

PROJECT MONITORING

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PMG333

Lecture 04

COST& TIME MONITORING 2

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Key Concepts Covered in This Session

1. Earned Value Management (EVM) Completion:

- Finalizing EVM metrics and forecasting techniques.
- Understanding cost and schedule variances.

2. Earned Schedule (ES):

- Shifting from cost-based to time-based schedule metrics.
- Core question: "When was this work actually supposed to be completed?"
- True schedule formulas: $SV(t)$ and $SPI(t)$.

3. Management Action (Step 10):

- Implementing corrective and preventive actions based on EVM data.
- The 6-step process for effective management response.

4. Baseline Maintenance (Step 11):

- Keeping the Performance Measurement Baseline (PMB) accurate.
- Formal Change Control Board (CCB) processes.
- Managing Contingency and Management Reserves.



ISO 21508:2018 Guidelines

- 1 Scope Decomposition:** Use **Work Breakdown Structure (WBS)** to define all required work.
- 2 Assign Responsibilities:** Identify persons or teams for each **Work Package**.
- 3 Schedule Work:** Develop a timeline for executing each part of the work.

- 4 Develop Time-phased Budget:** Distribute the budget across the project schedule.
- 5 Assign Performance Metrics:** Determine how to measure progress (e.g., **% complete, milestones**).
- 6 Establish PMB:** Approve the **Performance Measurement Baseline** integrating scope, time, and cost.

Step 7: Authorize & Execute Work - Begin actual task execution based on the baseline.

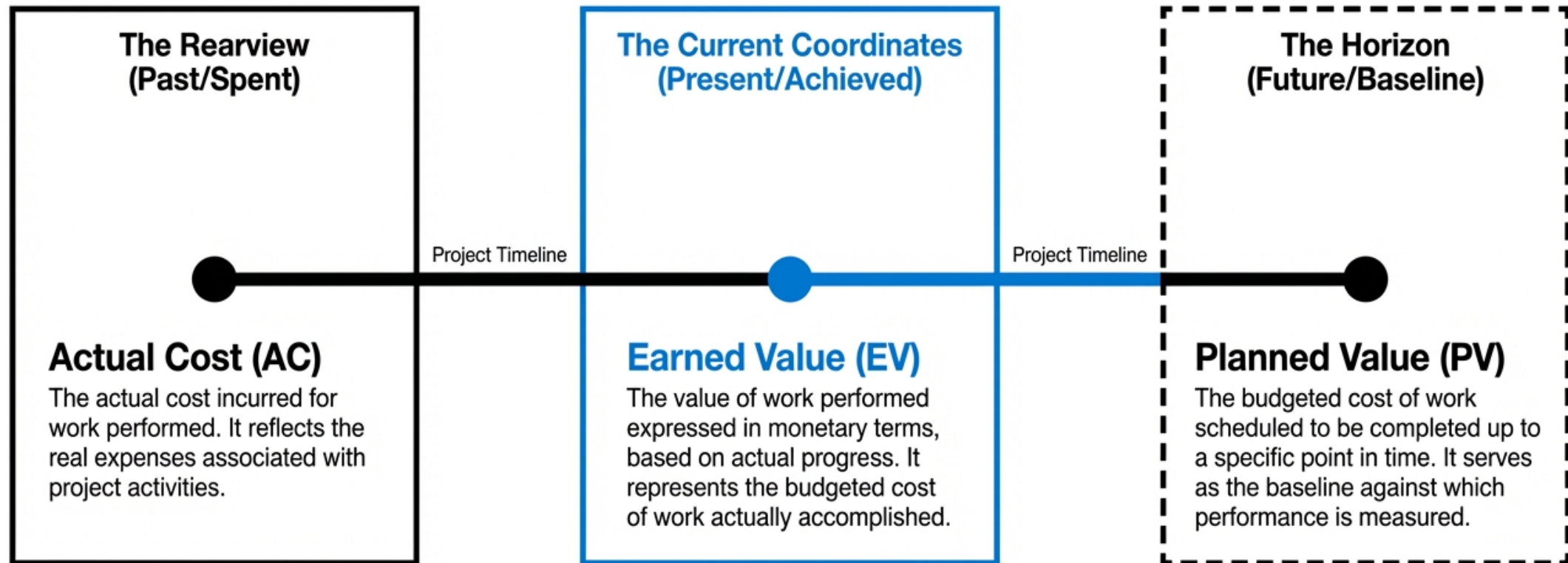
Step 8: Data Collection - Record actual costs and work progress.

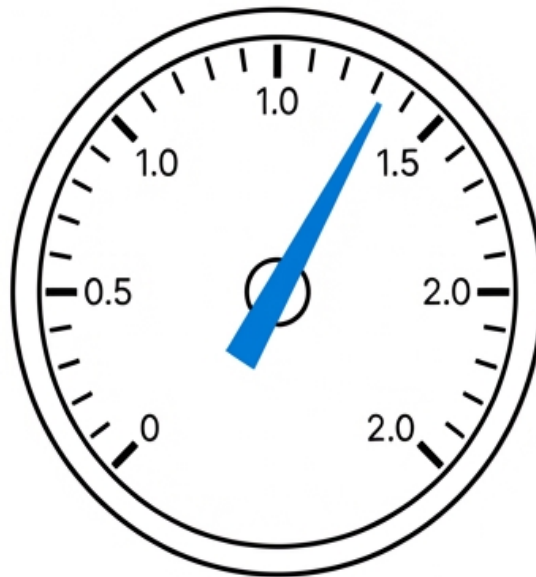
Step 9: Performance Analysis - Compare Earned Value with Planned Value and Actual Costs.

