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Review and Analysis of Earned Value Management in Software Project Management

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Abstract: This analysis study delves into the Earned Value Management (EVM) system as a vital tool for evaluating project performance in the modern industry of Software and IT. The research aims to enhance project management control, identify and mitigate risks, and emphasize the significance of monitoring construction work. Using a graphical representation, the analysis illustrates the project status, with a focus on cost and time elements. This term paper explores the adaptation of Earned Value Management (EVM) to various levels of project complexity. The review and analysis aim to understand the following questions: What are the significant elements in EVM? What is the maturity level of organizations in applying EVM? How can the application of EVM change based on the complexity of the project? How can EVM be practically adapted to different projects based on their level of complexity?

Through a comprehensive review of literature and interviews with industry experts, this study identifies key elements of EVM, assesses organizational maturity levels, examines the impact of project complexity on EVM application, and proposes practical adaptations of EVM frameworks. Overall, this term paper contributes to advancing understanding of EVM scalability and how does implementation of EVM in projects varies with complexity.

Keywords: Monitoring, Potential risk, Management technique, Earned value management (EVM), Budget at Completion (BAC), Planned Value (PV), Earned Value (EV), Actual Cost (AC), Cost Variance (CV), Cost Performance Index (CPI), Schedule Variance (SV), Schedule Performance Index (SPI), Estimate At Completion (EAC), Estimate To Completion (ETC), Variance At Completion (VAC), To-Complete Performance Index (TCPI)

I. Introduction

A. Background information on Earned Value Management (EVM) in Software Project Management

Earned Value Management (EVM) is a project management technique used to assess a project's performance and progress in terms of cost and schedule. Originally developed for the manufacturing and construction industries, EVM has been widely adopted in software project management due to its effectiveness in measuring project performance against planned objectives.

Developing software projects frequently encounter delays and cost overruns, necessitating rigorous monitoring and control measures. Earned Value Management (EVM) enables proactive decision-making to avert project escalations, enhance scope definition, and improve overall performance. This method emerges as a valuable technique for assessing project performance by integrating time and cost aspects. The paper underscores the consequences of EVM discerning project deviations and

aligning progress with planned schedules and budgets.

B. Review statement

This paper aims to explore the application of Earned Value Management in software project management, examining its key principles, metrics, and benefits, and discussing its challenges and limitations.

Objectives:

1. Emphasize the importance of monitoring project lifecycle.

2. Identify and control risks in potential risk areas.

3. Enhance the management control systems of software projects

II. Literature Review

Predicting project duration and cost, and selecting the best action plan using statistical methods for earned value management by Sajad Soltana and Maryam Ashrafia. : This article outlines a methodological approach for predicting project duration and cost and selecting the optimal action plan through statistical methods in earned value management (EVM). It aims to overcome the constraints of deterministic approaches by incorporating statistical analysis to effectively manage project uncertainties and risks. The methodology is demonstrated through a case study, offering valuable insights into its practical application.

STUDY AND ANALYSIS ON EARNED VALUE MANAGEMENT SYSTEM IN CONSTRUCTION INDUSTRY by M.Sharun, P. Sundara Kumar : The study involves a comprehensive analysis of Earned Value Management using P6 software, with a G+6 building selected as a case study. Data collection includes project schedules, cost elements, and activity details. Using P6, a new Enterprise Project Structure (EPS) and Work Breakdown Structure (WBS) are created, followed by activity 9/139 scheduling, cost allocation, and relationship establishment. Project tracking facilitates detailed progress monitoring, with variances in cost and schedule highlighted. Graphical representations offer insights into project status, aiding management decision-making.

The article, *"A Systematic Review of Earned Value Management Methods for Monitoring and Control of Project Schedule Performance: An AHP Approach,"* explores various earned value management (EVM) methods and their effectiveness in project schedule monitoring and control. The authors systematically review and compare EVM and its variations to determine the most appropriate method for managing project baseline schedules. They employ the Analytic Hierarchy Process (AHP) and consider five comparison criteria: critical task-focused schedule variation, recognition and measurement of task delay, schedule variation in time units, measurement of schedule adherence (P factor), and software support and development.

