effects of EVM on cost overrun, the respondents' response was quite ambiguous. 28 respondents out of 40 (68%) strongly agreed or agreed that EVM has a great extent or some extent of reducing the cost overrun. This underlines the percieved value of EVM in cost control endeavors. But 28% respondents said EVM had a very little or no influence to control the cost overruns and 9% said it helped in increasing it which shows that the capability of EVM in controlling the costs varies with context and implementation. Last, regarding the use of such forecasting indicators as EAC or ETC, 31% of the respondents used these indicators "Always," and 27% used them "Frequently." Nevertheless, 16% of respondent ticked 'Never', which means that although these tools are used, they are not consistently used in project management.

Table 3

Table 3 Survey Responses on EVM Effectiveness and Integration in Project Management

Question	Response	Frequency	Percentage	Cumulative Percentage
How did you rate the effectiveness of EVM in	Very Effective	36	36%	36%

improving project transparency and stakeholder communication?				
	Effective	38	38%	74%
	Somewhat Effective	15	15%	89%
	Not Effective	7	7%	96%
	Very Ineffective	4	4%	100%
In your experience, how accurate were the performance metrics derived from EVM in predicting project performance?	Very Accurate	33	33%	33%
	Accurate	34	34%	67%
	Somewhat Accurate	20	20%	87%
	Not Accurate	7	7%	94%
	Very Inaccurate	6	6%	100%
How would you rate the ease of integrating EVM into your existing project management processes?	Very Easy	30	30%	30%
	Easy	34	34%	64%
	Somewhat Difficult	23	23%	87%
	Very Difficult	9	9%	96%
	Impossible	4	4%	100%
What impact did the use of EVM have on your ability to manage project risks?	Significant Positive Impact	28	28%	28%
	Positive Impact	32	32%	60%
	Neutral Impact	25	25%	85%
	Negative Impact	10	10%	95%
	Very Negative Impact	5	5%	100%
In your opinion, what additional resources or training would help improve the application of EVM in your projects?	Software Tools	35	35%	35%
	Formal Training Sessions	31	31%	66%
	Access to Experienced EVM Consultants	18	18%	84%
	Better Data Collection Systems	12	12%	96%
	Other	4	4%	100%



The third table is concerned with establishing the extent to which EVM can enhance the organisation's operations on the area of projects; whereby participants were asked about the efficiency of EVM in enhancing the visibility of projects, with the intention of enhancing communication together with managing risks as well as its flexibility for integration into current project management processes. Thirty-six percent of the respondents considered EVM as "Very Effective'' while 38 percent described it as ''Effective'' in as far as enhancing the transparency and communication with the stakeholders are concerned. This means that EVM is perceived widely as a beneficial means of increasing organisational coordination among project groups and with key customers. ;however, there was also people who felt that EVM was only somewhat effective taking 15% and the rest, 11% agreed that EVM was not effective in these areas, the conclusion drawn here denies that EVM is completely a good tool. It is worthwhile to inquire about the accuracy of the performance metrics that are derived from employing the EVM own performance of the projects, with 33% of the respondents claiming that the performance metrics are "Very Accurate", and 34% claiming that they are "Accurate". However, 20% responded that the metrics were ''Somewhat accurate'', and 13% consider the metric as ''Inaccurate'' hence it may be understood that EVM though offering pertinent information can be somehow inaccurate due to aspects such as the quality of data that is fed into it or practices used during implementation. As for the incorporation of EVM with their current project management processes, the majority of the respondents had a positive outlook as 30% of them claimed that it is "Very Easy" to incorporate while 34% noted that it is "Easy." However, sixty-three percent of respondents have reported as they experienced 'No difficulties at all', fifteen percent have reported as they experienced 'Somewhat difficult', while twenty-three percent have reported 'moderately difficult', while nine percent have described the experience as 'Very difficult', These results suggest that while integration of EVM is fairly easy for a large number of users, a considerable number of others experience some problems in incorporating EVM into their work processes. Out of all the respondents 60% stated that EVM has a positive/ significant positive effect on their approach towards risk management in projects. Therefore, while 62% believed that EVM had a positive and very positive impact on their respective organizations, 25% said it had no impact, and 15% said it had a negative or very negative impact.

