Earned Value Management and its Applications: A Case of an Oil & Gas Project in Kazakhstan[1]

Assylkhan Ziyash

Abstract

This research is performed in the study of issues in project control and progress performance evaluation. Particularly, it focuses on the progress measurement by applying the Earned Value Management (EVM). EVM is one of the widely used approaches for project monitoring and control which allows one to assess project progress through scope, schedule, and cost measurements. In order to track the progress effectively the measurements data should be provided systematically. According to the previous research studies on this subject, there are a lot of benefits that have been associated with the use of EVM in Project Management (PM).

The main purpose of this research is to assess how EVM, when applied to a real project, helps a project manager to be successful in terms of budget utilization and adherence to schedule. This study is aimed to well understanding of the actual cost expenditures versus planned costs and potential usage of EVM to compare and analyze the available data.

For the purpose of data collection, this research evaluates a project that has recently been delivered in the oil and gas industry in Kazakhstan. The study compares actual spending against planned values. It should be noted that the current project did not apply the EVM methodology while being executed. The project had significant cost increase from original budget. Lessons learned revealed that cost increase was occurred due to several circumstances: scope changes, engineering omissions, construction failures due to engineering omissions, and severe winter conditions where the baselined schedule was optimistically evaluated during the planning stage of the project. In fact, to increase the efficiency of project control, it is advisable to decompose the work activities thus monitoring and corrective actions can be applied for each activity precisely. Timely performing an analysis on cost expenditures through EVM methodology may help to increase the efficiency of budget use and possibly protect from cost overruns and schedule delays.

The study reveals that EVM brings many benefits to project managers. In particular, it was determined that EVM allows one to recognize schedule delays in a timely manner, predict cost overruns, analyze the variances of the project cost and schedule performances, as well as forecast schedule and cost outcomes. Also, the approach is helpful as it assists project managers in the tasks of mitigating risks related to scope, schedule, and cost, timely informing project

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customers on potential issues regarding project progress and performance, and implementing corrective actions as necessary.

Keywords: Earned Value Management (EVM), Project Control, Oil and Gas, Kazakhstan.

Introduction

All projects create change; many projects change lives in significant ways and, in many parts of the world, projects actually save lives. To be successful, all projects should be planned and implemented properly. The PM World Library provides information and resources for managing projects, information not always available in many places and in many organizations. Project management information and knowledge can lead to more successful projects, transforming lives and creating a better future. (PM World Journal, 2016).

1.1 Definition

The Project Management Institute's (PMI) definition of Earned Value Management (EVM) is a method for integrating scope, schedule, and resources, and for measuring project performance. It compares the planned amount of work with what was actually earned with what was actually spent. This is to determine if cost and schedule performances are as planned (PMI, 2008). EVM known as "management with the lights on", is based on the principle that past patterns and trends can indicate future conditions. EVM helps you clearly and objectively see where your project is headed compared to where it's supposed to be (PMI, Practice Standard for Earned Value Management, 2011). Kerzner (2013) stated that EVM emphasizes prevention over cures by finding and agreeing project performance and progress issues as early as possible. EVM is an early warning system allowing for early identification of trends and variances from a plan. It allows a Project Manager (PMr) sufficient time to make course corrections in small increments. It is usually easier to correct small variances as opposed to large variances. Therefore, EVM should be used periodically throughout the project to determine the variances while they are small and possibly easy to take corrective actions. Large variances are more difficult to correct, has bigger impact and they may displease management to the point where the project may be cancelled.

EVM has been used to forecast cost at completion for over four decades (De Marco et al., 2016). This objective methodology integrates project cost, schedule and scope metrics into a single measurement system. It is widely applied for measuring and analyzing project actual status against its baseline, and for providing estimates of project cost and duration at completion (Narbaev and De Marco, 2017). According to Settlemire (2016), in his research paper called "A Theoretical Approach to Traditional Project Metrics-Bridging the Gap between Earned Value and Critical Path Project Management", describes as, EVM is a commonly used method for project performance measurements. EVM focuses on monitoring and controlling project metrics aimed at efficiency and effectiveness reporting. Two commonly used metrics include Cost Performance Index (CPI) and Schedule Performance Index (SPI). CPM is used to determine the longest path of activities throughout the duration of the project. Tasks residing on this path are

"critical," as delay in these activities can result in delay to the overall project. EVM calculations do not take into full consideration the criticality of tasks that are on the critical path exclusively. Calculations do not differentiate tasks that are "critical" from those that are not. Tasks are treated uniformly and are considered equal throughout EVM calculations". EVM is a project management technique for measuring project performance and progress.

This research is to help to project practitioners to evaluate performance of the budget and actual progress-to-date use. This will help to understand if the actual cost is within the budget and the tasks are aligned with baselined schedule which are prescribed in a work breakdown structure (WBS). The term 'value' defines the work at the date of analysis that represents the amount of the control budget earned, rather than the actual cost.

The forecasting method in this research utilizes the performance data obtained through the EVM. This method can provide early prediction of final result of the project. A forecasting process should be performed in a proactive manner in order to support a project during planning and execution.

1.2 Research Purpose

The main purpose of this research is to assess how the EVM system, when applied to a real project, helps project managers to be successful in budget utilization and schedule performance. The data obtained in this research can be compared with other similar projects. The proposed methodology can be used to improve the future project execution and therefore meet stakeholder's expectations.

1.3 Research Objectives

This research should enable practitioners who have not yet practiced the EVM methodology in various performance data analysis. According to Narbaev's research (2015), many companies in Kazakhstan have not been practicing the EVM methodology. This is caused by lack of requirements in performance data analysis and PM organizational capabilities. The EVM method requires measuring the data on execution phase of the project that includes engineering and construction activities. Especially during construction activities, monthly data analysis will enable to timely act on some delays or overspending. Specific industry requirements, with combination of complicated logistic arrangements, the projects in the Kazakhstanis oil and gas sector can have comparatively high execution cost. Cost of execution, especially if contractor has been asked to complete in optimistic timeframe, may increase the project cost significantly. Thereby the cost performance becomes a second priority giving the schedule requirements being performed at first.

Many of project managers are facing challenges in projects. It can be a poor performance in monitor and control of the project and lack of organizational capability. Accurate performance indicators like cost and schedule performances are critical to support decision making and predictable projects' results. According to recommended practices of Association for the Advancement of Cost Engineering (AACE, 2016), a proper application of EVM

processes and tools in each phase of the project increases the likelihood that the projects will achieve their cost and budget commitments and therefore enhance stakeholder's credibility.

