JOURNAL OF MARINE SCIENCES & ENVIRONMENTAL TECHNOLOGIES
Vol. 11, Issue No. 2 (December-2025)
DOI: https://doi.org/10.59743/jmset.v11i2.199
ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

Performance Evaluation Study of Cost and Time Benchmarks on Construction Projects Using the Earned Value Management Method: Road Duplication Paving Project in Zliten, Libya-Case study

Mustafa M. Sofia*, 1, Mustafa O. Hakoumah[1], and Atiya N. Njea[2]

1) Department of Mechanical and Industrial Engineering, Faculty of Engineering, Alasmarya Islamic University, Zliten, Libya.
2) Department of Civil Engineering, Faculty of Engineering, Alasmarya Islamic University, Zliten, Libya.

***E-mail**: m.sofia@asmarya.edu.ly

دراسة تقييم أداء معياريّ التكلفة والزمن على المشروعات الإنشائية باستخدام طريقة إدارة القيمة المكتسبة: مشروع تنفيذ ازدواج طريق معبد بمنطقة زليتن– ليبيا، حالة دراسية

مصطفى محمد صوفية1، *، مصطفى عمر حكومه1، و عطية نجي نجي2

1) قسم الهندسة الميكانيكية والصناعية، كلية الهندسة، الجامعة الأسمرية الإسلامية، زليتن، ليبيا.
2) قسم الهندسة المدنية، كلية الهندسة، الجامعة الأسمرية الإسلامية، زليتن، ليبيا.

Received: 10 December 2025; Revised: 10 February 2026; Accepted: 23 February 2026

Abstract

One of the most significant challenges facing engineering project management, including research and development, construction, and other projects, is completing projects according to schedules and budgets. These challenges often stem from shortcomings in the application of technical, time-related, and financial planning and monitoring mechanisms. Earned Value Management (EVM) is a powerful and effective tool for addressing these shortcomings by linking actual progress of completed work to time taken and cost incurred, and comparing it to the project's planned baseline. This paper aims to highlight the vital importance of adopting the EVM methodology in monitoring the implementation of construction projects and its use as a benchmark for evaluating cost and time performance. The paper provides a comprehensive overview of key EVM concepts and indicators, including Values of Planned, Earned, and Actual, Cost Variance, Schedule Variance, as well as Performance Indicators (CPI, SPI) which reached 0.76 and 0.90 respectively, and forecasting indicator (EAC) which is 6.44 M Libyan dinar, the project appears to have experienced a financial overrun of approximately 31.8% and a schedule delay of approximately 10% from what was originally planned. The paper also analyzes the implications of these indicators in different project performance scenarios, emphasizing the role of EVM in identifying deviations early, and guiding decisions for corrections that lead to the successful completion of projects. The contribution of this study the significance of this work is in importing sensitivity testing as a rare case study within the frameworks of infrastructure projects in Libya.

Keywords: *Earned Value Management (EVM), Construction Projects, Cost Control, Schedule Control, Cost and Schedule Performance Indicators.*

الملخص

يُعد تحدي إنجاز المشروعات وفقا للجداول الزمنية والميزانيات المرصودة ضمن مخططات التنفيذ، أحد أبرز المعوقات التي تواجه إدارة المشروعات الهندسية، بما في ذلك مشـروعات البحث والتطوير والمشـروعات الإنشـائية وغيرها. تبرز هذه التحديات غالبًا من قصـور في تطبيق آليات التخطيط والمراقبة الفنية

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

والزمنية والمالية، وتعتبر منهجية إدارة القيمة المكتسبة (Earned Value Management - EVM) أداة قوية وفعالة لمعالجة هذا القصور، من خلال ربط التقدم الفعلي للأعمال المنجزة بالزمن المستغرق والتكلفة المتكبدة، ومقارنتها بخط الأساس المخطط للمشروع. تستهدف هذه الورقة تسليط الضوء على الأهمية الحيوية لتبني طريقة إدارة القيمة المكتسبة EVM في متابعة تنفيذ المشروعات الإنشائية، واعتمادها كمعيار لتقييم أداء التكلفة والزمن. تستعرض الورقة تعريفًا شاملاً للمفاهيم والمؤشرات الرئيسية في EVM، بما في ذلك القيم المخططة والمكتسبة والفعلية، وكل من تباين التكلفة والجدولة الزمنية بالإضافة إلى مؤشرات الأداء (CPI، SPI)، حيث بلغ مؤشر أداء التكلفة 0.76 فيما بلغ مؤشر أداء الزمن 0.90 أداءً سلبياً، أما مؤشر التنبؤ (EAC) بيّن أن القيمة التنبؤية لإنهاء المشروع ستصل إلى 6.44 مليون دينار ليبي بزيادة تقدر بحوالي 31.8% إضافة إلى أن الجدولة الزمنية تأخرت بما يقارب 10% عن المخطط. كما تُحلل الورقة دلالات هذه المؤشرات في سيناريوهات مختلفة لأداء المشروع، مؤكدة على دور EVM في تحديد الانحرافات مبكراً، وتوجيه القرارات التصحيحية لضمان إنجاز المشروعات بنجاح. تكمن مساهمة هذه الدراسة وأهمية هذا العمل في اختبار حساسية دراسة حالة نادرة ضمن أطر مشاريع البنية التحتية في ليبيا.