Integration of Java Programming-Based Pert and Earned Value Management Methods Based on Residential Precast Case Study to Improve Project Cost Efficiency Zel Citra a, Paksi Dwiyanto Wibowo a, Yosie Malinda a, Rodliyan Yusuf Pranoto a, Fanny Pitaloka :* . The study explores combining the PERT method and earned value management (EVM) through Java programming in residential precast case studies. PERT is a probabilistic technique for project duration estimation by assessing various scenarios and their probabilities, aiding in critical activity identification and precise

completion time estimation. EVM, however, integrates project scope, schedule, and cost to evaluate performance by comparing planned value (PV), earned value (EV), and actual cost (AC) against the baseline. This research seeks to merge PERT and EVM using Java programming in residential precast case studies to enhance project cost efficiency and duration estimation accuracy.

Cost Performance Analysis and Time Development Construction Project Bridge Chain Karanggeneng Nawacita Cs Using the Earned Value Method B. Damara: The project focuses on efficient management of costs, quality, and time. It includes building a pedestrian suspension bridge, facing unique challenges like financial limitations, terrain issues, and weather conditions. The Earned Value Method is employed for monitoring project advancement and effectiveness. Past research on cost and time management through this method is cited, emphasizing the examination of Schedule Variance (SV), Cost Variance (CV), Cost Performance Index (CPI), Schedule Performance Index (SPI), Estimate to Complete (ETC), and Variance at Completion (EAC) to evaluate project efficiency.

Earned Value Management System State of Practice: Identifying Critical Subprocesses, Challenges, and Environment Factors of a High-Performing EVMS Vartenie Aramali, S.M.ASCE1 ; G. Edward Gibson Jr., Ph.D., P.E., Dist.M.ASCE2 ; Mounir El Asmar, Ph.D., A.M.ASCE3 ; and Namho Cho, S.M.ASCE4 : The study defines EVMS as a project management tool used across various industries to facilitate project management by objectively tracking performance and providing early warnings of performance problems. EVMS maturity is measured by the degree to which an EVMS complies with standards and guidelines encompassing ten core subprocesses, while EVMS environment encompasses qualitative factors impacting EVMS applications, such as culture, people, practices, and resources.

Forward-Looking State-of-the-Art Review on Earned Value Management Systems: The Disconnect between Academia and Industry Vartenie Aramali, S.M.ASCE1 ; Hala Sanboskani, S.M.ASCE2 ; G. Edward Gibson Jr., Ph.D., P.E., Dist.M.ASCE3 ; Mounir El Asmar, Ph.D., A.M.ASCE4 ; and Namho Cho, Ph.D., S.M.ASCE5 : Earned Value Management (EVM) is a widely used project management approach in various industries, supported by Earned Value Management Systems (EVMS). However, there is a lack of comprehensive literature review on EVM/EVMS. This paper aims to fill this gap by critically examining academic and industry publications, with a focus on EVMS maturity and implementation environment. A systematic review of 160 relevant publications from the past decade revealed key themes. Despite the significance of EVMS maturity, it is not extensively discussed. Variances between academic and industry literature underscore different views on EVM/EVMS limitations, expansions, environment, and adherence. The study underscores the importance of considering technical and social aspects when designing robust EVMS.

Distribution of EVM/EVMS Literature by Type: The Gap between Academia and Industry Exploring the disparity in crucial themes between academic and industry publications: Examining the distribution of EVM/EVMS literature reveals notable variations in topics covered. Key findings include: EVMS history, Compliance, Forecasting/prediction, Risk management in EVM/EVMS, EVMS application, and EVMS environment. This analysis

underscores the distinct interests and focuses of academia and industry in EVM/EVMS, offering diverse perspectives and insights.

The importance of Earned Value Management in Quality assurance and testing: Earned Value Management (EVM) plays a crucial role in quality assurance and testing by providing a structured approach to monitor and control project performance, including quality-related metrics. Here's how EVM contributes to quality assurance and testing: Objective Measurement of Progress, Early Detection of Quality Issues, Integration with Quality Metric, Cost of Quality Analysis, Resource Allocation for Testing, Performance-Based Incentives, Continuous Improvement. By analysing EVM data over multiple projects, organizations can identify trends, best practices, and areas for improvement in quality assurance and testing processes.