1.4 Background Research

Department of Defense (DoD) EVMS (EVM System) Interpretation Guide defines the EVM as, a widely accepted industry best practice for program management that is used across the DoD, the Federal government, and the commercial sector. Government and industry program managers use EVM as a program management tool to provide joint situational awareness of program status and to assess the cost, schedule, and technical performance of programs for proactive course correction. EVMS is the management control system that integrates program's work scope, schedule, and cost parameters for optimum program planning and control. To be useful as program management tool, program managers must incorporate EVM into their acquisition decision-making processes; the EVM performance data generated by the EVMS must be timely, accurate, reliable, and auditable; and the EVMS must be implemented in a disciplined manner consistent with the 32 EVMS Guidelines prescribed in Section 2 of the Electronic Industries Alliance Standard-748 EVMS (EIA-748) (Reference (a)), hereafter referred to as "the 32 Guidelines.

According to Performance Assessments and Root Cause Analyses (PARCA) EVM division in the Office of the Assistant Secretary of Defense for Acquisition, EVM is one of DoD's and industry's most powerful program planning and management tools. The purpose of EVM is to ensure sound planning and resourcing of all tasks required for contract performance. It promotes an environment where contract execution data is shared between project personnel and government oversight staff and in which emerging problems are identified, pinpointed, and acted upon as early as possible. EVM provides a disciplined, structured, objective, and quantitative method to integrate technical work scope, cost, and schedule objectives into a single cohesive contract baseline plan called a Performance Measurement Baseline for tracking contract performance.

According to Narbaev's research on identification of maturity level of Kazakhstani's organizations (Narbaev, 2015a, 2015b), the majority of Kazakhstani companies are facing significant problems in projects while performing them. Narbaev says, that based on the results of the PjM3 questionnaire with the mean maturity level of 2.42 out of 5, the study found out that PM tools and methods have not yet been used effectively in Kazakhstan. PMM in Kazakhstani organizations is gradually moving from Level 2 to Level 3. This shows that the organizations ensure that each project is run with its own processes and procedures to a minimum specified management standard set in the organizations. However, he has also indicated that there was limited consistency or coordination between different projects. Finally, the findings suggested that, as the maturity moves to Level 3, the organizations strived for having their own centrally controlled PM processes where all their individual projects would flex. All in all, the findings of the study add value to the existing PM body of knowledge in Kazakhstan and are background asset to be used in facilitating the 'projectification' of organizations in Kazakhstan.

Accurate performance indicators like cost and schedule performances are critical to support decision making and predictable projects' results. According to Guideline 7 of the ANSI/EIA-748 standard, objective indicators enable to measure the actual physical work allowing accurate comparison with planned work. Meaningful performance metrics enable better management insight and decision-making, ensuring that maximum time is allowed for management action to keep the project on plan. EVM practitioners should understand that if effectively use and treat the performance data the project products and outcomes will be achieved.

Besner and Hobbs (2006) in their research paper which is called "The Perceived Value and Potential Contribution of Project Management Practices to Project Success", says that there is a lack of use the EVM though being intensely studied.

According to Turner (2009), the EVM has currently become a key, recognized technique for PMr. Many practitioners are recommending as a powerful tool. The Figure 1 below, shows an overview of the full technique of EVM analysis.

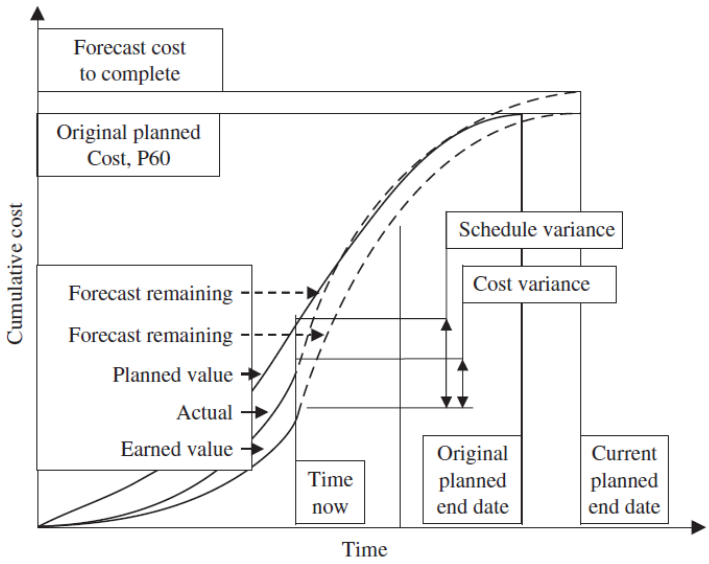

Figure 1 – An Example of EVM analysis (Turner, 2009)

In fact, the comparison of PV and AC tells PMr nothing. If AC is less than PV we do not know if that is because the work is underspent, or lack in schedule. In fact, one of the most misleading things is when the work is well behind schedule and overspent, but you are calmed into thinking it is underspent. For this reason, we also need to monitor how much work has already been done. We do this by calculating the value earned, that is the estimated cost of the work that has been done for the money spent to date (Turner, 2009).

Naderpour (2011) identified that, project control tools are commonly used in the construction industry. Unfortunately, many projects run over budget and behind schedule, which suggests that there is something wrong in our project control system. EVM is project control

technique that provides quantitative measure of work performance. It is considered the most advanced technique for integration of schedule and cost.

Vandevoorde (2006) published a research paper called "A comparison of different project duration forecasting methods using earned value metrics". and defined as, earned value project management is a well-known management system that integrates cost, schedule and technical performance. It allows the calculation of cost and schedule variances and performance indices and forecasts of project cost and schedule duration. The EV method provides early indications of project performance to highlight the need for eventual corrective action. EVM was originally developed for cost management and has not widely been used for forecasting project duration. However, recent research trends show an increase of interest to use performance indicators for predicting total project duration.

The research that was conducted by KPMG in India (KPMG, 2013), explains the problem with project schedule and cost overruns is in criticality of addressing the highly skilled professionals. The survey suggests that there is a dearth of manpower across categories; however, non-availability of highly-skilled professionals can have an adverse impact on the project delivery and cost. Dearth of skilled PMr has the greatest influence on project delivery. Shortage of skilled PMr emerges as the root cause for time and cost overruns in the project lifecycle. It has been observed that the inflow of talent in the infrastructure sector has been declining – as resources are going for alternative, more lucrative options. This concern is felt across various stages of project lifecycle.

Per the AACE (2014), the methodology is highly important to use and practical to achieve the results if recommendations are followed. The strengths of an EVM are that it integrates cost and schedule performance assessment of variances from plans while being objective and quantitative. However, the method in itself does not explain why the performance is what it is, nor how performance can be improved. It simply waves a red flag when there are problem areas that need further assessment, or when positive performance needs to be assessed for potential reduction in project costs and/or early completion. Hollman (2012) Total Cost Management Framework.

Solanki (2009), in EVM book defines that it is very important to recognize that EVMS requirements should be implemented to provide the management information needed by program management for effective management of the contract or project. In addition, it is important to recognize that no single EVMS application can meet every management need for performance measurement due to variations in organizations, products, processes, and working relationships.