Step 10: Management Action - Take corrective actions based on discovered variances.

Step 11: Baseline Maintenance - Update the baseline for approved scope or budget changes.

Earned value Management completion

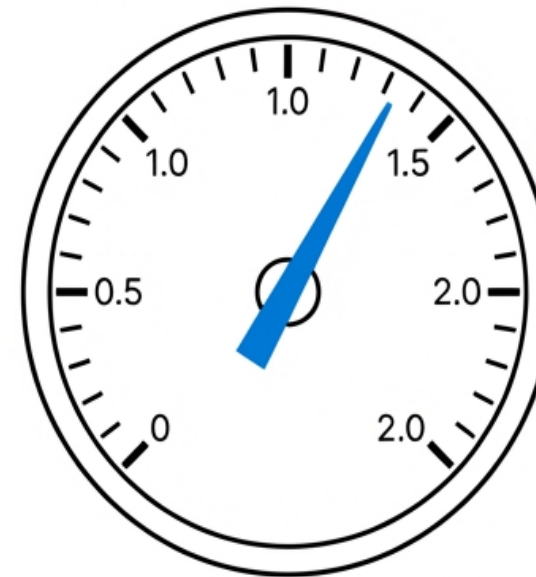




Cost Performance Index (CPI)

$$\text{CPI} = \text{EV} / \text{AC}$$

A ratio indicating the cost efficiency of the project.



Schedule Performance Index (SPI)

$$\text{SPI} = \text{EV} / \text{PV}$$

A ratio measuring the schedule efficiency and progress of the project.

Index Value	Cost (CPI)	Schedule (SPI)
> 1	Cost savings.	Ahead of schedule progress.
= 1	Exactly on target with the planned baseline.	Exactly on target with the planned baseline.
< 1	Cost overruns.	Behind schedule.

Variance Analysis

Variance analysis specifically compares EV, PV, and AC. Positive variances indicate favorable performance; negative variances signal potential issues.

Project Overview & Current Status

PROJECT OVERVIEW

- **Project Scope:** Design, manufacture, and deliver two military tanks
- **Budget at Completion (BAC):** \$2,000,000 (\$1M per tank)
- **Planned Project Duration:** 24 months
- **Current Status Point:** Month 12

STATUS AT MONTH 12

Planned Value (PV): **\$1,000,000**

Actual Cost (AC): **\$1,200,000**

Earned Value (EV): **\$800,000**

Physical Progress: **80% of Tank 1**

Cost and Schedule Variance Calculations

Cost Performance Analysis

Cost Variance (CV) = EV - AC

= \$800K - \$1.2M = **\$400K** (Over Budget)

Cost Performance Index (CPI) = EV / AC

= \$800K / \$1.2M = **0.67** (Poor Efficiency)

Schedule Performance Analysis

Schedule Variance (SV) = EV - PV

= \$800K - \$1M = **-\$200K** (Behind Schedule)

Schedule Performance Index (SPI) = EV / PV

= \$800K / \$1M = **0.80** (Delayed Progress)

Estimate at Completion (EAC) Based on Root Cause

EAC Scenarios

**Scenario A (Temporary Anomaly)**

EAC = \$2.4M. **Issue:** Resource reallocation.
Action: Needs \$400K more.

**Scenario B (Spend Plan Deviation)**

EAC = \$2.0M. **Issue:** Bulk purchasing.
Action: No extra funds needed.

**Scenario C (Permanent Cost Change)**

EAC = \$2.98M. **Issue:** Material inflation.
Action: Needs \$985K more.

**Scenario D (Systemic Degradation)**

EAC = \$3.43M. **Issue:** Ongoing poor performance.
Action: Needs \$1.43M more.

Benefits Demonstrated

- **Early Warning System:** Detected issues at 50% completion.
- **Root Cause Analysis:** Same metrics lead to different forecasts based on context.
- **Accurate Forecasting:** Provides multiple data-driven EAC scenarios.
- **Informed Decision-Making:** Objective metrics for stakeholder communication.

The “End of Project Anomaly”

Why Traditional Earned Value Management (EVM) Fails in Late-Stage Schedule Tracking.

EVM measures schedule performance using Cost Units (Dollars).

$$SV = EV - PV$$
$$SPI = EV / PV$$

The Flaw: At project completion, Earned Value (EV) always equals Planned Value (PV), also known as Budget at Completion (BAC).

Result: Due to the “End of Project Anomaly”, SV becomes 0 and SPI becomes 1.0, even if the project is months late!

Conclusion: EVM schedule metrics lose predictive value past the 2/3 mark of the project.

Earned Schedule (ES)

Upgrading Project Control: Moving from Cost-Based
to Time-Based Schedule Metrics.

The Flaw in Traditional EVM

EVM measures schedule performance using currency (dollars) rather than units of time.