Challenges and Opportunities of Completing Successful Projects Using Earned Value Management Cedric Stone Divisional Chairperson of Business, Philander Smith College, Little Rock, AR, USA: The abstract describes a research study focusing on analysing projects through the lens of risk and uncertainty, using Earned Value Management (EVM) as a tool to predict and manage both systemic (epistemic risk) and provisioning (aleatory risk) uncertainties to achieve project success. The study combines empirical findings with theories and concepts to effectively address these uncertainties. To bridge the theory-practice gap, the research aims to minimize or alleviate both epistemic and aleatory risk uncertainties. The methodological approach includes a qualitative exploratory study with thematic analysis. Participants are project managers with a Project Management Professional (PMP) certification and EVM knowledge, experienced in government contract requirements, and affiliated with the local Project Management Institute chapter. Keywords such as aleatory risk, epistemic risk, provisioning issues, systemic issues, and risk uncertainty highlight key research concepts. Overall, the study seeks to offer insights into the challenges and opportunities of successfully completing projects using Earned Value Management, especially in managing and mitigating various risk and uncertainty forms.

Adapting Earned Value Management to Different Project Levels Based on Complexity Risang Alludityo: In summary, this research presents a study focused on addressing the challenge of effectively applying Earned Value Management (EVM) to diverse projects in the construction industry. It emphasizes the importance of precise project identification, method selection for control, and monitoring techniques, especially in projects with unique complexities. The central research question is how to tailor EVM to different project complexity levels. To address this, the study delves into key EVM aspects and assesses the maturity of organizations utilizing it. Data from Van Oord, a chosen organization, is collected to comprehend their approaches and practices in managing past projects.

EVM Terms	Definition
Budget At Completion (BAC)	The project's budget
Actual Cost (AC)	The actual cost spent at any given point
Planned Value (PV)	PV = (Planned Percentage Completed) * BAC
Earned Value (EV)	EV = (Actual Percentage Completed) * BAC
Cost Variance (CV)	CV<0 is the amount the project is over budget

	CV>=0 is the amount the project is under budget CV = EV - AC
Cost Performance Index (CPI)	• CPI <1 shows the project is spending too fast and is over budget • CPI =1 shows the project budget is on track • CPI >1 shows the project is under budget CPI = EV/AC
Schedule Variance (SV)	• SV<0 is an estimate of how much the project is behind schedule • SV>=0 is an estimate of how much the project is ahead of schedule SV = EV - PV
Schedule Performance Index (SPI)	• SPI <1 shows the project as being behind schedule • SPI = 1 shows the project as being on track • SPI >1 shows that the project is ahead of schedule SPI = EV/PV
Estimate At Completion (EAC)	EAC = BAC/CPI
Estimate To Completion (ETC)	ETC = EAC - AC
Variance At Completion (VAC)	VAC = BAC - EAC
To-Complete Performance Index (TCPI)	TCPI (BAC – EV)/(BAC – AC)

Table 1 Earned Value Management Metrics

III. Methodologies: -

Review and Analysis of "Predicting project duration and cost, and selecting the best action plan using statistical methods for earned value management" : Methodological Rigor: The article introduces a novel approach by leveraging control charts and statistical distributions to predict project outcomes. It fills a gap in existing literature by considering project phases and offering a dynamic action plan selection process based on project performance states. The methodology is robust, involving a systematic process of indicator selection, control chart analysis, and action plan determination. The use of real-world data from a case study enhances the validity and applicability of the proposed approach.

Title: Study and Analysis of Earned Value Management System in the Construction Industry: Study Area: The research focuses on analyzing a G+6 commercial building project, specifically R&D block B with a plinth area of 21X34m, situated in Vaddeswaram, Guntur district. Research Methodology: The study involves a comprehensive analysis of Earned Value Management using P6 software, with a G+6 building selected as a case study. Data collection includes project schedules, cost elements, and activity details. Using P6, a new Enterprise Project Structure (EPS) and Work Breakdown Structure (WBS) are created, followed by activity 9/139 scheduling, cost allocation, and relationship establishment. Project tracking facilitates detailed progress monitoring, with variances in cost and schedule highlighted. Graphical representations offer insights into project status, aiding management decision-making.