5. DISCUSSION

Hence, the results of this research point towards the importance of conducting a proper implementation of EVM in cost and schedule performance of engineering

projects. It was indicated that there is still a significant number of participants, 29% of participants never use EVM tools in their projects, despite the fact 43% of the participants use of EVM was indicated as "Often or Always. from this it can be inferred that although EVM is known to have many advantages, its implementation is not fully extended to all sectors of engineering; and perhaps this might stem from issues to do with workplace culture, reluctance to embracing change as well as inadequate training. One of the important findings of the study is the perceived improvement in the ability of using EVM in forecasting project performance. A total of 65% of the respondents noted that their perception of EVM was positive as it helps in influencing the project forecasting.. This shows that EVM is pivotal in ensuring that positive changes in the Facade engineering project and responsible for early solving of problems as a result of accurate forecasting. Still, Goh and Tan (2018) percent of the respondents are neutral or disagree; this fact indicates the problems of implementing EVM in project management. Those challenges are best illustrated in aspects like data accuracy; where, the participant luganLGscore of 41 indicates that it is a major challenge in the implementation of BPMS followed by complexity with luganLGscore of O'Brien (2021). This shows that EVM is a beneficial framework, although its application highly depends on the error-free and unified input and output data. In addition, the survey respondent's opinion shows that although EVM can contribute to the control of other risks and cost overruns, its advantages are not always appreciated. Specifically, 28% of participants explained that EVM had limited or negative effect on cost control, 9% believed that EVM made it worse. These opinions imply that the use of EVM is not absolute given factors that include project size, experience of team members, and the extent to which is integrated to other management frameworks. All in all, through its capability to improved cost and schedule performance, EVM is found efficient in engineering projects; nonetheless, the optimum advantage they offer is always thwarted by problems with data and the low tolerance to change in some companies. These challenges can be effectively managed through training, better tools, and deciding on guidelines for integration of EVM to its potential for promoting project success.

6. CONCLUSION

EVM is an essential and versatile tool that is used in the management field, but particularly has a high demand in engineering as a way to effectively monitor cash flow, schedule, and the scope of work. Applying the essential indicators is an effective method of assessing the level of project performance. This particular framework helps to identify deviations that may have occurred and enables one to make timely decisions on the same. Budget together with the timeline and scope of the project is a more flexible and all-round view of the project to ensure that whatever issue is is addressed before it snowballs into a major concern. This has, however, not been without challenges; which include Data Gathering Challenges, Opposition to Transformation, Fluctuating EVM scope among others. It enhances the accuracy of forecasting of results, improves the quality of solutions and fosters decision making with due consideration to results, thus improving the probability of efficient completion of tasks within mentioned time and costs. Hence through the evaluation of project performance in an ongoing project, Earned Value Management increases effectiveness in managing a project as well as minimizing the risks in completion of engineering projects. Given the continuously rising complexity and cost associated with engineering processes, there is little doubt that the role of EVM will grow steadily to help project managers navigate challenges and guarantee project success. EVM must therefore bept regarded in management of projects as

being imperative for achieving the best results of the project in terms of the budget, time schedule and the total success of the project.

CONFLICT OF INTERESTS

None.

ACKNOWLEDGMENTS

None.

REFERENCES

Aguinis, H., & Gottfredson, R. K. (2019). Best-Practice Recommendations for Defining, Identifying, and Measuring Cost Performance. Journal of Project Management, 34(2), 145–156.

Anbari, F. T. (2016). Earned Value Project Management: A Powerful Tool for Project Control. International Journal of Project Management, 34(4), 561–572.

Antvik, R. P., & Holm, M. (2018). Implementing Earned Value Management in Construction Projects. Journal of Construction Engineering and Management, 144(9), 06018017.

Baah, A., & Agyekum, K. (2020). The Role of Earned Value Management in Managing Engineering Projects. Engineering Project Management Journal, 22(1), 56–64.

Baker, R., & Hill, L. (2017). Practical Applications of Earned Value Management in Large-Scale Projects. International Journal of Engineering Research and Development, 45(2), 123–135.

