The Earned Value Management - A Measurement Technique of the Performance of the Costs and Labor in the Project

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Abstract: Most of the planned projects have problems due to the cost and time overruns from different reasons. Earned value management (EVM) is a project performance evaluation technique that has been used in many projects from several fields, but which has been adapted to be used in project management to objectively track the physical accomplishment of certain work. The earned value analysis offers the possibility to manage the project performances in early stages of the project to point out the need of the eventual corrective action. This paper aims to present the main parameters involved in the calculation of the Earned Value Analysis (EVA) for a ballast plant on shipboard.

Keywords: Earned Value Management; Earned Value Analysis; Cost Variance; Schedule Variance; Planned Value

JEL Classification:

1. Introduction

An important tool required to deliver the project on time is Earned Value Management (EVM).

Earned Value Management is a project management methodology for control the project that is based on measuring work performance. It is a system that predicts the final cost and duration of the project by comparing the work done with that planned. In the same time, EVM is a warning tool, based on which the project manager identifies and controls any problem before it becomes critical, being able to exploit the project opportunities (Eun Hong et all, 2003, p. 375).

The concept of earned value management has been first introduced as a fundamental approach in 1966 when the United States Air Force mandated earned value in

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relationship with the other planning and controlling requirements on Air Force programs (Abba, 1997, p. 58).

Regardless the field where this concept is applied, either in research and development projects, or engineering, construction and contract administration companies as well as large design-manufacturers such as aerospace companies, it provides all levels of management with early visibility on cost and schedule problems.

Nowadays EVM is used in programs from world-wide. It becames a requirement of many U.S. Government agencies, including the Department of Defense, the National Aeronautics and Space Administration, the Department of Energy, the Intelligence Community, the Department of Homeland Security, the Federal Aviation Administration and Department of Transportation, Health and Human Services, and others (Abba, 2000).

This concept and its requirements have remained basically unchanged, although some updates have been done regarding its title. These updates have been the following:Cost/Schedule Control System Criteria, Earned Value Management Systems Criteria and so on, the only purpose being to provide a formal version of the „Earned Value” concept (Wesselius & Ververs, 1990, p. 319).

Even if there are still discussions and ongoing debates regarding its practical utility, Earned Value is recommended for monitoring and controlling project execution. It is a concept that must be appreciated because it shows how this performance measurement technique can be a valuable management tool for the project.

Due to the fact that the projects do not generally achieve the required scope and they are often late, the project performance must be managed using a logical technique like earned value, with the expectation that the project results will soon improve (Archibald, 2003).

EVM is regarded as a relationship between three variables that reflect the performance of the project: budget- to see how the project fits in estimates; time- to accomplish scope of the project and the work- to see how it was done physically and the way by which it can measure progress (Anbari, 2003, p. 12).

In the planning phase of the project each work package within the Work Breakdown Structure is assessed in terms of the cost estimates and the scheduling in a time sequence. In this way it can be obtained the project cost baseline represented as a graph of planned costs over time that represents in fact the planned value (PV). PV is a numerical reflection of the budgeted value of the work that is scheduled to be executed.

The project cost baseline or performance measurement baseline can be changed only to reflect the cost changes or programming produced by changes in the project content. This guideline describes how it is supposed to evolve the project throughout the execution period, in each programmed point. It helps the project manager to predict when the money must be spent and in what period.

The performance measurement performed in raport with the guideline (baseline) is shown in Figure 1.

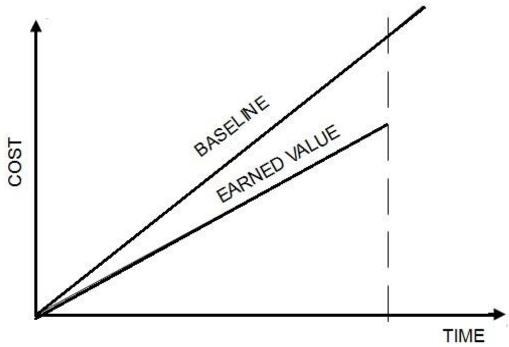

Figure 1. Comparison between the Baseline and the Earned Value

From this perspective, this paper aims to provide an overview of the way in which the earned value (EV) and the actual costs (AC) are calculated and compared with the planned value (PV) in a project that refers to a ballast plant on shipboard in order to establish conclusions on the performance of the project.

2. The Earned Value Terminology

Earned Value Management offers a set of guidelines that guide the project managers to perform a program for cost reduction when the cost is exceeded. This can be done either by decreasing the scope in some areas of the project or providing an additional budget to cover the overrun cost (Mohammad, 2010).

When the time is exceeded, it may plan another program for fast tracking to reduce the time.