Schedule Variance:

$$SV = EV - PV$$

Schedule Performance Index:

$$SPI = EV / PV$$



The 'Late Project' Illusion

On projects extending past their planned duration, traditional SV and SPI mathematically converge to 'perfect' upon completion—even if the project finishes months late.

$$(SV = \$0, SPI = 1.0)$$

Managers are left blind, with no reliable metric for schedule control during the most critical, delayed phase of a project.

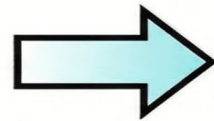
Earned Schedule (ES): The Solution Shifting from Cost to Time

The Paradigm Shift & Concept

Definition

- Earned Schedule is a time-based measure that identifies the point in time when the current Earned Value (EV) should have been achieved.

Traditional EVM
(Cost Units)



Earned Schedule
(Time Units)

The Shift & Concept

The Shift: ES measures schedule performance in Time Units (Months, Weeks) instead of Cost Units.

Concept: It provides a true indication of schedule status by determining the 'time' value of the accomplished work.

New Metrics & True Schedule Formulas

New Metrics

Earned Schedule (ES): The planned duration for the work actually accomplished.

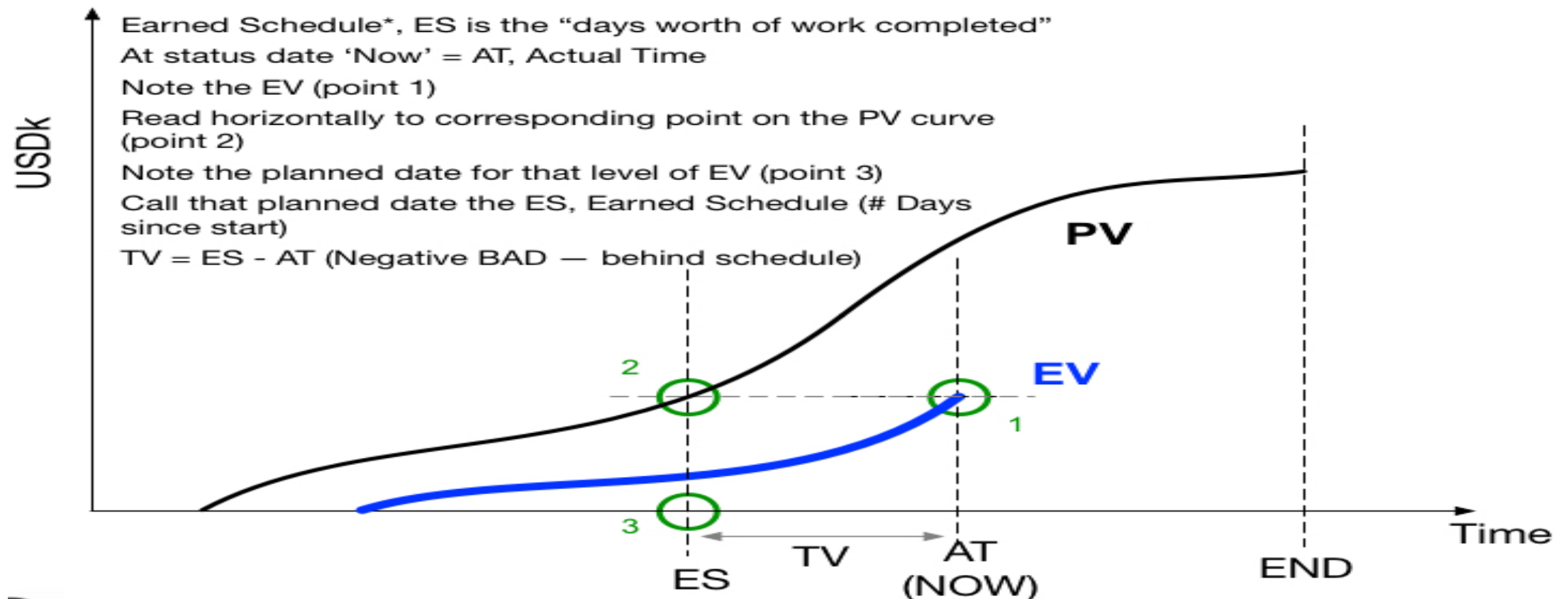
Actual Time (AT): The actual time elapsed since the project started.

True Schedule Formulas

SV(t) = ES - AT (Negative = Behind Schedule)

SPI(t) = ES / AT (< 1.0 = Slow Progress)

Earned Schedule



	Traditional EVM	Earned Schedule (ES)
Unit of Measure	Dollars / Currency	Time (Days / Months)
Schedule Variance	$SV(\$) = EV - PV$	$SV(t) = ES - AT$
Performance Index	$SPI(\$) = EV / PV$	$SPI(t) = ES / AT$
Behavior on Late Projects	Fails (SV returns to 0, SPI to 1.0)	Accurate (Reflects exact time delayed)

2003

Initiated by Walt Lipke.

2011

Officially adopted globally as an appendix
in the PMI Practice Standard for EVM.