الكلمات الدالة: إدارة القيمة المكتسبة EVM، المشروعات الإنشائية، ضبط التكلفة، ضبط الجدولة، مؤشرات الأداء للتكلفة والجدولة.

1. Introduction

Contemporary projects are faced with an ever-increasing number of hurdles, regardless of their type of project (e.g., construction engineering, R & D, etc.) when it comes time to meet project deadlines and budgets (Doloi, 2013). These hurdles pose a significant hindrance to the successful completion of the strategic goals set forth by the companies implementing the project. Often, this is due to insufficient planning, setting a timeframe, and establishing financial specifications, as well as monitoring mechanisms, for the technical aspects of each project. While a project manager/engineer must prepare a detailed plan for the execution of a project, it should be noted that a detailed plan is not enough to achieve success without the incorporation of a robust monitoring and control system (Kerzner, 2025). Failure to be able to analyze the actual progress of the project at various intervals along the way could lead to the late identification of cumulative deviations, limiting the project manager/the construction engineer's ability to take effective corrective action and placing the project at increased risk of cost overruns and delays.

In light of these circumstances, the Earned Value Management methodology offers a systematic and effective means to monitor and evaluate project performance. The unique feature of EVM allows for the integration of three different dimensions of project performance (Scope -actual completed work-, Schedule, and Cost) within a single measurement framework (PMBOK Guide, 2017). Through the integration of the three dimensions of project performance, the project manager/engineer will have the ability to view a clear picture of the project's actual conditions at any given point in time, identify areas of variance from the original plans, and predict how the project will perform in the future (Anbari, 2003).

This paper highlights the impact of lack of applicable an effective mechanism for monitoring the financial and schedule performance of a project, leading to time delays or cost overruns, or both of them. It aims to review the EVM methodology in detail, emphasizing its importance as a key tool for planning, monitoring, and controlling construction projects and improving their management efficiency. The paper explores how these indicators can be used to evaluate project performance and provide a future outlook by analyzing the various performance scenarios that EVM indicators can reveal. It also examines how project activities

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

align with or deviate from the allocated schedule and budget, highlighting the value of this methodology in supporting proactive decision-making and offering recommendations for improving the management of similar projects in the future.

2. Methodology

The methodology was divided into two parts. The first one is the theoretical part consists of preparing a theoretical background on the basic concepts of the Earned Value Management method (EVM), explaining the methods and techniques for preparing calculations related to deviations, variances, performance indicators, and forecasting. The second part is a field study, a case study of an ongoing project: the Doubling of a Paved Road in the Zliten Area. This case study utilizes actual project documents, including bills of quantities, schedules, allocated budgets, financial reports, and other relevant materials. Additionally, interviews with the project team management were conducted to gather data and information on performance, which will be discussed later in a section titled (Case Study) EVM is an integrated project performance monitoring system that relies on measuring completed work and linking it to cost and schedule (Fleming & Koppelman, 1997). The earned value of completed work in a project is defined as the planned cost associated with that work when the project budget is created (Christensen, 1998). EVM is classified among project control forms based on (Milestones), which aims to calculate deviations, variances, and performance indicators for both time and cost at any part of the project, as well as predictive indicators for completion, by the following criteria:

First: Basic Concepts

To analyze project performance using EVM, we define the following basic variables (PMBOK Guide, 2017):

- Planned Value (PV): Known as the Budgeted Cost of Work Scheduled (BCWS).
- Budget at Completion (BAC): Budget allocated for completing all project works.
- Earned Value (EV): Known as the Budgeted Cost of Work Performed (BCWP).
- Actual Cost (AC): Also known as the Actual Cost of Work Performed (ACWP).
- Estimate at Completion (EAC): The predicted total cost of the project upon its completion.

Second: Performance Indicators

Based on the basic variables, performance indicators expressing project efficiency can be calculated (Anbari, 2003):

Cost Performance Index (CPI): $CPI = EV/AC$ …… (1)

Schedule Performance Index (SPI): $SPI = EV/PV$ …… (2)

Third: Variance Indicators

In addition to efficiency indices, EVM is used to calculate project variances regarding cost and time factors (Lipke, 2003):

Cost Variance (CV): $CV = EV - AC$ …… (3)

Schedule Variance (SV): $SV = EV - PV$ …… (4)

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

Fourth: Forecasting Indicators

Estimate at Completion (EAC): EAC provides a future view of the total expected project cost (Budd & Budd., 2009). There are several formulas for its calculation, depending on assumptions about future performance:

- If current performance continues: $EAC = BAC/CPI$ …… (5)
- If future performance will return to the plan: $EAC = AC + (BAC - EV)$ …… (6)
- Based on current cost and schedule performance:

$$EAC = AC + \left(\frac{BAC-EV}{CPI*SPI}\right) \quad \text{……} \quad (7)$$

EVM indicators provide an overview of the project status, and their implications can be summarized in four main scenarios shown by the relationship between PV, EV, and AC. These scenarios are fundamental to understanding project performance and making corrective decisions (Czarnigowska, 2008), as following:

- Scenario 1: Ideal (Ahead of schedule and under budget (SPI > 1 and CPI > 1)).
- Scenario 2: Worst (Behind schedule and over budget (SPI < 1 and CPI < 1)).
- Scenario 3: Intermediate (a) (Behind schedule but under budget (SPI < 1 and CPI > 1)).
- Scenario 4: Intermediate (b) (Ahead of schedule but over budget (SPI > 1 and CPI < 1)).