This technique uses the cost, that allows the measurement in currency, hours, worker-days, or any other similar quantity, of the values associated with project work (EunHong, 2003, p. 375).

To evaluate the project performance Earned Value technique uses the following project parameters such as: Planned Value (PV) or budgeted cost of work scheduled, Earned value (EV) or budgeted cost of work performed and Actual Cost (AC) or actual cost for work performed.

The Earned Value method indicates the performed labor costs till a point in a project, as well as the amount of the work already accomplished of the activity in question (Gasparotti, 2014, p. 574).

EV of a project activity is the cost associated with that activity when the project budget has been defined. It is determined by summing the individual value of each activity in the project, considering fractional completion of each activity (Suketu, 2002).

To determine the actual cost AC it is required a registration system of the costs that enables the data collection that refers to the recorded costs for labor and materials used in the project.

The value of this cost is compared with the earned value (EV) from which resulting the cost variance (CV).

The cost of work scheduled (PV) is used to compare the achievements with the plan. Both PV and EV are expressed in money and measures the amount of work or the achievements. To calculate PV it is need the following items: the estimated costs of all activities from the tables with estimates; the date that the activities are scheduled to begin, from the work schedule; the expenditure profile of each activity during its performance (Kuehn, 2007).

The graph PV reported in time is drawn immediately after the costs of all activities are estimated and it is developed a work schedule indicating when each task should be executed.

The schedule variance (SV) results from the comparison of the works planned with those performed, thus obtaining the difference between the outputs and the expected values. The term used in the earned value system that measures the work done compared to the plan expressed in financial terms. In other words, SV measures, in money how much have progressed the works compared with the plan (Fleming, 2000, p. 212).

At the end of the project, PV reaches the agreed value for the estimated cost for the end of the project, namely the project budget (PB), and the AC value summing the total costs recorded in the project (Czarnigowska, 2008, p. 15).

Among the terms used for the costs control the following are important: total estimated cost at completion (ECAC); the cost performance index (CPI), the schedule performance index (SPI), the estimated completion date (EDC) and the cost to complete (CTC).

The total estimated cost at completion (ECAC) can be interpreted by the project manager, either considering that remaining works to be achieved will fit within the values provided in the budget or remaining works will be carried out with the same costs recorded as in the case of the completed works by that time. Depending on the interpretation of ECAC, this is calculated differently (Kim et all, 2003, p. 375).

The cost performance index (CPI) is not a very safe clue in the early stages of the project, when the percentage of the completed works is small, because it is based on insufficient data. After the execution of more than 30% of the works and later, as the works progress and the project draws near of 100% completion, it is appropriate to use the CPI index within the calculations (Kerzner, 1984).

The schedule performance indicator (SPI) shows if the project is carried out faster than plan or it is lagging behind.

When the project is nearing completion, the EV approaching the PV and the SPI value tends to 1, regardless of the project duration.

The estimated completion date ECD is determined considering two alternative interpretations (Kwak & Anbari, 2012, p. 77).

The first interpretation is the situation when it is assumed that all the remaining works will be carried out in the rhythm indicated by the work schedule, in which the estimated completion date ECD is obtained by adding or subtracting of the time lag to/from the initial date of completion, as appropriate.

The second interpretation refers to the situation when it is assumed that the work schedule for the remaining works not fall into the same delay as the works done so far, when the estimated completion date ECD is obtained by multiplying the initial date with the overcome factor (Vandevoorde & Vanhoucke, 2006, p. 289).

The cost to complete (CTC) is the estimated cost of the remaining works to be executed by the end of the project, which is the most relevant cost in the decision to continue or not a project. When the CTC value is higher than the likely benefits that would be achieved if the project will be continued, there is need to take the decision to cancel the project to avoid further losses (Pajares & Lopez-Parades, 2010).

Table 1. Terms use for the cost control in Earned Value Analysis (from Suketu, 2002)

Symbol	Name	Significance and formula
AC	Actual cost of work performed until a certain moment	It is calculated by collecting the recorded data as the project progresses
EV	Budgeted cost of work performed until a certain moment	It is calculated by summing the value of each work from the project taking into account the completion percent of each element
PV	Budgeted cost of work scheduled	It is calculated by summing the value of all scheduled works
CPI	Cost-Performance Indicator	CPI= BCWP/ACWP CPI>1 project is under budget (saving);