ES replaces the dollar value of work with a focus on units of time. Instead of asking 'How much dollar value did we earn?', it asks a radically different question:

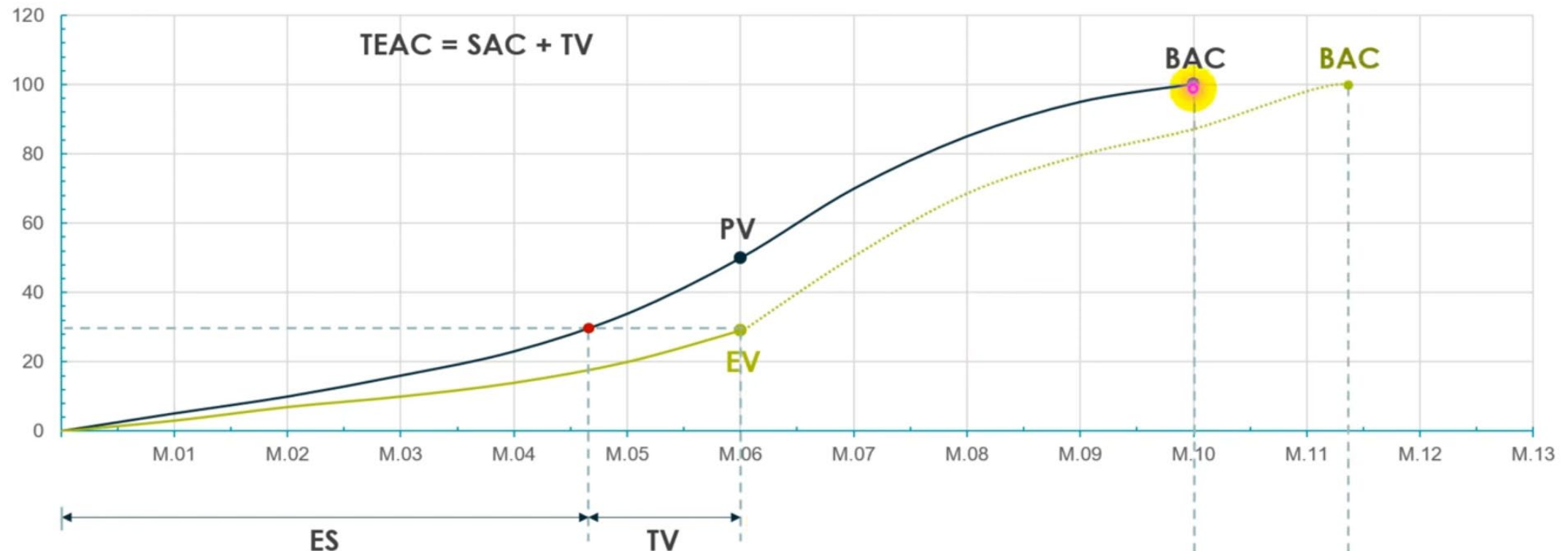
When was this work actually supposed to be completed?

Discussion of Schedule Value Scenarios

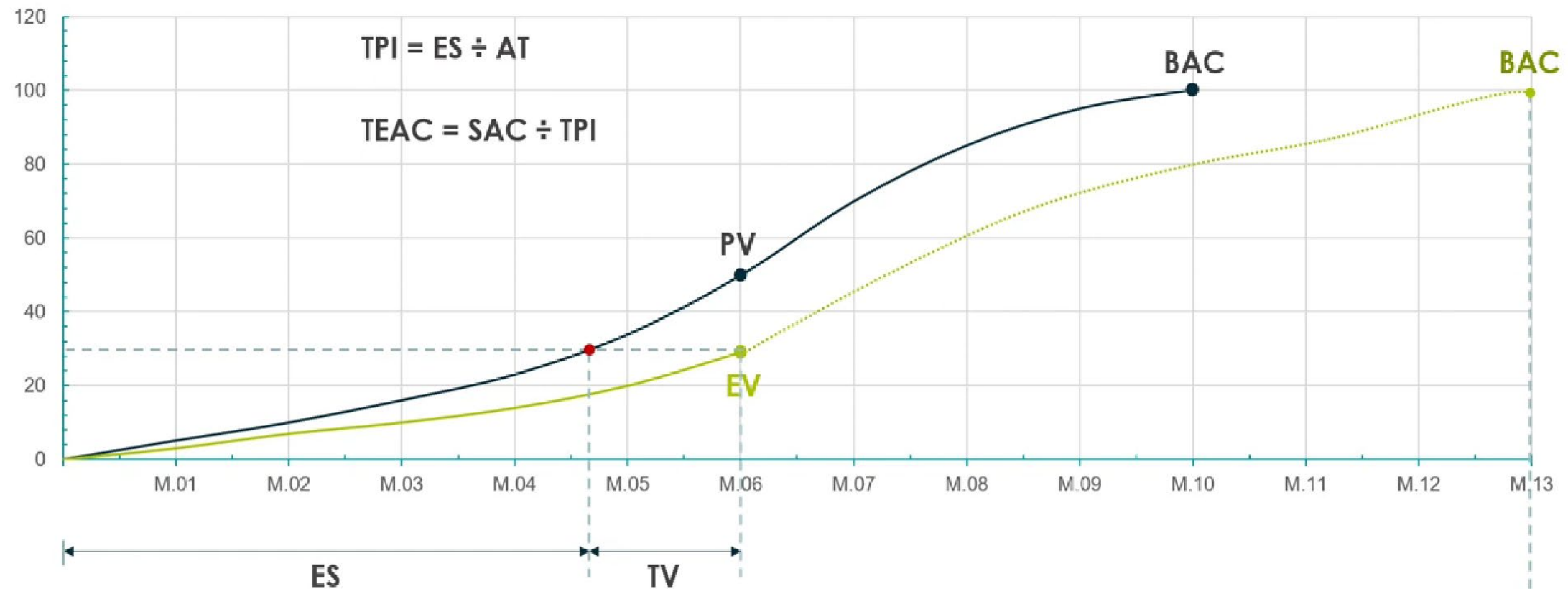
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Forecasting of Completion Time Scenario 1