Giammalvo (2013), in his research paper published in PM World Library, concludes that EVM, applied in a "common sense" manner, can provide us with a way to measure and manage those projects in a way that should ensure that the project is "successful"- on time, within budget, in substantial conformance to the technical and contractual requirements. And if used appropriately, EVM affords us a great tool to identify problems when there is still time to fix

them and if the problems are not fixed, then EVM provides a great audit trail to identify those who should be held legally and financially accountable for the failure.

Methodology

This research is based on quantitative study applied to real data from the historical project which was implemented to deliver portion of an oil and gas plant. The purpose of this research to assess how EVM, when applied to a real project, help a PMr to be successful in terms of budget utilization and meet the deadlines. The company which provided the data desires to keep anonymity in this research. This study is aimed to well understanding of the actual cost expenditures versus planned costs and potential usage of EVM to compare and analyze the available data.

With the purpose of accomplishment of the project control exercise, it is important to define the elements of scope of work into Work Breakdown Structure (WBS). According to PMBoK, WBS is the process of subdividing of project deliverables and project work into smaller, more manageable components. On the other side for incorporation of data, it is mandatory to identify the organizations of the project for establishment of Organizational Breakdown Structure (OBS), which distributes the roles and responsibilities of each organization within Company.

Following identification of the deliverables and decomposition of the scope of work, normal practice when PMr together with project team develop WBS. Decomposition break down on an agreed scope into elements for which work can be planned and controlled in proper way. Each element of the WBS should be performed separately, finally resulting the whole asset. Once completed the WBS, it is important to assign responsible party who will be controlling an execution of deliverables. An OBS should identify by whom the elements of the WBS will be delivered, allowing for PMr to control the resource availability.

Furthermore, combination of the above two structures – WBS and OBS – will deliver another control document that required within EVMS such as a Responsibility Assignment Matrix (RAM). With reference to John K. Hollmann (2012), RAM is the intersection of WBS and OBS, which brings up the level, where budget and schedule are measured with its own responsible and scope of work. This level is named as Control Account, refer to Figure 2.

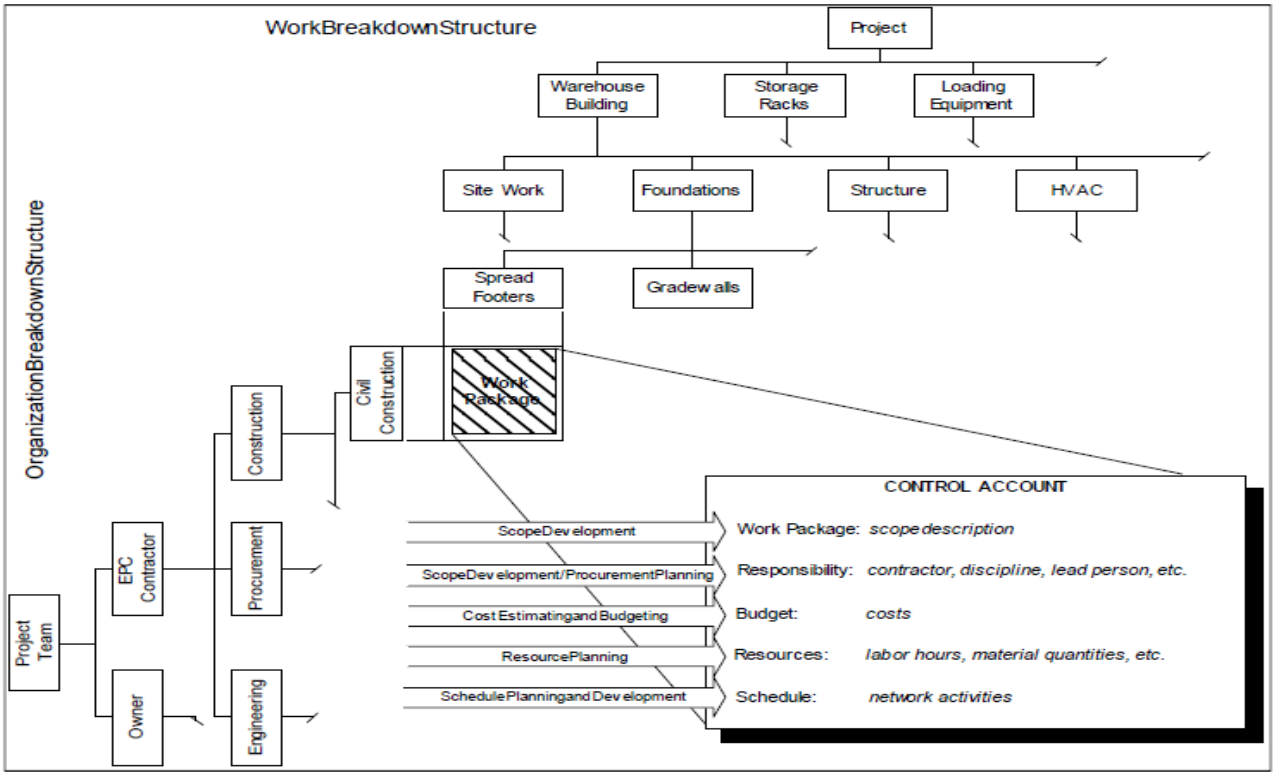

Figure 2 – Example of WBS and OBS relationship (Hollman, TCM, 2012)

The EVM method implies that control accounts' values are summed to the total value for the project. The percent progress of any sub-tasks of the WBS, at any point in time, is then the sum of the value of each control value in that WBS sub-task that has been earned at that time, divided by the total value of that sub-task of the WBS. The earned value for each control is the value multiplied by the earned work measured by EVM techniques of the scope.

Project performance measurement is the process of measuring the expenditure or physical work status on a project and the degree of completion or status of project work packages or deliverables, as well as monitoring of how work is being accomplished. Together with project cost measures of the commitment and expenditure, project performance measures are the basis for project performance assessment. Fleming and Koppelman (2000). For this purpose, it is important that estimate and schedule are well enough developed.

The opportunity is to improve the processes on how the critical data should be selected, turn it into valuable information, and use it to improve project performance and its achievement.

According to AACE TCM Framework, the progress and performance measurement is the process of measuring the expenditure or status of nonmonetary resources on a project (e.g., tracking the receipt of materials or consumption of labor hours) and the degree of completion or status of project work packages or deliverables (e.g., the extent that materials have been installed, deliverables completed, or milestones achieved), as well as observations of how work is being performed (e.g., work sampling). Together with project cost accounting measures of the

commitment and expenditure of money, progress and performance measures are the basis for project performance assessment.