The article titled "A Systematic Review of Earned Value Management Methods for Monitoring and Control of Project Schedule Performance: An AHP Approach": The article discusses the challenges associated with traditional EVM in accurately identifying delays in project schedules and proposes alternative methods to address these challenges. These alternative methods focus on critical tasks, recognize and measure delays in activities, report schedule variations in time units, and measure schedule adherence. Through a systematic review and comparison using the Analytic

Hierarchy Process (AHP), the authors determine that the critical path earned schedule method is the most suitable for monitoring and controlling project baseline schedules. This method addresses the limitations of traditional EVM and its variations by effectively managing critical tasks and accurately measuring schedule performance. The methodology section outlines the approach taken to evaluate and compare different versions of earned value management (EVM) for project schedule management. The Analytical Hierarchical Process (AHP) is selected as the framework for this evaluation. AHP, developed by Professor Thomas L. Saaty in 1980, is a decision-making method that assists in selecting alternatives based on a series of hierarchical criteria or variables, often in conflict. It aims to select the alternative with the highest score based on evaluation. To ensure the effectiveness of the method, careful selection and definition of criteria and sub-criteria are essential.

Integration of Java Programming-Based Pert and Earned Value Management Methods Based on Residential Precast Case Study to Improve Project Cost Efficiency Zel Citra a*, Paksi Dwiyanto Wibowo a, Yosie Malinda a, Rodliyan Yusuf Pranoto a, Fanny Pitaloka : The EVM method is applied to evaluate project cost efficiency. Cumulative Planned Value (PV), Cumulative Earned Value (EV), and Cumulative Actual Cost (AC) are analyzed to assess project performance. The findings indicate an improvement in project cost and time performance, with a 7% increase in cost efficiency and a 1% acceleration in development time. The integration of PERT and EVM methods optimizes project performance and prevents overruns. Integrating PERT and EVM methods enhances project cost and time efficiency. The study concludes that the implementation of PERT increases project duration efficiency by 6%, while EVM implementation improves project cost efficiency by 7%. The integration of both methods leads to an improved Schedule Performance Index (SPI) and Cost Performance Index (CPI).

Assessment of Project Performance Six categories are used to assess project performance: The Method of Concept Value Result (CVR) involves analyzing performance and estimating achievement of targets using three key indicators: Actual Cost (AC), Earned Value (EV), and Planned Value (PV).

1. Cost Variance (CV): Compares the value obtained after completing work packages with actual costs.

2. Schedule Variance (SV): Calculates deviations between Planned Value (PV) and Earned Value (EV).

3. Cost Performance Index (CPI): Compares the value of work completed (EV) with costs incurred (AC).

4. Schedule Performance Index (SPI): Compares the value of work completed (EV) with planned costs (PV).

5. Estimate to Completion (ETC): Represents the estimated cost for remaining work.

6. Variance at Completion (EAC): Estimated total cost at the end of the project obtained from actual costs plus ETC.

Earned Value Management System State of Practice: Identifying Critical Subprocesses, Challenges, and Environment Factors of a High-Performing EVMS Vartenie Aramali, S.M.ASCE1 ; G. Edward Gibson Jr., Ph.D., P.E., Dist.M.ASCE2 ; Mounir El Asmar, Ph.D., A.M.ASCE3 ; and Namho Cho, S.M.ASCE4 :

1. Focus on Critical Subprocesses: Prioritize planning and scheduling, and change control subprocesses, dedicating adequate time and resources for effective implementation.

2. Implement EVMS Surveillance: Regularly assess EVMS to ensure reliability and accuracy of data, facilitating proactive decision-making.

3. Address Leadership Attitude: Establish and communicate leadership support, accountability, and commitment towards EVMS implementation, providing necessary policies, processes, and training.

4. Enhance EVMS Environment: Foster a positive organizational culture supportive of EVMS, utilize formal processes/practices, and ensure a skilled team with EVMS knowledge.