A summary table of the key EVM metrics (PV, EV, AC, CV, SV, CPI, SPI), including their formulas and interpretation rules, is presented in Table (1).

Table 1. Summary of Key EVM Indicators and Interpretation

Indicator	*Formula*	*Interpretation for Cost (CPI, CV)*	*Interpretation for Schedule (SPI, SV)*
Planned Value (PV)		Approved budget for work *scheduled*	
Earned Value (EV)		Approved budget for work *performed*	
Actual Cost (AC)		Total cost *incurred* for work performed	
Cost Variance (CV)	EV - AC	CV > 0: Under budget	
		CV < 0: Over budget	
Schedule Variance (SV)	EV - PV		SV > 0: Ahead of schedule
			SV < 0: Behind schedule
Cost Performance Index (CPI)	EV / AC	CPI > 1: Under budget (Efficient)	
		CPI < 1: Over budget (Inefficient)	
Schedule Performance Index (SPI)	EV / PV		SPI > 1: Ahead of schedule
			SPI < 1: Behind schedule
Estimate at Completion (EAC)	BAC/CPI (Continuation of current CPI)	Forecast total final project cost	

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

3. Literature Review

Numerous studies have demonstrated the effectiveness of EVM in monitoring project performance, controlling costs, and scheduling. Both of them Fleming & Koppelman (2010) presented in their book (Earned Value Project Management) provided comprehensive evidence on how to use EVM to improve project management, highlighting its ability to provide early warnings of deviations, enabling project managers to take proactive corrective actions. Other study, such as that conducted by Anbari (2003), emphasized that the application of EVM directly contributes to improving project success chances by providing a transparent and objective view of progress against the plan. In the context of construction projects, Dvir *et al*. (2003) through their empirical analysis of the relationship between project management methodologies and project success, indicated that adopting robust tools like EVM is positively correlated with achieving project objectives in terms of cost, time, and scope. Also, Czarnigowska (2008) in her review of EVM applications in construction projects pointed to the increasing reliance on this methodology in the global construction sector, noting that it provides quantitative performance measures that facilitate project efficiency assessment. The application and adoption of EVM in monitoring infrastructure projects in Zliten-Libya will contribute to improving performance indicators and controlling both cost and time scheduling to achieve targets.

Despite the application of EVM in multi fields, there is growing interest in studying its effectiveness in complex infrastructure projects, such as road construction. Numerous studies have focused on how to adapt EVM principles to the unique nature of these projects. According to this, Rad & Levin (2002) in their work on advanced project management discussed the application of EVM in large infrastructure projects, emphasizing the importance of defining accurate Work Breakdown Structures (WBS) to ensure effective earned value measurement. Also, Aramali *et al*. (2023) presented a comprehensive model for applying EVM in construction projects, focusing on integrating its indicators with risk analysis to provide a more complete picture of project performance. On the other hand, Abdelrahman & Nassar (2024) reviewed the challenges of implementing EVM in the Egyptian construction industry, concluding that success depends on multiple factors, including top management commitment and staff training.

These studies indicate that road projects, with their unique characteristics, require specific application methods for EVM to maximize its benefits. This is the aim of this research paper, which presents a case study of a paved road project in Zliten, Libya. Although the many benefits of EVM, the literature also refers to some challenges and constraints in its application. One of the most important of these challenges is data accuracy and quality. Vargas (2003) states that inaccurate or insufficient data can skew the actual calculation of the Earned Value Management (EVM) indicators causing incorrect decisions from being made. In order for EVM to work well, it requires a well-organized system for the collection and updating of regular data. There is also a barrier to the implementation of EVM due to the resistance to change within the organization, as there needs to be a change in the culture of the company and the work processes of the employees that will have to adopt this type of detailed monitoring of designated criteria (Abdelrahman & Nassar, 2024). Some researchers, such as Lipke (2003), believe that the complexity of EVM may make it unattractive for small and simple projects; however, there are

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

still ongoing efforts to develop ways to simplify EVM so that it can be applied to projects on a broader scale than its original intent. In addition, EVM indicators can be severely impacted by external unforeseen events such as economic downturns, raw materials becoming more expensive, and extreme weather conditions (Doloi, 2013). That was evident in the case of the Zliten, Libya, which the paved road project discussed in this study. While EVM allows for financial impact assessments to evaluate these issues, such as in terms of using the Cost Performance Index (CPI); EVM does not provide a direct solution for the unforeseen event issues, but it does highlight the need to develop a strong risk management plan to deal with such occurrences.

3.1. Research Gaps

The literature review shows extensive research in field of EVM. However, some gaps still exist, particularly regarding the following:

- Specific and detailed case studies: While general studies exist, detailed case studies of paved road construction projects within specific geographic and economic contexts are still needed to provide clear, practical insights into the actual challenges and successes in these environments.
- Influence of specific external factors: The literature has indicated the influence of external factors in general, so there remains a need for further quantitative analysis of how certain factors, such as fluctuations in building material prices, affect EVM indices in road construction projects.