Balaji, M. S., & Natarajan, T. (2021). A Study of Earned Value Management in Project Cost and Schedule Performance. Nternational Journal of Engineering and Technology, 13(4), 189–197.

Bhatia, K., & Seth, A. (2018). Evaluating Project Success Through Earned Value Management and its Impact on Cost Control. Journal of Project Management, 32(3), 223–234.

Bing, L., & Li, H. (2019). Assessing the Effectiveness of Earned Value Management in the Construction Sector. Construction Management and Economics, 37(2), 137–150.

Bradley, A. J. (2020). Cost Control and Earned Value Management in Complex Engineering Projects. Journal of Construction Management, 39(3), 315–325.

Chen, H., & Zhang, Q. (2017). Application of Earned Value Management in Construction Projects: Case Studies and Practical Implications. Construction Innovation, 17(4), 474–489.

Chien, S., & Lin, M. (2020). The Impact of Earned Value Management on Project Performance: A Comparative Study. International Journal of Project Management, 39(6), 533–540.

Dvir, D., & Shenhar, A. J. (2020). A Multi-Dimensional Perspective on Project Performance: The Role of Earned Value Management. Project Management Journal, 51(2), 105–116.

Freeman, J., & Reeve, M. (2021). Integrating Earned Value Management and Traditional Methods in Project Control. Journal Of Engineering Project Management, 29(4), 242–255.

Gelbard, R. D., & Shtal, T. (2019). Advanced Techniques in Earned Value Management for Cost Optimization. Journal of Engineering and Technology Management, 38(5), 299–312.

Goh, S., & Tan, L. (2018). The Challenges and Advantages of Implementing Earned Value Management in International Projects. Global Project Management Journal, 10(1), 77–88.

Hwang, B., & Ng, W. J. (2021). Project Performance Tracking: The Role of Earned Value Management. Journal of Project Management Research, 42(3), 267–280.

Jones, T., & Lee, K. (2020). Earned Value Management as a Tool for Predictive Project Performance Analysis. Journal of Management in Engineering, 36(2), 120–130.

Kogut, B., & Zander, U. (2019). Linking Earned Value Management to Strategic Project Success. Strategic Project Management Review, 17(1), 55–66.

Kumar, V., & Dey, P. (2020). Cost and Schedule Performance Measurement using Earned Value Management in Engineering Projects. International Journal of Project Performance Management, 31(4), 417–426.

Lee, J., & Park, J. (2017). Utilizing Earned Value Management for Effective Project Risk Management in Engineering Projects. Engineering Management Journal, 29(3), 210–220.

Li, Y., & Wei, H. (2021). Evaluating Project Performance in Real Time Using Earned Value Management. Engineering Project Management Journal, 22(6), 45–59.

Liss, P., & Fuchs, M. (2018). The Role of Earned Value Management in Complex Engineering Projects: A Case Study. Journal of Construction Engineering and Management, 144(5), 04018036.

Man, H., & Foo, W. (2019). Application of Earned Value Management in Project Cost and Schedule Tracking. Project Performance Management Journal, 25(1), 71–83.

Martin, R., & Mills, G. (2020). Earned Value Management: A key to Maintaining Project Schedule and Budget Control. Journal of Engineering Management, 35(2), 167–180.

McNaughton, D., & Wong, W. (2018). Earned Value Management in the Construction Industry: The Impact on Project Delivery. Construction Project Management Review, 24(2), 112–123.

O'Brien, R. M. (2021). Optimizing Engineering Project Performance Using Earned Value Management Principles. Journal of Construction Project Control, 33(3), 150–162.

Phan, D., & Le, P. (2020). The Future of Earned Value Management in Large Engineering Projects. International Journal of Project Control and Management, 12(1), 89–99.

Rodriguez, S., & López, F. (2019). Critical Factors Influencing the Application of Earned Value Management in Engineering Projects. International Journal of Project Performance, 11(4), 348–359.

Shenhar, A. J., & Dvir, D. (2018). Mapping Project Performance: A Framework for Using Earned Value Management. Journal of Engineering Project Management, 19(2), 113–124.

Smith, L., & Thompson, P. (2021). Earned Value Management in the Engineering Sector: Tools, Techniques, and Applications. Project Management Journal, 47(6), 78–91.