PMr receives various cost and schedule reports on a monthly basis to help to identify the accurate project progress measurements. The table below provides the list of data sources used to accomplish correctly progress measurement within EVM requirements:

PV	Planned Value
EV	Earned Value
AC	Actual Costs
BAC	Budget at Completion

Based on above data available within each project, the following measurement indices should be provided while executing the project, AACE:

Cost Variance (CV)	EV – AC
Schedule Variance (SV)	EV – PV
Variance at Complete (VAR)	BAC – EAC
Cost Performance Index (CPI)	EV / AC
Schedule Performance Index (SPI)	PV/ EV
Estimate at Completion (EAC)	AC+(BAC-EV)/CPI
Estimate to Complete (ETC)	EAC – AC

CPI – The ratio of EV to AC (CPI = EV/AC); often used to predict magnitude of a possible cost overrun by dividing it into the original cost estimate (original cost estimate/CPI = projected cost at completion), with a:

- CPI greater than 1.0, the project is under the control budget.
- CPI less than 1.0, the project is over the control budget.
- CPI equal to 1.0, the project is exactly on the control budget.

SPI – Ratio of work performed (EV) to work scheduled (PV). SPI = EV/PV, with a:

- SPI greater than 1.0, the project is ahead of schedule.
- SPI less than 1.0, the project is behind schedule.
- SPI equal to 1.0, the project is on schedule.

Variance analysis such as schedule variance will give insight into detail for both ahead of and behind scheduled work baseline and its trend can provide useful indication of current

performance and future projection. Whereas cost variance is a measure of both over and under cost position for work accomplished relative to budget baseline. In addition to both variances, it is also important to analyze the variance at completion, which periodically assesses remaining requirements and maintain a most likely estimate of cost and schedule to complete project objectives. John K. Hollmann (2012).

Application to a Case Project

The research shows the difference in application of performance measurements. The historical project is analyzed with the aim to find the ways how and where the corrective actions had to be taken to reach the completion within the budget and schedule.

The past example of capital project from the oil and gas industry has been evaluated to conduct the case study and identify the methodology approach for the performance measurement. The project is to construct the storage reservoir at the oil and gas plant. The project was estimated to complete within 48 months. The initial budget for this project was estimated as 53mln US Dollars. The scope of this project is to provide additional capacity for two interrelated tank systems – off-spec crude and sour water handling. The preferred alternative to accomplish this is to construct true 'duplicate' tanks nearly co-located with the existing tanks. The new tank will have a nominal capacity of 10,000 m3. The new tank is built within international standards as the existing tank. The tank will tie-in with the suction piping on the existing pumps. The tank will be internally and externally coated with an appropriate coating system. All associated civil works, mechanical piping works, and electrical and instrumentation are included in the work scope. A dedicated flaring system, firefighting, other ancillary systems including utilities, fire protection, and cathodic protection are also included in the tank work scope.

The figure 3 below shows the completed tank. The construction was performed with involvement of international experienced subject matter expertise (SME), who deliver such kind of deliverables on constant basis. Each subgroup was responsible for their parts. Construction manager was responsible for the total construction progress. The vendor to manufacture the tank, and assist on assembling on site. Third party inspectors are responsible for quality checks and Factory Acceptance Tests (FAT) on vendor's facility.

Figure 3 – Photo of the case study project

The figure 4 below shows the project layout of the construction area. The circle in the center of the picture is a new tank. To match to national and technical organizational standards and requirements, and meet stakeholder's expectations, highly experienced SMEs were hired to complete engineering. Engineering third party was engaged in this work, and were responsible to obtain all necessary State conclusions and permissions.

The other facilities which may not be visible on this layout, include the underground utilities, fire & gas system, access road construction. The boundary of the area is to prevent the liquid from being spilled around. These are the items that sum to the total cost, and may cause a delay of project completion if any issues.

This scope has been divided into disciplines, civil/structural, mechanical/piping, electrical, and instrument work packages. Each discipline is assigned by individual SME group. Separate work packages are controlled and responsible by those SME groups.

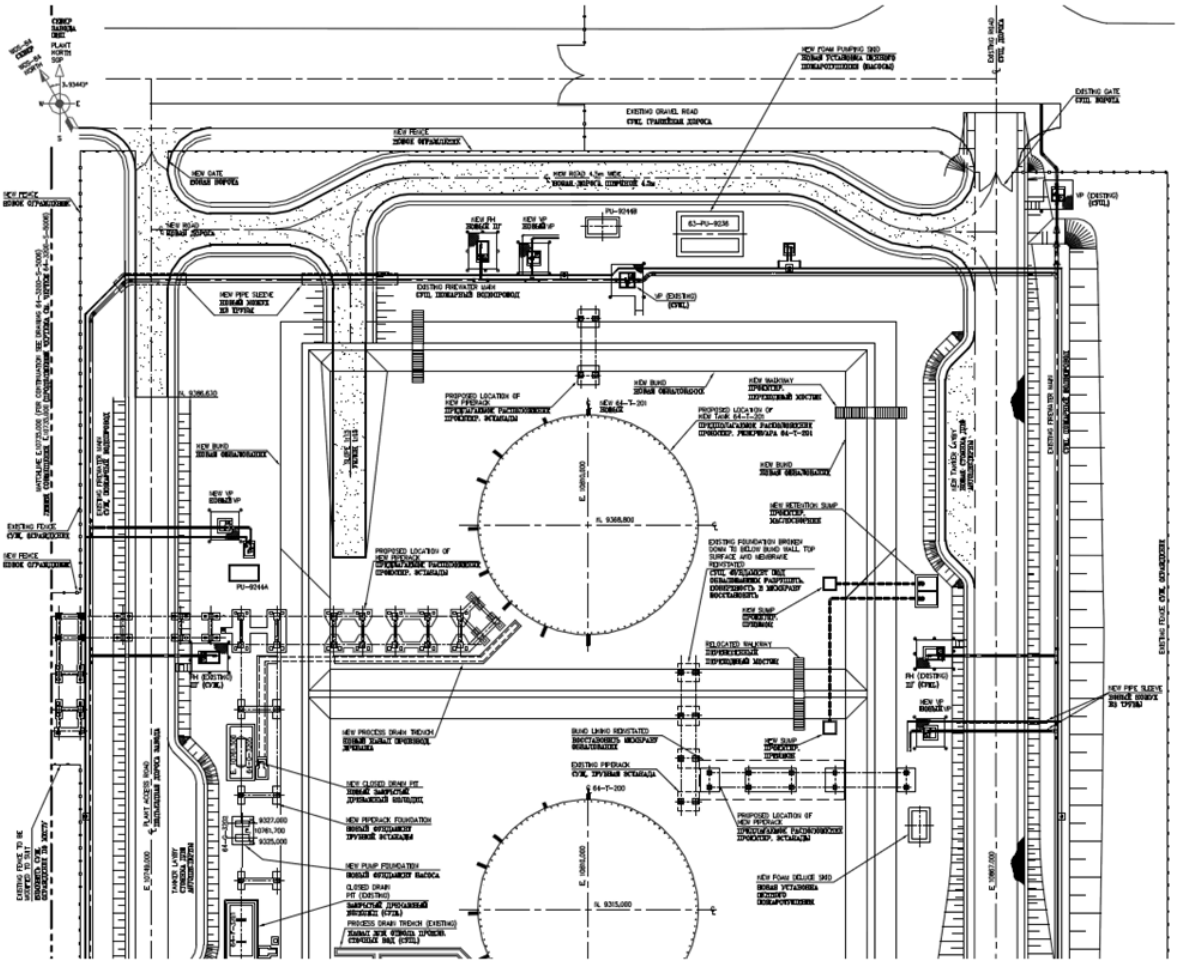

Figure 4 – Project Layout

The cost of construction of additional facility is comparatively small to the construction of the main tank. The plot plan provided above as an example of out of other hundreds project drawing and document deliverables.