This current study attempts to address the identified needs in the literature by examining and discussing the application of EVM to a paved road project located in Zliten-Libya, with an emphasis on interpreting EVM indicators and the impact of external factors, in order to provide valuable information to practitioners and researchers who work in this field.

4. Case Study

4.1. Project Description

The project "Implementation of Duplication of the Road Linking the Coastal Road Intersection and the Sab'ah Quraniyah Lighthouse" with a length of 3.5 km in Zliten Municipality - Libya, located 5 km east of the city center, affiliated with the Secondary Road Projects in Zliten - the Client - under the Projects Implementation Authority of the Ministry of Transportation of the Government of National Unity in Libya. It was contracted in 2024 with one of the private general contracting companies in Zliten, with a total contractual value of four million eight hundred eighty-five thousand Libyan Dinars "4,885,000 LYD", and an implementation period of 6 months starting from 01/10/2024 to 01/04/2025, according to the bill of quantities and values tables contracted with the client.

4.2. Project Status and Calculations

Based on project documents, the contract was for 3.5 km of road duplication paving, as described above. The executed portion is 1.5 km of duplication, meaning 750 meters in each direction, as of 30/11/2024. This date, indicated in the technical and financial report submitted

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

by the contractor showing actual percentage of implementation works (Projects Implementation Authority, 2024), was considered the chosen measurement point for applying Earned Value Analysis (EVA) concepts at (Time Now: Week No. 9). It is worth noting here that the completed portion of the project is about 43% of the total project, and the execution time is two months. EVM concepts and tools will be applied to this project to monitor and control the execution of its activities in terms of time and cost performance according to the bill of quantities attached to the contract, containing the statement of work, quantities, prices, and the planned cost of items as shown in Table (2) detailing these aspects. This is to measure each of:

- Cost Performance Index (CPI) as shown in Eqn. (1).
- Schedule Performance Index (SPI) as shown in Eqn. (2).
- Cost Variance (CV) as shown in Eqn. (3).
- Schedule Variance (SV) as shown in Eqn. (4).
- Estimated Cost at Completion (EAC) as shown in Eqn. (5).

These are the monitoring and measurement criteria for variances and deviations in both cost and time in terms of advancement or delay relative to the baseline. Based on this, the cost and schedule performance indices can be known, and accordingly, the estimated cost at project completion can be calculated. To perform the necessary calculations, the following values need to be determined: Planned Value (PV), Actual Cost (AC), Earned Value (EV), and Budget at Completion (BAC). According to the following mathematical relationships, the mentioned variances and deviations and the estimated budget at completion can be calculated based on these calculations as shown in the equations mentioned previously.

Table 2. Basic Project Data and Budgets

No	Activities	Unit	Quantity	Price "LYD"	"BCWS- PV" (LYD)	"ACWP- AC" (LYD)	"BCWP-EV" %
1	Study and Design	Km	3.5	6000	21000	76000	100
2	Removal of Old Asphalt Pavement Layers	m^2	17000	11	187000	81708	43.6
3	Excavation in Normal Soil	m^3	2400	23	55200	108800	42.85
4	Excavation in Rocky Soil	m^3	1500	72	108000	9792	9.05
5	Backfilling	m^3	500	27	13500	3051	21.43
6	Granular Base Course Treatment	m^2	29000	30	870000	784200	45.53
7	Supply and Application of MCO Impregnation Layer	m^2	29000	7	203000	91490	40.65
8	Asphalt Binder Layer	m^2	28000	79	2212000	973517	44.01
9	Type 1 Cement Concrete: 250 kg Cement/m³	m^3	20	300	6000	3795	41.66
10	Type 2 Cement Concrete: 350 kg Cement/m³	m^3	40	700	28000	34800	42.85
11	Construction of Service Culverts using 8mm Φ Plastic Pipes	m	100	300	30000	30000	42.85
12	Thermal Plastic Coating (Yellow Line)	m	7000	9.5	66500	105000	39.7
	Thermal Plastic Coating (Yellow Line)	m	3500	9.5	33250	52500	39.7
13	Supply and Installation of Directional and Warning Signs	No	15	460	6900	2760	42.85
14	Excavation of a Trench in Normal Soil for Cables	m	1000	52	52000	52000	42.85
15	Excavation of a Lighting Pole Base	No	40	1184	47360	39072	82.47
16	Supply, Installation, and Testing of Underground Electrical Cables	m	1000	480	480000	205680	42.85
17	Installation of an Outdoor Lighting Control Panel	No	1	2500	2500	2500	100
18	Supply and Installation of a Lighting Pole	No	40	1600	64000	52800	82.44
19	Supply and Installation of Double-Arm Lighting Pole Supports	No	40	515	20600	16995	83.33
20	Supply and Installation of a Pole Service Box	No	40	150	6000	4950	83.33
21	Supply and Installation of a Lighting Inspector	No	80	1440	115200	95040	82.62
22	Supply and installation of PVC pipes	m	140	45	6300	6300	42.85
23	Cemented enclosure of culvert pipes	m^3	15	300	4500	4500	42.85
24	Supply and installation of concrete curbs	m	2000	73	145690	98195	67.44
25	Supply and installation of piers	m^2	1500	67	100500	57754	57.28

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

These calculations were performed using pre-prepared Excel templates by "Vertex42; American utility", specialized in preparing Excel sheets related to engineering project management. The Actual Costs (AC) were shown in Table (3), the actual completion percentages representing the Earned Value (EV) were shown in Table (4), and the Planned Values (PV) were shown in Table (5), were entered into the prepared Excel templates for EVM calculations to perform variance and deviation calculations for the aforementioned criteria and produce a comprehensive project report showing the values of each of the variances and performance indices.