5. Democratize EVMS Evaluation: Develop objective EVMS maturity and environmental evaluation tools accessible to all stakeholders for consistent assessment.

6. Emphasize Stakeholder Engagement: Proactively engage project teams and stakeholders, ensure compliance with standards/guidelines, and establish oversight mechanisms.

7. Address Implementation Challenges: Mitigate challenges related to data availability, compliance, complexity, and flexibility through strategic planning and proactive measures.

Forward-Looking State-of-the-Art Review on Earned Value Management Systems: The Disconnect between Academia and Industry Vartenie Aramali, S.M.ASCE1 ; Hala Sanboskani, S.M.ASCE2 ; G. Edward Gibson Jr., Ph.D., P.E., Dist.M.ASCE3 ; Mounir El Asmar, Ph.D., A.M.ASCE4 ; and Namho Cho, Ph.D., S.M.ASCE5:

The methodology outlines the systematic literature review process, starting with identifying relevant publications and narrowing them down for detailed analysis. The authors categorize literature by themes and conduct trend and comparison analyses between academic and industry sources. The approach aims to provide insights into current practices, issues, and potential gaps in EVM/EVMS research.

Preparatory Step: The authors initially collected a broad dataset of 600 publications dating back to 1962 from academic sources like Google Scholar and ASCE, as well as industry references suggested by the advisory group. Through this preliminary review, they identified 282 publications discussing EVM/EVMS as their primary focus. This step provided insights into the historical evolution of earned value management practices and informed the scoping process.

Defining the Scope: Building on insights from the preparatory step, the authors narrowed the scope of their study to focus on recent literature (from 2011 to March 2021) relevant to EVMS implementation and application. While previous reviews by Chen and Zhang (2012) and others covered specific EVM topics, the authors aimed to provide a comprehensive review of recent findings. They selected keywords for their search engines based on this refined scope, opting for "earned value management" or "EVM" to ensure inclusive results.

Selection Process for the Publications: The authors began by utilizing Google Scholar as the initial search engine due to its widespread use and accessibility. Most publications found were journal articles and conference proceedings, with the majority sourced from three prominent

academic databases: ASCE, ScienceDirect, and IEEE Xplore. For industry publications, the authors relied on recommendations from the research steering committee. They considered conference papers, recommended practices, journal articles, and newsletters from AACE International and the College of Performance Measurement's (CPM) database. While some guidelines from US government agencies were shared, only those directly relevant to EVMS implementation and execution were included.

Screening of Publications: To manage the extensive literature, the authors established inclusion and exclusion criteria. Publications had to be available in full-text English online, with "earned value management" or "EVM" mentioned in the title or abstract. Excluded were publications not focused on EVM/EVMS or those addressing unrelated topics like sustainability or labor productivity. State-of-the-art papers and recommended practices were used as foundational references but not included in the analysis. After applying the criteria, the initial 600 publications were narrowed down to 301. Further refinement left 160 publications for detailed analysis.

Classification of Literature: Publications were categorized into themes through a descriptive review. Data were compiled in a spreadsheet and organized by various parameters. Preliminary themes included "EVMS compliance," "EVMS maturity," and "EVMS environment." Thematic analysis was employed to identify patterns and trends, with keywords representing the main topics of each study guiding the process.

The interconnectedness between elements within the TOE (Technical, Organizational, External) complexity framework and aspects of Earned Value Management (EVM) based on the ANSI/EIA-748 standard. Here is a breakdown of the connections:

1. High number of project goals: Connection to EVM: Project measurement baseline plan Scaled Aspect: Establish and maintain a time-phased budget baseline

2. Non-alignment of project goals: Connection to EVM: Project measurement baseline plan Scaled Aspect: Work authorization documents, Early PMB establishment; Control account plans

3. Unclarity of project goals: Connection to EVM: Project measurement baseline plan Scaled Aspect: Time-phased performance measurement baseline; Formal plan for each control account manager accomplish the authorized work within the time

4. Instability of project environment: Connection to EVM: Identification of unit cost Scaled Aspect: Identify unit cost, equivalent unit cost, or lot costs by type and amount of material