Results, Analysis, and Findings

The original baseline schedule was estimated to complete within 4 years. The project utilized the traditional approach to complete the project thru the phases. Phase 1 includes identification of the problem, formalization of the issue, and preparation of framing document. Phase 2 considers development of feasibility study, and selection of the best economically effective alternative. Phase 3 is to develop and complete FEED with detailed engineering. In phase 4 execution of construction works, followed by commissioning and start-up. Each phase includes updates of cost estimate and schedule, when more information is available.

The figure 5 below shows the standard approach for managing projects in 5 phases.

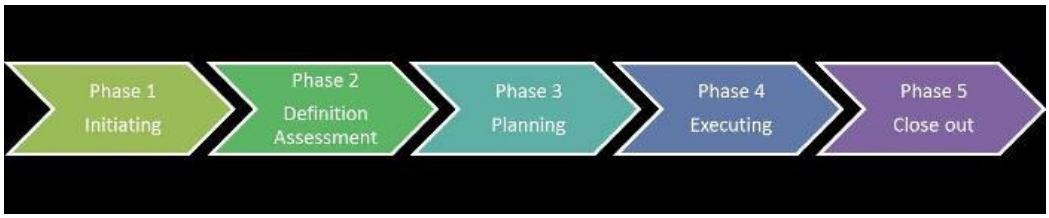

Figure 5 – 5 Phases of the Project

During the Phase 2 of the project, the cost estimate was prepared to complete the full project. The graph in Figure 6 below shows time-phased budget plan against which performance should be measured, S-curve also called as Performance Measurement Baseline (PMB).

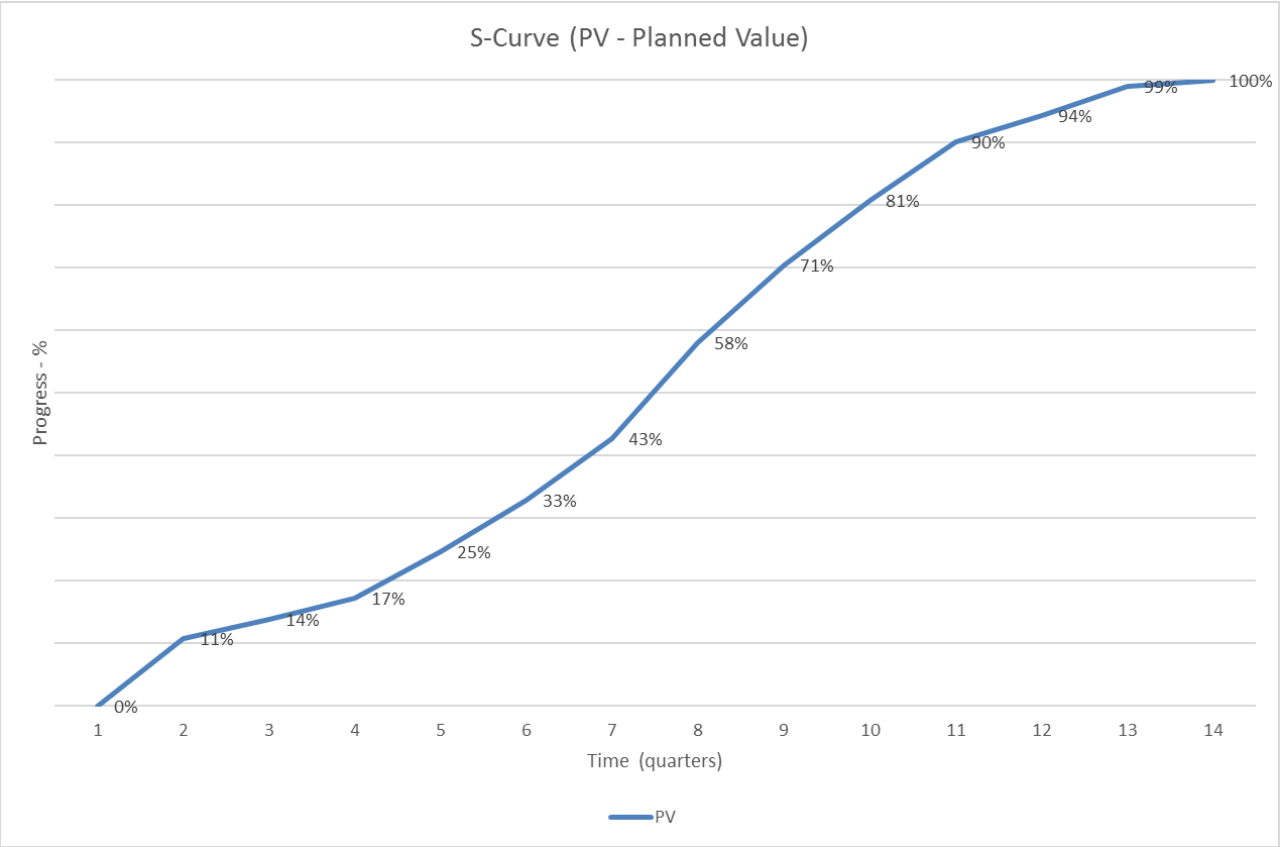

Figure 6 - S-Curve of the project - Planned Value (PV)

The tables below show the cycle of the planned value (PV) spread during the execution timeframe. This is an important part of the EVM. The sum of time-phased PV will determine the total BAC of Project. Comparing work accomplishment against baseline plan provides a measure of work status and basis for verifying the work to be done in order to accomplish the project requirements, including technical, cost, and schedule objectives.