Table 3. Actual Financial Cost of Activities "Actual Values"

Actual Cost (AC) of Work Performed

WBS	Task Name	TBC	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9
1.1	Study and Design	76600	38300	38300							
1.2	Removal of Old Asphalt Pavement Layers	81708			81708						
1.3	Excavation in Normal Soil	92000				23000	23000	23000	23000		
1.4	Excavation in Rocky Soil	9792						9792			
1.5	Backfilling	3051					762.75	762.75	762.75	762.75	
	Granular Base Course Treatment	784200						258785	258785	266630	
	Supply and Application of MCO Impregnation Layer	91490							45745	45745	
	Asphalt Binder Layer	973517							321260	321260	331000
	Type 1 Cement Concrete: 250 kg Cement/m³	3795							3795		
	Type 2 Cement Concrete: 350 kg Cement/m³	34800							34800		
	Construction of Service Culverts using 8mm Φ Plastic Pipes	30000					15000	15000			
	Thermal Plastic Coating (Yellow Line)	105000									41820
	Thermal Plastic Coating (Yellow Line)	52500									21210
	Supply and Installation of Directional and Warning Signs	2760									2760
	Excavation of a Trench in Normal Soil for Cables	52000					10400	10400	10400	10400	10400
	Excavation of a Lighting Pole Base	39072							19536	19536	
	Supply, Installation, and Testing of Underground Electrical Cables	480000								96000	206400
	Installation of an Outdoor Lighting Control Panel	2500									2500
-	Supply and Installation of a Lighting Pole	52800									52800
-	Supply and Installation of Double-Arm Lighting Pole Supports	16995									16995
-	Supply and Installation of a Pole Service Box	4950									4950
-	Supply and Installation of a Lighting Inspector	95040									95040
-	Supply and installation of PVC pipes	6300				1260	1260	1260	1260	1260	
	Cemented enclosure of culvert pipes	4500					2250	2250			
	Supply and installation of concrete curbs	98195							49097	49098	
-	Supply and installation of piers	57754									58290
Insert new rows above this one											
		Total Actual Cost	38300	38300	81708	24260	52672.8	321250	768441	810692	844165
		Cumulative Actual Cost (AC)	38300	76600	158308	182568	235241	556491	1324931	2135623	2979788

Table 4. Actual Completion Percentages "Earned Value"

Cumulative Earned Value (EV)

WBS	Task Name	TBC	Wk 1	Wk 2	Wk 3	Wk 4	Wk 5	Wk 6	Wk 7	Wk 8	Wk 9
1.1	Study and Design	21000	50%	100%	100%	100%	100%	100%	100%	100%	100%
1.2	Removal of Old Asphalt Pavement Layers	187000			44%	44%	44%	44%	44%	44%	44%
1.3	Excavation in Normal Soil	55200				11%	22%	33%	44%	44%	44%
1.4	Excavation in Rocky Soil	108000						9%	9%	9%	9%
1.5	Backfilling	13500					5%	6%	16%	21%	21%
1.6	Granular Base Course Treatment	870000						15%	30%	45%	45%
	Supply and Application of MCO Impregnation Layer	203000							20%	41%	41%
14	Asphalt Binder Layer	2212000							14%	28%	44%
	Type 1 Cement Concrete: 250 kg Cement/m³	6000							42%	42%	42%
	Type 2 Cement Concrete: 350 kg Cement/m³	28000							43%	43%	43%
	Construction of Service Culverts using 8mm Φ Plastic Pipes	30000					20%	43%	43%	43%	43%
	Thermal Plastic Coating (Yellow Line)	66500									40%
	Thermal Plastic Coating (Yellow Line)	33250									40%
	Supply and Installation of Directional and Warning Signs	6900									44%
	Excavation of a Trench in Normal Soil for Cables	52000					10%	20%	30%	43%	43%
	Excavation of a Lighting Pole Base	47360							40%	82%	82%
	Supply, Installation, and Testing of Underground Electrical Cables	480000								20%	43%
	Installation of an Outdoor Lighting Control Panel	2500									100%
	Supply and Installation of a Lighting Pole	64000									83%
	Supply and Installation of Double-Arm Lighting Pole Supports	20600									83%
	Supply and Installation of a Pole Service Box	6000									83%
	Supply and Installation of a Lighting Inspector	115200									83%
	Supply and installation of PVC pipes	6300				10%	20%	30%	40%	43%	43%
	Cemented enclosure of culvert pipes	4500					10%	20%	30%	43%	43%
-	Supply and installation of concrete curbs	145690							30%	68%	68%
-	Supply and installation of piers	100500									58%
Insert new rows above this one											
		Cumulative EV	10500	21000	102532	109074	128261	287922	859561	1521833	2260494

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

Table 5. Budgeted Costs of Scheduled Work "Planned Values"