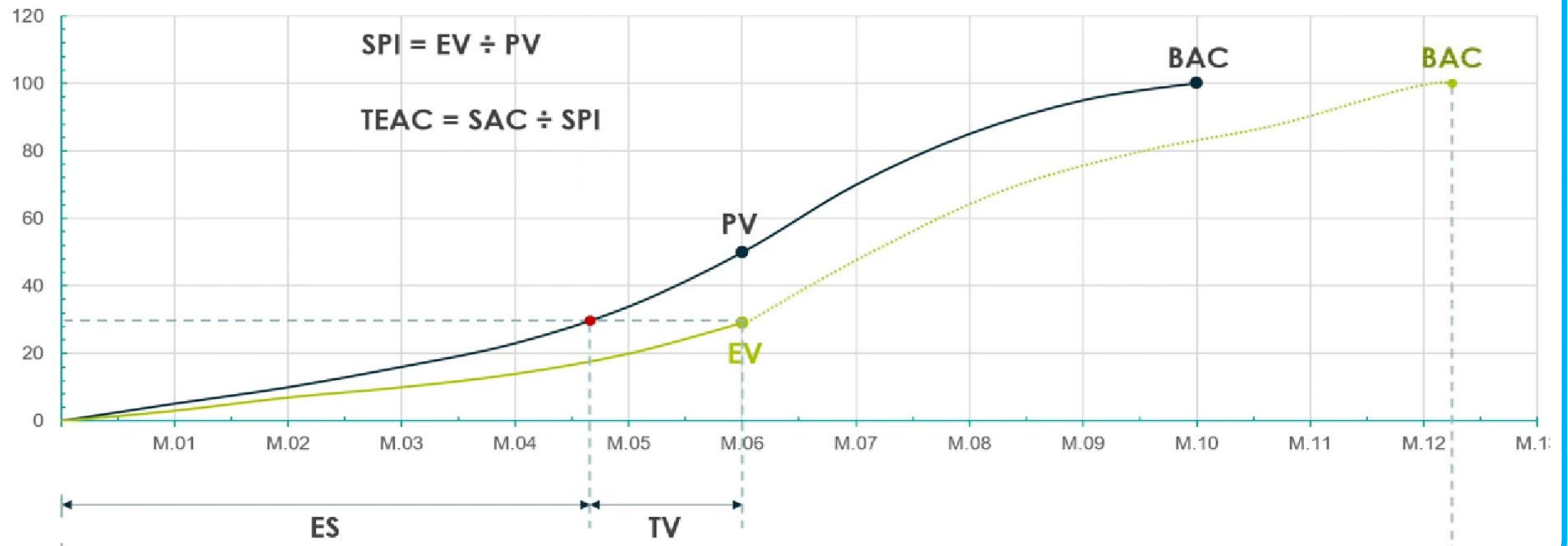
The remaining work will be performed according to the original plan and there will be no further delay to (or speeding of) the project, **TEAC = SAC + TV**



The remaining work will be performed while maintaining the same rate of doing work for the rest of the project, **TEAC = SAC ÷ TPI**



TEAC can also be calculated using the SPI, they depend on whether the project has reached the planned completion date. If the date is earlier than SAC and the project has not yet finished: **TEAC = SAC ÷ SPI**



Case Study 1 - Water Treatment Programme (Part 1)

£30M Infrastructure Project

- Budget: **£30 Million**
- Planned Duration (PD): **20 months**
(April 2025 - November 2026)
- Current Status: Month 12 (March 2026)
- Actual Time (AT): **12 months**
- Current Earned Value (EV): **£16.8 Million**

Baseline Planned Values - Cumulative							
Month	8	9	10	11	12	13	14
PV (£M)	10.8	13.2	15.5	17.9	20.4	22.6	24.8

Case Study 1 - Water Treatment Programme (Part 2)

Earned Schedule Analysis & Performance Indicators

Step 1: Calculate Earned Schedule (ES)

Formula:

$$ES = C + (EV - PV_C) / (PV_{C+1} - PV_C)$$

Where C = 10

Calculation:

$$ES = 10 + (16.8 - 15.5) / (17.9 - 15.5) \\ = 10.54 \text{ months}$$

Performance Indicators

Schedule Variance:

$$SV(t) = ES - AT = 10.54 - 12 = -1.46 \text{ months (1.5 months behind)}$$

Schedule Performance Index:

$$SPI(t) = ES / AT = 10.54 / 12 = 0.878 \text{ (87.8\% efficiency)}$$

Independent Estimate at Completion:

$$IEAC(t) = PD / SPI(t) = 20 / 0.878 = 22.8 \text{ months (2.8 months delay)}$$

Comparison with Traditional EVM

$$\text{Traditional SPI} = EV / PV = 16.8 / 20.4 = \mathbf{0.824}$$

SPI(t) remains accurate throughout project, while traditional SPI converges to 1.0 at completion.