The below tables 1 and 2 are data taken within existing sample project for the case study:

Table 1 – Progress measurements for 2011-2013 (Part 1)

Month /Periods	0	1	2	3	4	5	6	7	8	9	10
Year	**2011**			**2012**				**2013**			
PV	0	5,772	7,376	9,194	13,149	17,586	22,824	31,002	37,684	43,189	48,160
%	0	10.8	13.8	17.2	24.6	32.9	42.7	58.0	70.5	80.8	90.1
AC	0	296	1,267	2,310	4,586	7,858	19,518	26,397	31,903	39,741	50,245
%	0	0.55	2.37	4.32	8.58	14.70	36.51	49.38	59.69	74.35	94.00
EV	0	5,506	7,109	9,514	14,165	16,837	19,457	22,717	25,657	28,650	34,263
%	0	10.3	13	17	26.5	31.5	36.4	42.5	48	53.6	64.1
Contingency reserve	0	6,931	6,931	6,931	6,931	6,931	6,931	6,931	6,931	6,931	6,931

During collection of above data sources, the time-phased period has been taken as 6 years with subdivision by quarters. The total BAC is $53mln. The project was planned to be completed in Q3 of 2014. The actual completion has taken place only in Q2 of year 2016. The total AC of the project at the end is equal to $69mln. Contingency reserve was available from the start of project until end of year 2013 and remained at the same value. The full usage of contingency reserve occurred in Q1 of year 2014.

Table 2 - Progress measurements for 2014-2016 (Part 2)

Month /Periods	11	12	13	14	15	16	17	18	19	20
Year	**2014**				**2015**				**2016**	
PV	50,459	52,917	53,452	53,452	53,452	53,452	53,452	53,452	53,452	53,452
%	94	99	100	100	100	100	100	100	100	100
AC	56,055	59,116	62,559	64,031	65,595	66,593	67,734	68,426	68,798	69,005
%	104.87	110.60	117.04	119.79	122.72	124.59	126.72	128.01	128.71	129.10
EV	41,158	45,434	50,245	50,779	51,314	52,383	52,383	52,917	52,917	53,452
%	77.00	85.00	94.00	95.00	96.00	98.00	98.00	99.00	99.00	100.00
Contingency reserve	0	1,061	1,061	0	0	0	0	0	0	0

Based on the above data, the following progress measurements shown in tables 3 and 4 had been held in order to analyze the project from different prospective. Each indicator has been measured quarterly, however it is important for PMr for better control, these data should be available and taken for analysis on the monthly basis.

Table 3 - Performance indicators for 2011-2013 (Part 1)

Month /Periods	0	1	2	3	4	5	6	7	8	9	10
Year	**2011**			**2012**				**2013**			
CV	-	5,210	5,842	7,204	9,578	8,979	-61	-3,680	-6,246	-11,090	-15,983
CPI	-	18.61	5.61	4.12	3.09	2.14	1.00	0.86	0.80	0.72	0.68
SV	-	-267	-267	321	1,016	-748	-3,367	-8,285	-12,027	-14,539	-13,898
SPI	-	0.95	0.96	1.03	1.08	0.96	0.85	0.73	0.68	0.66	0.71
EAC	-	2,872	9,527	12,979	17,307	24,946	53,621	62,110	66,465	74,143	78,386
VAC	-	50,580	43,925	40,473	36,145	28,506	-169	-8,658	-13,013	-20,691	-24,934
%	-	106	122	132	148	188	-31661	-617	-411	-258	-214
TEAC (year)	-	4.19	4.15	3.87	3.71	4.18	4.69	5.46	5.88	6.03	5.62
Time overrun	-	-0.19	-0.15	0.13	0.29	-0.18	-0.69	-1.46	-1.88	-2.03	-1.62

Looking at the above tables, the attention can be pointed at various sides of the progress measurements through overall lifecycle of the project. Based on formulas indicated in section 1.4, the above calculated cost variance has been increased from the beginning of year 2013, while CPI has been in the range from 0.86 to 0.68 until re-evaluation of budget, that had taken place in the last quarters of year 2014. Thus, it brought CPI equal to 0.80.

As per norms and standards of EVMS, EIA-748, CPI value equal to 1 or more than 1 explains that project is within or under budget. The CPI equal to less than 1 coefficient is the alert where project will require its attention and detailed analysis to avoid the future overrun in the budget. The CPI has been changed in period Q1 2014, due to the usage of contingency reserve to cover over-spends of total budget that had occurred already in 2013.

AACE International has defined contingency as an amount included to estimate to allow for cost items, conditions, or events for which the state, occurrence, or result is uncertain and that experience shows will likely result, in aggregate, in additional costs. Typically estimated using statistical analysis or judgment based on past asset or project experience.

Table 4 - Performance indicators for 2014-2016 (Part 2)

Month /Periods	11	12	13	14	15	16	17	18	19	20
Year	**2014**				**2015**				**2016**	
CV	-14,897	-13,682	-12,314	-13,251	-14,281	-14,210	-15,352	-15,509	-15,880	-15,553
CPI	0.73	0.77	0.80	0.79	0.78	0.79	0.77	0.77	0.77	0.77
SV	-9,301	-7,483	-3,207	-2,673	-2,138	-1,069	-1,069	-535	-535	-
SPI	0.82	0.86	0.94	0.95	0.96	0.98	0.98	0.99	0.99	1.00
EAC	72,799	69,549	66,552	67,401	68,328	67,952	69,117	69,117	69,493	69,005
VAC	-19,347	-16,097	-13,100	-13,949	-14,876	-14,500	-15,665	-15,665	-16,041	-15,553
%	-276%	-332%	-408%	-383%	-359%	-369%	-341%	-341%	-333%	-344%
TEAC (year)	4.90	4.66	4.26	4.21	4.17	4.08	4.08	4.04	4.04	4.00
Time overrun	-0.90	-0.66	-0.26	-0.21	-0.17	-0.08	-0.08	-0.04	-0.04	-

As per schedule wise, based on calculated SV and SPI data, analysis shows that project has been completed with certain delay. The baseline completion was scheduled to complete in Q3 of 2014, whereas the actual completion was in Q2 of 2016, which shows the delay of 1.5 year. Using EVM progress measurement, the alert of delay which would have caused the overall delay of project can be seen during periods of year 2013, where SPI has dropped to 0.66. This change as mentioned earlier could happen due to several circumstances, severe weather conditions (+40/-40°C), minor scope changes that led to "scope creep", and lack of engineering resources.

To get into alignment with original baseline schedule, the corrective action should involve scrutiny review of the work tasks which are on critical path(s). The delay of 34% could be compensated by increase of additional manhours required in specific areas where delay causes the overall project and float is equal to 0.

The PMr is responsible for evaluating the amount of resources which are required to complete the work task. The evaluation of the Estimate to Complete (ETC) for every ongoing work task and update it monthly. The monthly review is for re-evaluation of the ETC which is based upon the remaining work that should be completed. During the review the PMr should consider the material commitments with its availability in the warehouse, and future estimates for labor and non-labor resources.