Planned Value (PV) or Budgeted Cost of Work Scheduled (BCWS)

WBS	Task Name	TBC	wk1	wk2	wk3	wk4	wk5	wk6	wk7	wk8	wk9
1.1	Study and Design	21000	10500	10500							
1.2	Removal of Old Asphalt Pavement Layers	187000			187000						
1.3	Excavation in Normal Soil	55200				13800	13800	13800	13800		
1.4	Excavation in Rocky Soil	108000						108000			
1.5	Backfilling	13500					3375	3375	3375	3375	
1.6	Granular Base Course Treatment	870000							145000	145000	145000
	Supply and Application of MCO Impregnation Layer	203000							40600	40600	
	Asphalt Binder Layer	2212000							316000	316000	316000
	Type 1 Cement Concrete: 250 kg Cement/m³	6000							1980	1980	2040
	Type 2 Cement Concrete: 350 kg Cement/m³	28000							9240	9240	9520
	Construction of Service Culverts using 8mm Φ Plastic Pipes	30000					7500	7500	7500	7500	
	Thermal Plastic Coating (Yellow Line)	66500									32250
	Thermal Plastic Coating (Yellow Line)	33250									16625
	Supply and Installation of Directional and Warning Signs	6900									2967
	Excavation of a Trench in Normal Soil for Cables	52000					10400	10400	10400	10400	10400
	Excavation of a Lighting Pole Base	47360							23680	23680	
	Supply, Installation, and Testing of Underground Electrical Cables	480000								16000	16000
	Installation of an Outdoor Lighting Control Panel	2500									2500
	Supply and Installation of a Lighting Pole	64000									64000
	Supply and Installation of Double-Arm Lighting Pole Supports	20600									20600
	Supply and Installation of a Pole Service Box	6000									6000
	Supply and Installation of a Lighting Inspector	115200									115200
	Supply and installation of PVC pipes	6300				1260	1260	1260	1260	1260	
	Cemented enclosure of culvert pipes	4500						1125	1125	1125	1125
	Supply and installation of concrete curbs	145690							43707	91785	
	Supply and installation of piers	100500									58290
Insert new rows above this one											
	Total Budgeted Cost	4885000	10500	10500	187000	15060	36335	145460	617667	667945	818517
	Cumulative Planned Value (PV)		10500	21000	208000	223060	259395	404855	1022522	1690467	2508984

5. Results and Discussion

5.1. Presentation and Analysis of Quantitative Results

This study aims to apply the Earned Value Management (EVM) methodology as a quantitative tool to evaluate the performance of the road duplication paving project in Zliten Municipality – Libya, by tracking the project's temporal and financial performance at Time Now, Week Nine of execution. The data included in the monthly statements and project bill of quantities were analyzed using the basic performance indicators of the EVM methodology, including Planned Value (PV), Earned Value (EV), and Actual Cost (AC). To ensure clarity and reproducibility, the key raw values used for the calculations at the measurement period (Time Now, Week Nine) are: Budget at Completion (BAC) = 4,885,000 LYD, Planned Value (PV) = 2,508,984 LYD, Earned Value (EV) = 2,260,494 LYD, and Actual Cost (AC) = 2,979,788 LYD. Table (6) shows the values obtained from simulating the project's data and information, and the calculations of variances and performance indices for both time and cost at the measurement period Time Now, Week Nine.

5.2. Analysis of Project Temporal and Financial Performance

5.2.1. Schedule Performance:

It is clear from the value of the Schedule Performance Index (SPI = 0.90) shown in Table (7) that the project is proceeding at an execution rate 10% lower than the planned rate, indicating a clear schedule delay in several critical activities such as excavation in rocky soil, backfilling, priming works, and some concrete works. This delay is likely due to poor coordination among suppliers and delayed material delivery, in addition to field execution conditions in some rocky areas along the path. It is noted that the total execution percentage (42.85%) at (Time Now: Week Nine) is less than the planned percentage of about 45% in this period, indicating a slight delay in the project's overall scheduling.

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

Table 6. Results of Simulating Project Data and Information

Indicator	*Symbol*	*Value (LYD)*	*Implication*
Planned Value	PV	2,508,984	The amount of work that should have been completed by Week Nine according to the schedule
Earned Value	EV	2,260,494	The amount of work actually completed according to the plan
Actual Cost	AC	2,979,788	The actual amounts spent up to the same period
Cost Variance	CV = EV – AC	-719,294	Negative, meaning cost overrun compared to plan
Schedule Variance	SV = EV – PV	-248,490	Negative, meaning progress delay compared to the time plan
Cost Performance Index	CPI = EV / AC	0.76	Less than 1, meaning spending is higher than planned cost
Schedule Performance Index	SPI = EV / PV	0.90	Less than 1, meaning the project is behind schedule
Estimate at Completion	EAC	6,439,417	Indicates an expected increase of 31.8% over the original contract value (4,885,000 LYD)