Case Study 2 - Residential Apartment Complex (Part 1)

Real-Time Application in India

Project Overview

- Location: Bengaluru, Karnataka, India
- Project Type: Multi-unit residential apartment complex
- Data Source: Planning department records
- Evaluation Point: Month 10 (M10)

Methodology

- Applied both EVM and ESM (Earned Schedule Management) to real project data
- Generated parameters from actual planning department data
- Compared deterministic forecasting results between EVM and ESM

Key Finding

- Project showed significant fluctuations in performance metrics throughout execution, requiring careful monitoring and intervention strategies.

Case Study 2 - Residential Apartment Complex (Part 2)

Performance Results & Comparative Analysis

Metric	Value	Interpretation
Performance at Month 10:		
Cost Variance (CV)	-0.91 Crore INR	Budget overrun (~9.1 Million INR)
Schedule Variance (Time-based)	-6.71 months	Project is 6.71 months behind schedule

Key Observations:

- Project is significantly behind schedule and over budget
- Requires immediate corrective actions and improvements
- Performance is unfavorable and needs amelioration

Critical Conclusion:

Using EVM and ESM methods in conjunction provides more accurate interpretation and forecasting than using each method independently. The combined approach reveals the true severity of schedule delays that might be masked by traditional cost-based metrics alone.

Case Study 2: Benefits & Key Insights

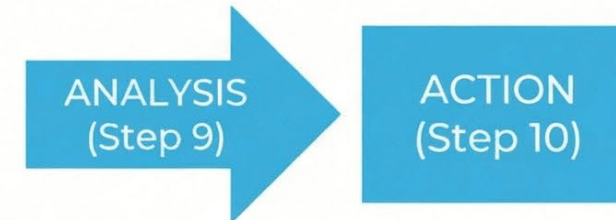
Value of Combined EVM & ESM Approach

- ◆ **Complementary Metrics:** EVM and ESM provide complementary insights into project performance.
- ◆ **Early Detection:** Combined analysis enabled early detection of severe schedule delays (6.71 months).
- ◆ **Accurate Forecasting:** ESM provides reliable schedule predictions throughout the project lifecycle, unlike traditional SPI.
- ◆ **Objective Measurement:** Eliminates subjective assessments, providing quantifiable metrics for stakeholder confidence.
- ◆ **Integrated Analysis:** Connects scope, schedule, and cost to reveal systemic management challenges in complex construction projects.

Step 10: Management Action

- **Definition:** Taking management action based on variance analysis (Step 9).

- **Importance:** Transforms data analysis into tangible decisions to keep the project on track.



- **Primary Goal:** **Correct** current deviations and **prevent** future ones.
- **Connection:** Directly impacts Step 11 (Maintaining the **Performance Measurement Baseline - PMB**).

Bringing Performance Back to the Baseline

Definition & Trigger

- **Definition:** Actions aimed at bringing a deviated project's performance back to the **Performance Measurement Baseline (PMB)**.
- **Trigger:** Taken *after* a deviation (negative SV or CV) has occurred.

Common Examples

- **Adding Resources:** Hiring more staff or equipment to speed up work.
- **Rescheduling:** Changing task priorities or executing tasks in parallel (**Fast Tracking**).
- **Crashing:** Reducing activity duration by adding resources (often increases cost).
- **Improving Efficiency:** Training the team or using better tools.

Key Points

- **Definition:** Actions aimed at preventing **potential** future deviations from occurring.
- **Focus:** **Proactive** risk management and **process improvement**.

Examples

- **Contract Review:** Ensuring contracts have clauses protecting against price fluctuations.
- **Process Improvement:** Implementing more effective procurement strategies.
- **Team Training:** Providing additional training to reduce errors and rework.
- **Risk Reviews:** Conducting regular risk assessments to identify threats.

Case Study: Software Project

Applying Preventive Actions

Context:

- Development of a complex database management system.

Anticipated Risk:

- Frequent requirement changes (**60% probability**) and misunderstandings.

1. Improve Requirements Gathering

Intensive workshops with stakeholders and comprehensive documentation.

**2. Team Training**

Training on modern documentation tools and change management.

**3. Change Control Board (CCB)**

Established a formal process for evaluating and approving changes.

Result: Unplanned changes reduced from **60%** to **15%**.

1. Identify

Detect variances using EVM metrics (CV, SV).



2. Root Cause Analysis

Understand the underlying reasons for deviations.



3. Develop Options

Create multiple corrective or preventive solutions.

4. Evaluate

Assess options based on effectiveness, cost, and impact.



5. Implement

Execute the chosen management actions.