5. Company internal strategic pressure: Connection to EVM: Budget authorization; Management reporting Scaled Aspect: Internal reports (show budgets for each control account)

6. Size of project team: Connection to EVM: OBS Organization Breakdown Structure intersections with WBS Scaled Aspect: Distinct task using WBS to track progress, schedule variance

7. High project schedule drive: Connection to EVM: Scheduling work; Calculate schedule variance Scaled Aspect: Planning and structuring schedules for progress status and forecast; Maintaining schedule and forecasting schedule update

8. Lack of Resource & Skills availability: Connection to EVM: Budget by cost elements; OBS Resource Plan Scaled

Aspect: Planning for overhead budget and risk budget; Updating estimate

9. Lack of Experience with parties involved: Connection to EVM: Unauthorized revisions; Target cost goal; Management performance reports Scaled Aspect: Interfaces between different disciplines; Control account/work package plans

10. Interfaces between different disciplines: Connection to EVM: Discrete work and objective measures Scaled Aspect: Accounting system and actual cost (scalability); Record allocation direct cost.

Outlining the ABCD EVM Framework, detailing the scalability aspects based on the NDIA Scaled Product. Here is a breakdown of each element:

1. Planned Value: A: Authorization of Work Scope: WBS developed until the level of activity package. B: WBS developed until the level of planning package. C: WBS developed until the level of planning work package (1 level below control account). D: WBS developed to the level of Control Account.

2. Schedule Scope: A: Integrated Schedule: Project schedule plan on each activity integrated with subcontractor plans and potential unmeasured activity calculation. B: Assumption and judgment required to validate schedule plan; specified planner controlling schedule and critical cycle on site. C: Assumption and judgment required to validate schedule plan; analyzing critical equipment cycle time controlled by project manager. D: Project schedule plan created using estimation for each activity, setting significant interdependencies between work segments.

3. Setting Project Milestones: A: Having shorter intermediate internal milestones. B: Creating intermediate internal milestones. C: Creating intermediate internal milestones. D: Milestones following what is set by contract.

4. Budget Scope: A: Detail of planning budget summary until the level of activity package; Class 1 Estimate. B: Detail of planning budget until the level of planning work package; Class 2 Estimate. C: Detail of planning budget until the level of planning work package; Class 2 Estimate. D: Detail of planning budget summary until the level of Control Account; Class 3 Estimate.

5. Planning Budget for Future Effort and Unmeasured Budget: A: Non-measurable and future effort budget with fixed budget. B: Measurement on currency and possible changing of rates with fixed budget. C: Percentage on budget spare from planned budget; using balancing act concept. D: Percentage on budget spare from planned budget.

6. Indirect Budget: A: Calculating integrated calculation to include the percentage of indirect cost. B: Indirect cost becoming a percentage of budget summary. C: Having fixed indirect rates cost. D: Management reserve and undistributed budget may not be specified at this project level.

7. Actual Cost: A: Recording actual cost on activity level (Extensive and detailed report). B: Recording actual cost on planning work package level. C: Recording actual cost on planning work package level. D: Recording actual cost on control account level (Summarized cost)

IV. Results and Discussion

Earned Value Management (EVM) provides a structured framework for project monitoring and control, allowing project managers to assess project performance against planned targets. Central to EVM analysis are several key metrics and formulas that help in evaluating project progress, identifying

variances, and forecasting project completion.

1. Cost Variance (CV): CV = EV - AC If CV > 0, it indicates a favorable variance (underrun); if CV < 0, it indicates an unfavorable variance (overrun).

2. Schedule Variance (SV): SV = EV - PV If SV > 0, the project is ahead of schedule; if SV < 0, it is behind schedule.

3. Cost Performance Index (CPI): CPI = EV / AC If CPI = 1, the project is on budget; if CPI > 1, it is under budget; if CPI < 1, it is over budget.

4. Schedule Performance Index (SPI): SPI = EV / PV If SPI = 1, the project is on schedule; if SPI > 1, it is ahead of schedule; if SPI < 1, it is behind schedule.