Table 7. of Results for Cost and Time Variances and Performance Indicators

	wk1	wk2	wk3	wk4	wk5	wk6	wk7	wk8	wk9
Total Badgeted Cost 4885000	10500	10500	187000	15060	36335	145460	617667	667945	818517
Cumulative Planned Value (PV)	10500	21000	208000	223060	259395	404855	1022522	1690467	2508984
Actual Cost and Earned Value									
Cumulative Actual Cost (AC)	38300	76600	158308	182568	235240.8	556490.5	1324931	2135623	2979788
Cumulative Earned Value (EV)	10500	21000	102532	109073.9	128261	287922	859561	1521833	2260494
Project Performance Metrics									
Cost Variance (CV=EV-AC)	-27800	-55600	-55776	-73494.08	-106980	-268569	-465370	-613790	-719294
Schedule Variance (SV=EV-PV)	0	0	-105468	-113986.1	-131134	-116933	-162961	-168634	-248490
Cost Performance Index (CPI=EV/AC)	0.27	0.27	0.65	0.60	0.55	0.52	0.65	0.71	0.76
Schedule Performance Index (SPI=EV/PV)	1.00	1.00	0.49	0.49	0.49	0.71	0.84	0.90	0.90
Estimated Cost at Completion (EAC)	17818619	17818619	7542373	8176516	8959474	9441641	7529761	6855230	6439418

5.2.2. Cost Performance:

The results of the Cost Performance Index (CPI = 0.76) shown in Table (7) indicate poor efficiency in using financial resources, as an earned value equivalent to (0.76) LYD is achieved for every LYD actually spent, meaning the project is spending more than the actual progress achieved. The Cost Variance (CV = -719,294 LYD) also reached, meaning a financial overrun estimated at about 14.7% of the budget allocated to date. This overrun is linked to several factors, most importantly:

- Poor estimation of some items during the preparation of the tender bill of quantities, especially in excavation items, asphalt layers, and initial designs.
- Increase in fixed daily expenses (sundries) due to the extended execution period (1200 LYD daily).
- Weak field financial control and absence of a weekly monitoring system linked to actual progress.

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

- Impact of External Factors: The documented cost overrun is also aggravated by significant fluctuations in the price of key imported materials, notably the bitumen used for asphalt paving layers, which is a high-cost activity. This fluctuation was not adequately covered by the initial cost estimates, directly contributing to the poor CPI value.

5.2.3. Forecasting:

The Estimate at Completion is approximately EAC approx. 6.44 million LYD as shown in Table (7), meaning the final project cost will exceed the original budget by about 31.8%, unless urgent corrective actions are taken. This calculation uses the formula EAC = BAC / CPI (Eqn. 5) and assumes current cost inefficiency (CPI = 0.76) will persist. For comparison, if future performance were assumed to immediately return to the original plan, the forecast using EAC = AC + BAC - EV (Eqn. 6) would be 6,504,294 LYD. The most conservative forecast, accounting for both current cost and schedule inefficiency using EAC = AC + ((BAC - EV) / (CPI * SPI)) (Eqn. 7), would be 6,950,911 LYD. The range of forecasts clearly signals a significant and urgent need for budget revision. Also, the continuation of the Schedule Performance Index (SPI) at 0.9 means that the actual execution duration will exceed the planned duration by about (10–15%), which will lead to an increase in daily and fixed expenses over time. These results show that the project faces a dual risk of cost and time overruns, which necessitates re-evaluating the execution plan and scheduling the available resources as shown in Figure (1).

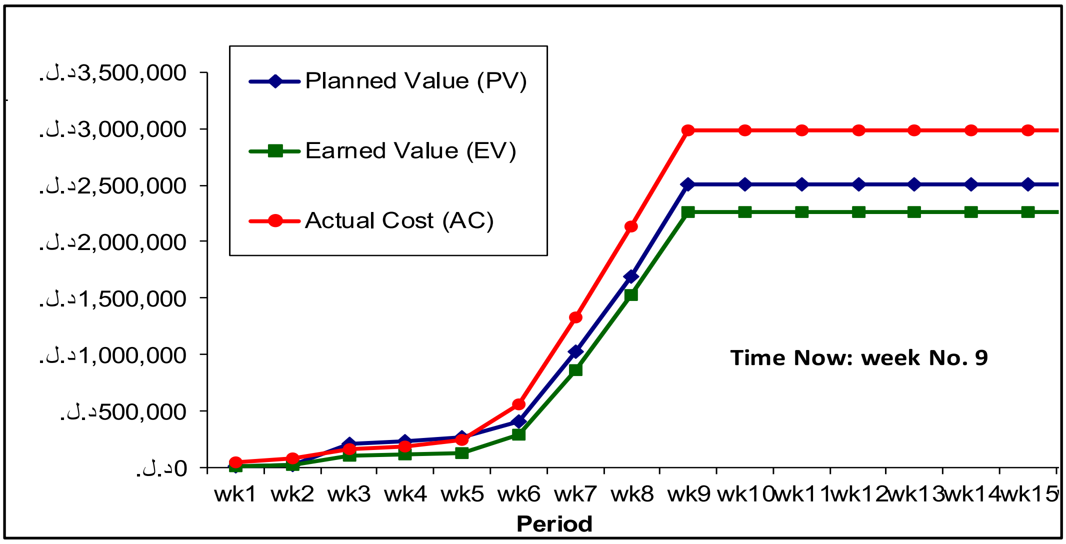

Figure 1. "S-Curve" Representing Planned, Actual, and Earned Value Performance

5.2.4. Analysis of Execution Items Performance:

By comparing completion percentages and costs across work items, the following was found:

- Items with high cost and good progress: Such as the granular base course and the asphalt binder course; they were executed with a high completion percentage but accompanied by cost increases due to work acceleration and purchases.
- Delayed and costly items: Such as concrete works, paints, and road markings; suffering from slow execution and high cost due to multiple suppliers and poor coordination.