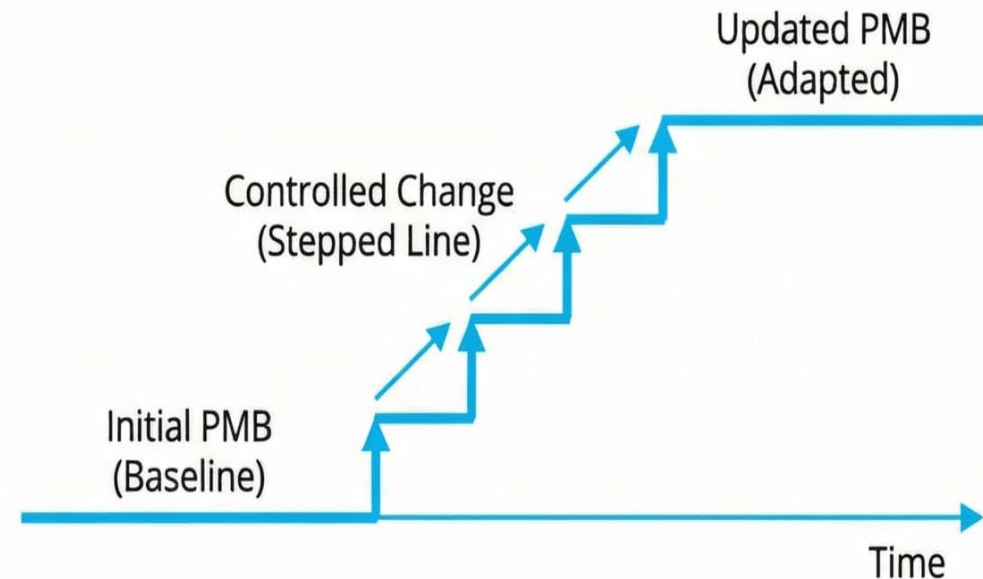
6. Monitor

Track results to ensure the actions are effective.

Step 11: Baseline Maintenance

Key Points

- **Objective:** Keep the Performance Measurement Baseline (PMB) accurate and reflective of the project's true status.
- **Why it matters:** Ensures EVM reports provide a reliable reference for measuring performance.
- **Key Focus:** Managing changes to the PMB and Management Reserves through formal processes.

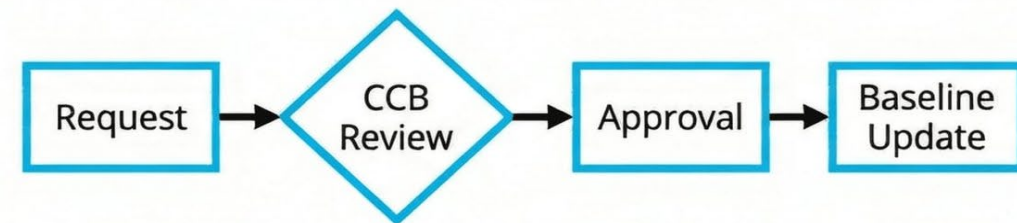


Symbolizing controlled flexibility: Baseline adapts through formal change management.

Managing Baseline Modifications

Key Points

- **Formal Change Process:** All proposed changes must be documented and evaluated.
- **Change Control Board (CCB):** A designated group (CAMs, Management, Sponsors) that reviews and approves changes.
- **Managing Reserves:**
 - Contingency Reserves: Kept separate from the baseline.
 - Management Reserves: Strictly controlled and only added to the baseline upon formal approval.



Symbolizing the controlled flow of baseline modifications.

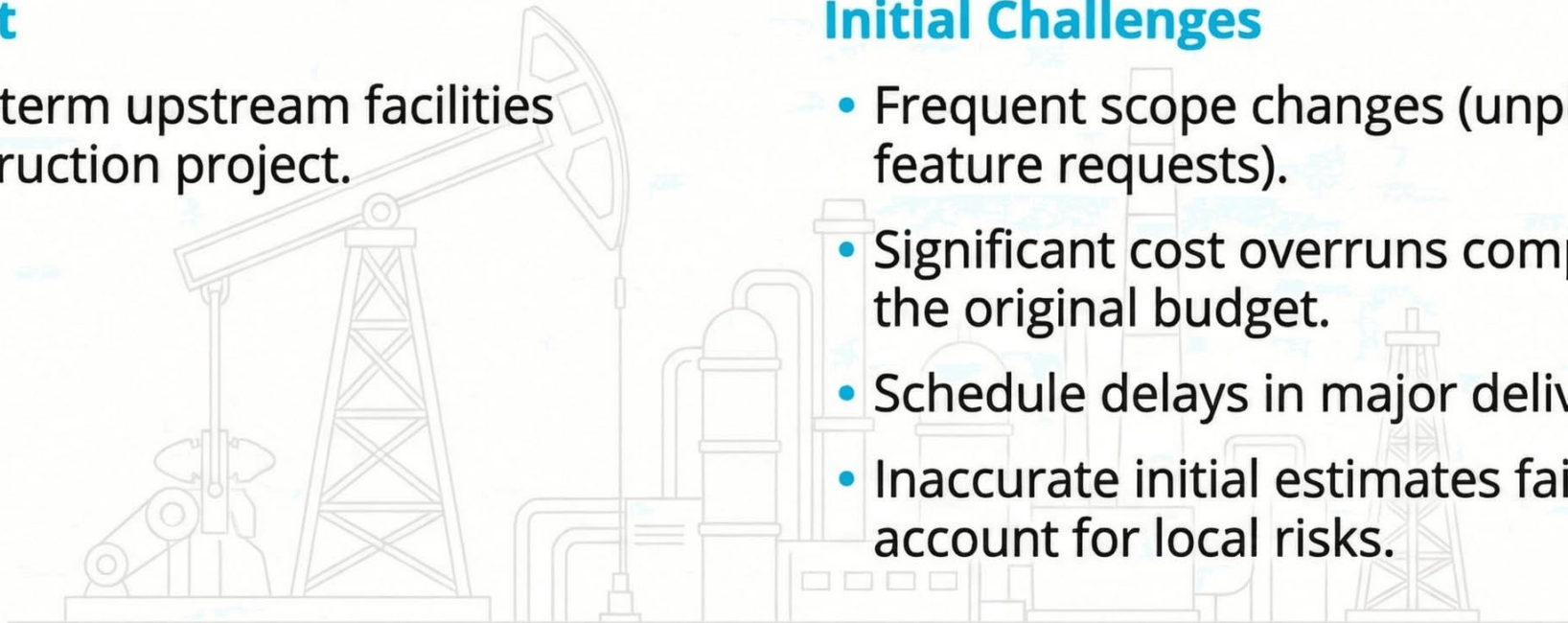
Upstream Facilities Construction in Kazakhstan