These metrics help project managers gauge project health and identify deviations from the plan. Establishing variance thresholds provides guidance on acceptable deviations, beyond which corrective actions are necessary. Bullseye charts and SPI/CPI performance graphs are commonly used to monitor variances over time. In addition to monitoring project status, EVM facilitates forecasting project completion. Key terms and formulas for forecasting include:

Estimate at Completion (EAC): EAC = AC + ETC

Estimate to Complete (ETC): ETC = EAC - AC

The 10-step model of Earned Value Management (EVM), aligned with the ANSI/EIA-748 standard guideline for scaling:

1. Project Goals: While the definition of project goals may not be directly scalable, adherence to standardized project management principles can ensure consistency and alignment with project objectives across different scales.

2. Work Breakdown Structure (WBS): Scaling the WBS involves defining the levels of breakdown to suit the complexity and size of the project. This ensures that the WBS remains manageable and effectively captures all project activities.

3. Organization Breakdown Structure (OBS): Establishing the project organization structure can be scaled by adapting reporting chains, procedures, and communication channels to suit the size and complexity of the project.

4. Responsibility Assignment Matrix (RAM): Scaling the RAM involves defining responsibilities and reporting structures in a way that accommodates the project's scale and complexity, ensuring clarity and accountability throughout the project execution.

5. Schedule Planning: Integrating schedules with the WBS and OBS, structuring schedules for progress status and forecasting, and planning resource budgets can be tailored to the specific needs and scope of the project while adhering to standardized scheduling principles.

6. Planned Budget: Planning resource budgets, creating holding accounts for work scope and budget, and ensuring proper allocation of indirect budgets can be scaled to accommodate project size and complexity while maintaining consistency with budgeting standards.

7. Actual Cost: Ensuring actual costs are comparable to project budgets and updating financial condition reports periodically are scalable aspects that ensure accurate cost tracking and management across different project scales.

8. Results/Deliveries: Regulating changes in the performance measurement baseline and preparing summarized information for management evaluation are scalable aspects that facilitate effective project monitoring and control.

9. Earned Value: Providing performance metrics for project analysis, analysing variances, and evaluating and updating estimates at completion can be scaled to suit the project's size and complexity while maintaining consistency with EVM standards.

10. Analysis: Utilizing tools to support changes, analysing variances at distinct levels, and evaluating and updating estimates at completion can be scaled to ensure effective analysis and decision-making throughout the project lifecycle.

EVM maturity level indicates the extent to which an organization has integrated EVM into its project management processes. Stratton (2006) suggests a five-level maturity model for EVM implementation:

1. Initial Level: Limited or no usage of EVM for project monitoring.

2. Partial Implementation: Basic incorporation of EVM components, usually for small projects.

3. ANSI/EIA-748 Compliant Implementation: Complete integration of EVM as per ANSI/EIA-748 standards, with capabilities for performance assessment.

4. Managed Implementation: Additional metrics and training initiatives to boost EVM effectiveness and awareness.

5. Optimizing Implementation: The highest level of EVM maturity, with EVM as the primary project monitoring tool and continuous improvement endeavours.

The implementation of the ABCD EVM Framework and the TOE EVM Framework involves a systematic approach to address project complexities effectively. Here is a summarized version of the implementation procedure:

1. Utilize ABCD Project Classification: Begin by employing the ABCD questionnaire or a similar project sizing questionnaire to categorize projects into several levels. This classification system provides a practical and consistent way to categorize projects based on their size and complexity.

2. Incorporate TOE Complexity Assessment: Use the TOE complexity assessment to identify intricate project complexity aspects that may not be adequately covered by the ABCD classification method. This ensures that critical elements are addressed to enhance the effectiveness of project management practices.

3. Select EVM Procedures: Choose the EVM procedures based on the ABCD EVM Framework following the categorized project levels. For example, for projects categorized at level B, select the EVM application suitable for that level.

4. Enhance EVM Activities: Integrate select improvements from the TOE EVM Framework to optimize the execution of EVM practices. This involves incorporating additional activities from the TOE framework to address critical complexity elements identified during the assessment.

5. Resolve Contradictions: In cases where there is contradictory or overlapping activities between the two frameworks, prioritize the activity with higher intensity to anticipate potential project complexity. This ensures consistency and effectiveness in project management practices.