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

- Items completed according to plan and cost: Such as work on columns and electrical cables, this maintained balanced performance ratios, indicating improved technical management during the electromechanical installation phase.
- The research problem lies in the absence of an effective mechanism for monitoring the projects financial and temporal performance, which may lead to time delays or cost overruns, the Earned Value Method will use as analysis approach.

5.2.5. Overall Project Performance Assessment:

The indicators indicate that the project falls within the "Weak" quadrant in the Earned Value Management matrix, meaning it is both behind schedule and over budget simultaneously. This is a dangerous indicator that requires rapid administrative and technical intervention through the following:

- Re-planning human and financial resources.
- Identifying critical activities affecting the critical path.
- Controlling daily operational expenses.
- Activating weekly monitoring using a digital performance dashboard.

6. Conclusions

The Earned Value Management methodology was able to accurately assess the project's performance from both a time and cost perspective using quantitative data that can be relied upon for making decisions. From the data analysis, the project appears to have experienced a financial overrun of approximately 31.8% and a schedule delay of approximately 10% from what was originally planned. The project was found to have low values for the Cost Performance Index (CPI) = 0.76 and Schedule Performance Index (SPI) = 0.90, indicating poor administration of monitoring project plans against actual costs. The primary sources of the deviation from project plan are attributed to weak financial controls within the field, lack of an integrated system to monitor the schedule and actual expenses, as well as increases in material costs and late deliveries. Performance indicators for paving layers, as items consuming the highest financial weight, were impacted negatively; therefore, secondary service items were more stable. In summary, cooperative agreement projects are in need of improvements in their planning and monitoring system to maximize the effectiveness of available resources and to minimize delays and financial losses.

7. Recommendations

- Adopting the Earned Value Management method as an official mechanism for monitoring the implementation of engineering projects in the Projects Authority of the Ministry of Transportation in Libya.
- Researchers advise to put both weekly and monthly performance reports which linking cost and achievement in an electronic monitoring system for follow-up and taking the right actions in a timely manner.

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

- Preparing training and qualification programs for engineers and project managers in the fields of analyzing performance indicators for both CPI and SPI, and using the EVM methodology in monitoring the implementation of engineering projects.
- Reviewing the process of preparing the first set of schedules & prices to ensure that they match the actual capacities of the contractor and the conditions under which the work is done, as well as fluctuations in the market that affect the execution of the work.
- Implementing urgent corrective measures that include rearranging implementation priorities, adjusting daily expenses, and assessing the efficiency of working resources.
- Proposing to include new contractual clauses relating to mechanisms for adjusting and controlling prices and the time period for addressing changes in market prices or substantial technical modifications.

References

Abdelrahman, S. A., & Nassar, A. H. (2024). Integrating theory and practice in value engineering within Egypt’s construction industry. *Journal of Engineering and Applied Science*, *71*(1), 188.

Anbari, F. T. (2003). Earned value project management method and extensions. *Project Management Journal*, *34*(4), 12-23.

Aramali, V., Gibson Jr, G. E., El Asmar, M., & Sanboskani, H. (2023). Novel earned value management system maturity framework and its relation to project performance. *Journal of Construction Engineering and Management*, *149*(6), 04023031.

Budd, C. I., & Budd, C. S. (2009). *A practical guide to earned value project management*. Berrett-Koehler Publishers.

Christensen, D. S. (1996). Project advocacy and the estimate at completion problem. *The Journal of Cost Analysis*, 13(1), 35-60.

Czarnigowska, A. (2008). Earned value method as a tool for project control. *Budownictwo i Architektura*, 3(2), 15-32.

Doloi, H. (2013). Cost overruns and failure in project management: Understanding the roles of key stakeholders in construction projects. *Journal of Construction Engineering and Management*, *139*(3), 267-279.

Dvir, D., Raz, T., & Shenhar, A. J. (2003). An empirical analysis of the relationship between project planning and project success. *International Journal of Project Management*, 21(2), 89-95.

Fleming, Q. W., & Koppelman, J. M. (2010). *Earned value project management*. Project Management Institute.

Kerzner, H. (2025). *Project management: a systems approach to planning, scheduling, and controlling*. John Wiley & Sons.

Lipke, W. (2003). Schedule is different. *The measurable news*, *31*(4), 31-34.

PMBOK Guide (2017). *A Guide to the Project Management Body of Knowledge*, 6th ed. Project Management Institute.

Projects Implementation Authority. (2024). *Technical and financial report of Contract No. 200/2024*. Ministry of Transportation, Government of National Unity of Libya.

ISSN (Print): 2413-5267
ISSN (Online): 2706-9966

Rad, P. F., & Levin, G. (2002). *The Advanced Project Management Office: A comprehensive look at function and implementation*. CRC press.

Vargas, R. V. (2003). Earned value analysis in the control of projects: Success or failure. *AACE International Transactions*, *21*(4), 211-214.