Context

- Long-term upstream facilities construction project.

Initial Challenges

- Frequent scope changes (unplanned feature requests).
- Significant cost overruns compared to the original budget.
- Schedule delays in major deliverables.
- Inaccurate initial estimates failing to account for local risks.



Case Study: Actions & Results

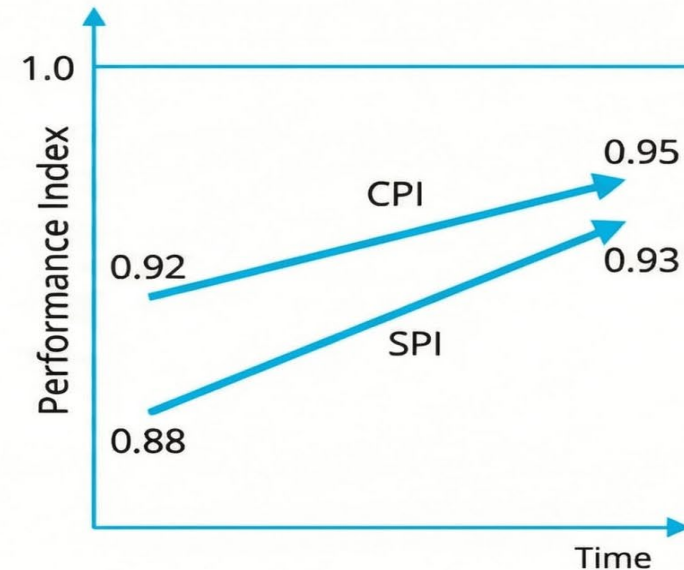
Kazakhstan Oil & Gas Project

Key Actions

- Established formal Change Control Board (CCB).
- Updated Work Breakdown Structure (WBS) to reflect approved changes.
- Managed Contingency and Management Reserves effectively.

Positive Results

- Cost Variance reduced from **-\$50,000** to **-\$15,000**.
- CPI improved from **0.92** to **0.95**.
- SPI improved from **0.88** to **0.93**.
- Unplanned change requests dropped from **60%** to **15%**.



Key Takeaways: The 11 Steps of EVM

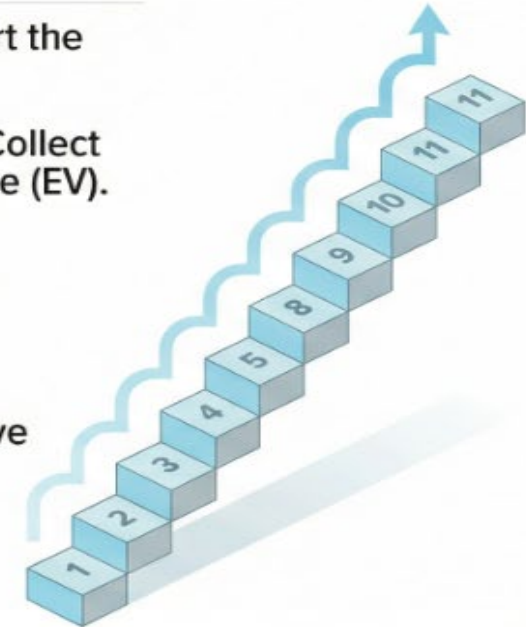
A Comprehensive Overview of Earned Value Management (ISO 21508)

PLANNING & BASELINING

1. **Deconstruct the Project:** Break down the project into manageable components (WBS).
2. **Assign Responsibility:** Allocate tasks to specific teams or individuals (OBS).
3. **Schedule the Work:** Develop a detailed project schedule.
4. **Establish the Budget:** Determine the cost for each scheduled task.
5. **Define Measurement Methods:** Select how to measure progress (e.g., milestones, percent complete).
6. **Establish the Baseline (PMB):** Finalize the Performance Measurement Baseline.

EXECUTION, ANALYSIS & CONTROL

7. **Authorize the Work:** Officially start the project tasks.
8. **Accumulate Performance Data:** Collect actual costs (AC) and earned value (EV).
9. **Analyze Variances:** Compare actuals against the baseline (CV, SV, CPI, SPI).
10. **Take Management Action:** Implement corrective or preventive measures based on analysis.
11. **Maintain the Baseline:** Manage changes through a formal Change Control Board (CCB).



Thank You