The AC on the original finish date of the project shows that additional budget will be required to complete the project. If EVM methodology would be applied on this project, on the period Q4 2013, EAC would have been calculated as 78mln USD, based on the trend of AC

values shown on the table 3. The formula for EAC calculation, EAC=AC+(BAC-EV)/CPI, has been used for calculation of the supplement required considering index for cost performance on previous periods. This clearly shows that in the middle of the project the available budget would not be enough for project completion. It has been determined that supplement of 23mln USD should be requested.

Considering the calculation of variance at completion, the final period shows that 15mln USD is overspent. This is a key message that should be delivered to the client and internal project management team. Based on this information the budget should be adjusted to complete the project on time. The graph below shows the PV, AC, and EV of the project.

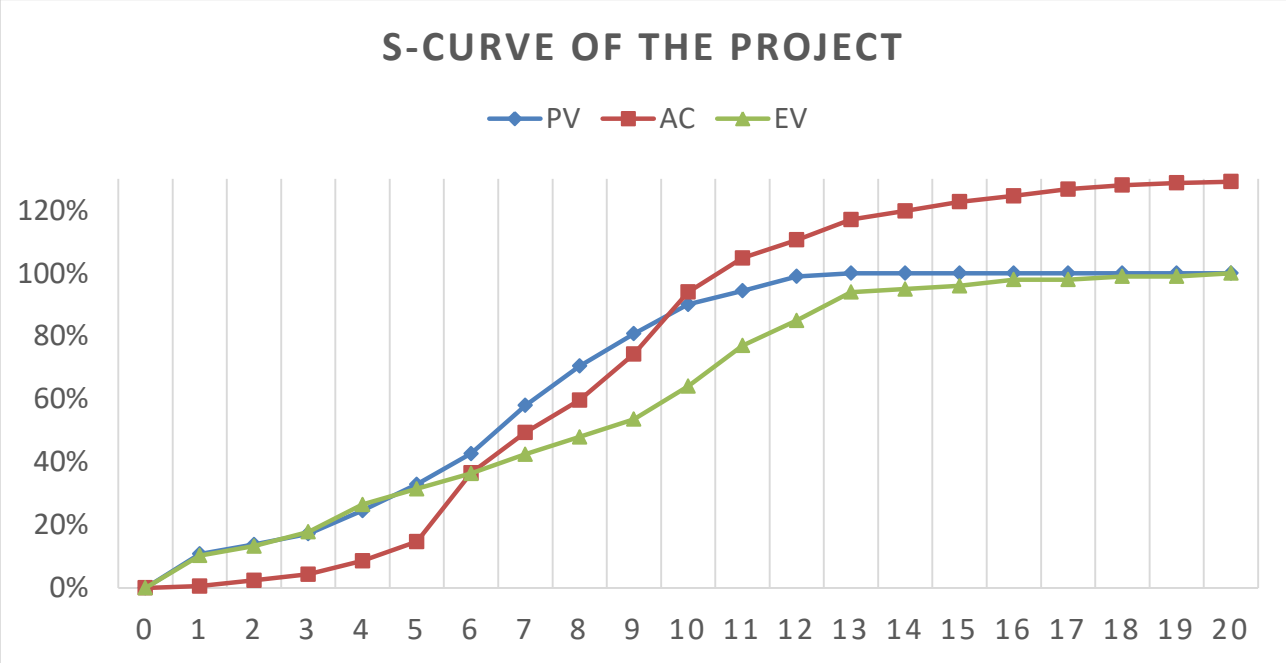

Figure 7 – S-curves (PV, EV, AC)

The figure 7 above shows how the works are being earned against planned. It can be seen, that effort of work performance at the first half is low compared to planned, due to late construction works start. From the effort shown the conclusion can be made towards that engineering was completed with significant delay, subsequently caused delay in construction start date, thus resulting in the shift of the start-up date.

According to Turner (2009), comparing two parameters of progress measures like EV and PV, tells us that on average the project is ahead or behind schedule. Only on average, the progress on critical path tells us how the project is being performed, which will determine the duration of the project.

The data taken from the above figure, would allow us to calculate further parameters to indicate the project performance: cost performance index (CPI); schedule performance index (SPI); cost variance (CV); and schedule variance (SV). When CPI is less than one, then the

project is overspending, and when the SPI is less than one then the project is delaying. Turner (2009). The Figure 8 below shows the cost and schedule performance indexes.