EVM Maturity Level Confirmation: The validation process confirmed that the EVM maturity level of the selected projects was estimated to be at level 1. This was based on the observation that although Earned Value Management monitoring was employed in the majority of projects, it

was not yet applied universally across all projects within the organization.

Activity Arrangement: It was emphasized during the validation process that the framework should distinguish between activities that directly impact Earned Value Analysis and supporting activities that contribute to the broader Earned Value Management System. This subdivision ensures clarity in implementing the framework.

Specificity of Activity Points: Concerns were raised during validation that some activity points in the framework were too specific, potentially leading to overuse or misinterpretation. Additionally, not all projects within the same level category can carry out activities with the same level of detail. To address this, the framework's activity points were made more general and practical, ensuring applicability across various project scenarios.

Scaling Aspect Precision: Feedback from the validation process highlighted the need for greater precision in presenting the scaling aspect of the framework. Specifically, there was a recommendation to make the monitored aspects more specific by aligning them with the ANSI/EIA-748 standard, which provides detailed guidelines for Earned Value Management practices.

V. Advancement and Future Scope:

The evolution of Earned Value Management (EVM) has witnessed diverse approaches and adjustments to suit various project scenarios and enhance its efficacy. Below are some significant advancements and potential areas for enhancement in EVM:

1. Advancing Project Management Maturity Level: There exists a connection between EVM development and project management maturity level. As project management methodologies progress and mature, EVM can be honed and optimized to better align with project requirements.

2. Restructuring Utilizing Singularity Function Strategy: Attempts have been made to restructure EVM using a singularity function strategy, involving the analysis of metric axis interactions and alterations in data recording periods. This strategy aims to boost the precision and adaptability of EVM metrics.

3. Enhancing Cost-Duration Tracing Accuracy: Research has concentrated on enhancing the precision of cost-duration tracing in EVM through probability modeling analysis. By refining cost-duration tracing, project managers can more effectively monitor project advancement and performance.

4. Incorporation with Project Schedule Management: Integrating project schedule management can result in the emergence of Earned Duration Management (EDM). In contrast to conventional EVM, which employs budget as the monitored parameter, EDM assigns value to activities based on their duration, providing a unique perspective on project performance evaluation.

5. Accurate Evaluation for Project Completion Prediction: Assessing the accuracy of EVM as a tool for forecasting project completion is another area of advancement. By evaluating the dependability and precision of EVM forecasts, project managers can make well-informed decisions and adaptations to project strategies.

6. Adjustment of EVM Components: EVM components can be adapted and scaled to suit the specific requirements of individual projects. Aspects such as project scope and breakdown structure, integrated project scheduling, budgetary planning, accounting system integration, variance analysis, and corrective action management can be customized to align with the distinct attributes of each project.

VI. CONCLUSION

In conclusion, this study has analysed the use of Earned Value Management in software project management, emphasizing its main principles, metrics, advantages, and difficulties.

The results enhance comprehension of how EVM can enhance software project management and attain project success.

Potential future research areas could involve investigating new methods of integrating EVM with Agile practices, performing extended studies to evaluate the lasting effects of EVM on software project results, and exploring the application of EVM in cutting-edge technologies like artificial intelligence and blockchain. Recommendations for better research, review, and analysis: -

1. Diversification of Case Studies

2. Evaluation of the 10-Step Model

3. Development of Standard Project Leveling Classification

Several considerations, such as the validation of work estimates and data consistency, are essential for accurate forecasting. Various formulas, including those based on current performance or anticipated future performance, can be used to calculate EAC, providing project managers with insights into future project trajectories.

Earned Value Analysis contributes to our project management activities by aligning cost and schedule metrics, offering early warnings of cost overruns or schedule delays, providing valuable benchmarking data from similar projects, and ultimately enhancing project success rates. By integrating EVA into our project management practices, we aim to improve cost control and schedule adherence

Overall, EVM analysis, with its metrics and forecasting capabilities, empowers project managers to make informed decisions and take timely corrective actions, ensuring project success and alignment with planned objectives.

VII. References

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