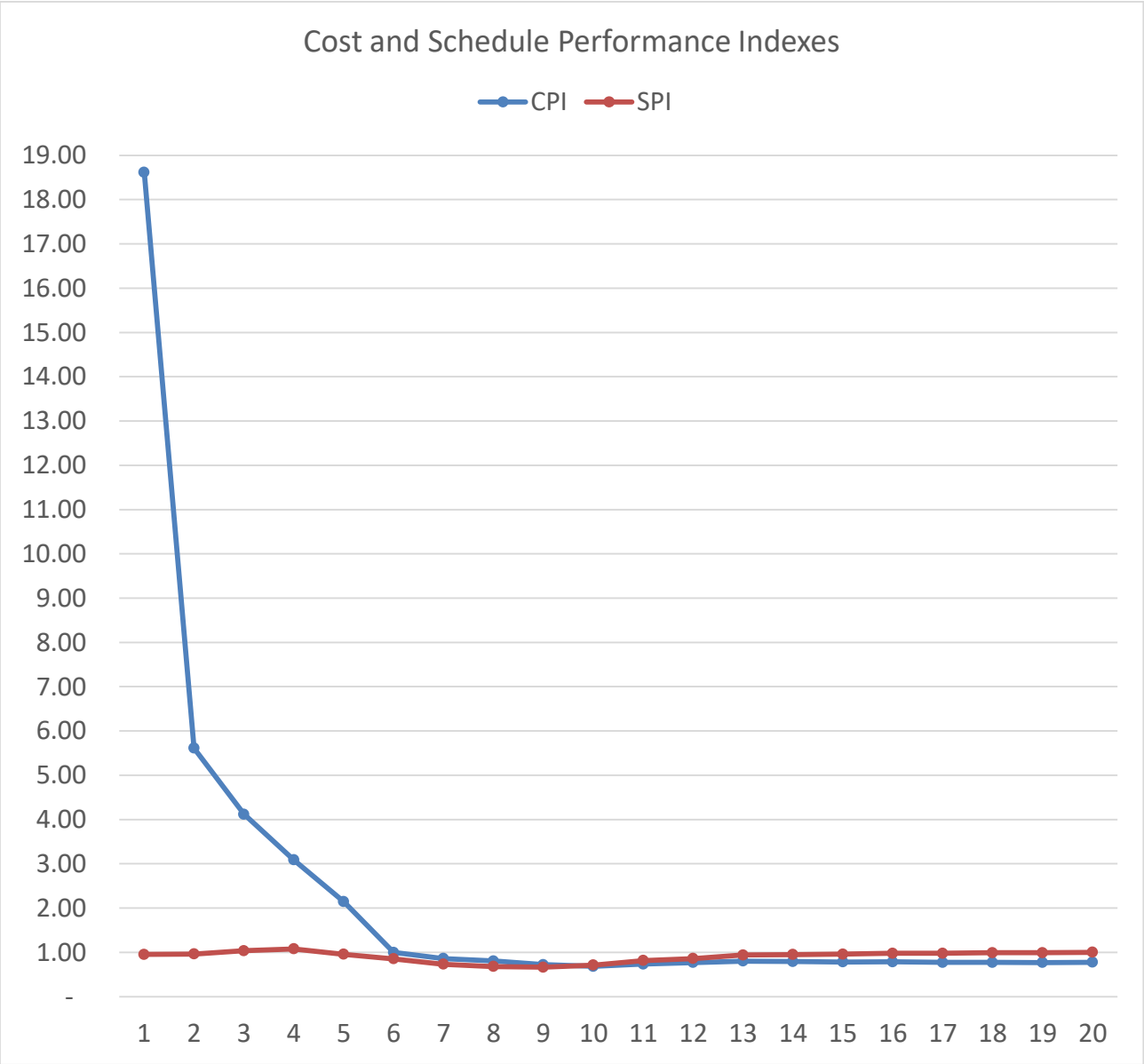

Figure 8 – Cost and schedule performance indexes

From the figure 9, it can be observed that at the beginning of the project, the cost expenditures were highly earned. The schedule performance was at normal range for first five quarters, SPI near 1. Starting from the quarter 6 the CPI and SPI starts moving towards below 1. This can be explained that the project started performing with schedule delays. On quarter 10 the positive movement can be observed with construction start, but still not enough to reach index 1.

EVM method requires measuring the data on execution phase of the project that include engineering and construction activities. Especially during construction activities, the monthly data analysis will enable to timely act on some delays or overspending of the requirement.

During the periodic analysis, the cost and schedule reviews should reflect work package accomplishment provided by PMr. The cost and schedule reports should contain all necessary cost and schedule performance data in order to allow PMr to analyze the work package level.

PMr may ensure cost and schedule components of the control items (work packages). It is important to ensure that AC is not accumulated without EV and BAC for the work. From the example provided it can be seen that AC in every year exceeds the PV, hence the EV is less. By timely identification of such discrepancies of the work performed, the PMr should act accordingly to address the issue in order to take corrective actions and thus ensure the project is back on cost and schedule baseline.

Together with the development of the WBS, the planning process includes the master schedule preparation. This master schedule then should be baselined, according to which the work progress should be measured and compared. The master schedule should include the milestone dates, and start and finish date for every deliverable and work package.

The budget is an amount of the total allocated monetary resources. The budget should be identified for each element of the WBS and OBS elements. This will ensure the complete monitoring of the expenditures against each cost element.

The initial engineering and construction schedule was defined to complete the works in four years. However, during the execution some change occurred in which resulted the schedule extension for another one year. Therefore, it has resulted in 30% of budget increase.

This is a complex scope of work which had included all engineering disciplines. Construction in several years had considered the severe winter conditions and simultaneous operations in one area. The operating plant in vicinity to the construction area also creates additional risks, such as loss of containment, hazardous gases release, and subsequently time for evacuation of the personnel to a safe location if necessary.

Conclusion

The findings of this study demonstrate that EVM is an effective methodology for project control. The EVM principles reveal that there is a significant potential for tracking the performance and progress of project and for providing forecasts of schedule and cost outcomes. The correct data and timely collection of the performance progress are critical for decision making and project execution. It is also important that the reliable data is reflected in the estimate and Schedule. PMr together with cost control should regularly check that the basis of performance assessment is correct and in alignment to agreed cost and schedule plans.

The key practice of EVM includes two steps: first, establishing a PMB and, second, measuring and analyzing project's performance against the baseline. Steps to effectively build a PMB include decomposition of work scope to a manageable level, assigning responsibilities, developing a time-phased budget for each work task, and maintaining the baseline integrity throughout the project execution (NDIA, ANSI/EIA-748-C Intent Guide, 2014). Performance

measurement and analysis comprises recording resource usage during the project execution, objectively measuring the actual physical work progress, analyzing and forecasting cost performance and schedule progress, reporting performance problems, and taking corrective actions (PMI, 2011).

It is also recommended that EVM practical tools and competencies are integrated into organizational process. The key progress measurement should be timely obtained and provided to PMr, which should be accurate and reliable. EVMS should be used in a manner consistent with the 32 Guidelines contained in the EIA-748.

This research has utilized one example taken from oil and gas processing plant located in Kazakhstan. The project has been recently completed without injuries and days away from work. The safety targets achieved the planned values. This project can be considered as successful project, despite some cost overruns and schedule delays. For such oil and gas projects, it is important that quality and safety are not compromised, as safe operations ensure overall stability of the plant production and subsequently delivery of final products to the market.

Considering the abovementioned analysis, the project faced cost overrun and schedule delay which were found based on applied EVM methodology and progress measurement. Taking into account the data calculated with EV formulas, the calculated cost variance has been increased from the beginning of project, while CPI is below 1 until re-evaluation of budget, that had taken place in the last quarters of year 2014. Thus, later it brought CPI to be increased. According to the norms and standards of EVMS, Earned Value Management Systems, EIA-748, CPI value equal to 1 or more than 1 explains that project is within or under budget. The CPI equal to less than 1 coefficient is the alert where project will require its attention and detailed analysis in order to avoid the future overrun in the budget. The CPI has been changed in period Q1 2014, due to the usage of contingency reserve to cover over-spends of total budget that had already occurred in 2013.

In fact, we should also pay attention to the amount of contingency reserve. Any risks associated with execution of the work, should be evaluated and quantified, and be included identifiable contingency cost in the estimates. More accurate and detailed technical data ensures solid cost estimation.

The responsibility of PMr includes and not limited to control cost and schedule progress. The PMr should ensure that AC is not accumulated without EV and BAC for the work. From the historical example provided it can be seen that the AC in every year exceeds the PV, hence the EV is less. By timely identification of such discrepancies of the work performed, the PMr should act accordingly to address them and take corrective actions. Based on above value of the data, it is highly recommended to all organizations to integrate into the project control framework the EVM methodology.

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About the Author

Assylkhan Ziyash

Almaty, Kazakhstan

Assylkhan Ziyash is a Kazakhstan based Project Manager working in the oil and gas industry. He holds a Master's of Science degree in Supply Chain and Project Management from the Kazakh-British Technical University. He has been working in Project Management field for over 6 years, managing the complex multidiscipline projects in the oil and gas plants.

Assylkhan can be contacted through email: assylkhanz@gmail.com or LinkedIn