		CPI=1, which is estimated =current; CPI<1 project is over budget;
CTC	Cost to complete	CTC=ECAC-ACWP
CV	Cost variance	CV= BCWP-ACWP CV<0 the project exceeded the budget CV>0 the project has savings
SV	Schedule variance	SV=BCWP-BCWS SV <0 the project is behind the schedule; SV> 0 the project is ahead of the schedule;
ECAC	Total estimated cost at completion	ECAC=PB-CV, if the unexecuted works will be completed within the budgeted limits ECAC=PB X (ACWP/BCWP), if the remaining works will be executed with the same costs recorded for the completed works until then
ECD	Estimated completion date	$ECD=ECD_0$ +/- gap, if all the remaining work will be performed in the rhythm indicated by the initial planning; $ECD=ECD_0$ x overcome factor, if the remaining work will be performed by maintaining the gap of left behind of the works; overcome factor = BCWS/BCWP
SPI	Schedule Performance Indicator	SPI=BCWP/BCWS SPI> 1 project is ahead of programming; SPI = 1 which is estimated = current; SPI <1 project is delayed (over the limit);
PB	Project budget	The estimated costs of the work performed until the project completion

In figure 2 there are shown the terms from the Earned Value Analysis (Fleming, 2000, p. 212).

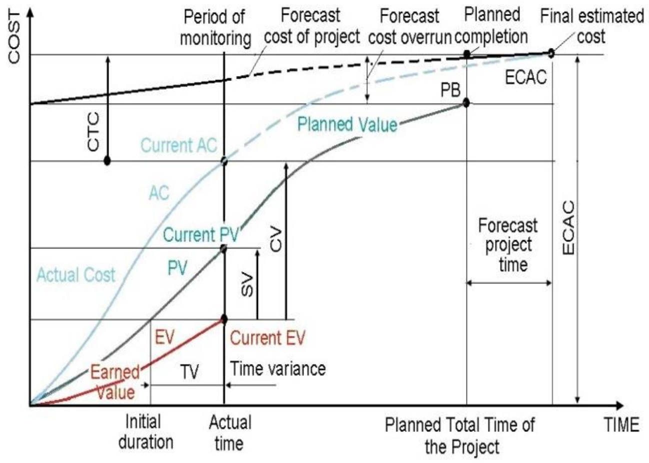

Figure 2. Terms use for the cost control in Earned Value Analysis (from Fleming, 2000, p. 212)

In Table 2 it can be observed what measures EVM, indicating what happens with the project in terms of work scheduled and the budgeted resources.

Table 2. Performance measurement using EVM (Anbari, 2003)

Performance measurement	SV & SPI			
		>0 & >1	=0 & =1	< 0 & <1
CV & CPI	>0 & >1	In advance of the programming and the budget savings	According to the programming and the budget savings	Delayed to the programming and the budget savings
	=0 & =1	In advance of the programming and according to the budget	According to the programming and the budget	Delayed to the programming and according to the budget
	< 0 & <1	In advance of the programming and over the budget	According to the programming and over the budget	Delayed to the programming and and over the budget

3. Case Study, Earned Value Analysis for Monitoring Costs in Case of Ballast Plant on Shipboard

The commercial ships are built for the transport of various cargoes or passengers. When a ship is not fully loaded, the additional weight is required to provide the ship's seaworthiness, to compensate the increased buoyancy which can lead in the lack of the propeller immersion to an inadequate transversal and longitudinal inclination, as well as other stresses on the ship's hull (Gasparotti et all, 2013, p. 987). The material that is used for the adding the weight on the ship is referred to ballast water. Even when a ship is fully loaded it can require the ballast water operations due to a non-equal distribution of weights on the ship or due to the bad weather conditions and the sea conditions. As a result of these factors, the ship is fundamentally based on the ballast water for safe operations as a function of their design and construction (Gasparotti & Rusu, 2012, p. 1751), (Ivan et all, 2012, p. 1673).

The organizing of the work is the one of the first tasks for the program management of implementing EVM. Within the organization (the shipyard) is defined the project scope of work and the groups who will be responsible for performing work as is showed in the Statement of Work (SOW). So, if is developed a Work Breakdown Structure (WBS) of the project, that is the framework for the project effort which breaks down the complex project into individual components by listing all the products, components, software, data, and services to be delivered, this is used as a common base for project planning, scheduling, budgeting, cost accumulation, and reporting of the performance.

Once the project has begun, the performance of the project against the Performance Measurement Baseline is checked regularly. The actual work performed, the schedule, and the costs are monitored regularly and the reports are created.

The project of fabrication and mounting of the ballast plant from the Tulcea shipyard is performed over a period of 48 weeks (12 months). The start data of the project is 18 August 2014 which corresponds with the finalization data of the hull mounting from 12 August 2015. During the entire process are used 46 tones of equipment including 40 tones of piping and 6 tones of valves.

The duration estimated by the staff at planning for fabrication was 4663 hours, but actually there were consumed 5349 hours, more than the estimated value, and for mounting there were estimated 7716 hours from which there were used 7162 hours, less than the estimators expected, as it can see in figure 3.

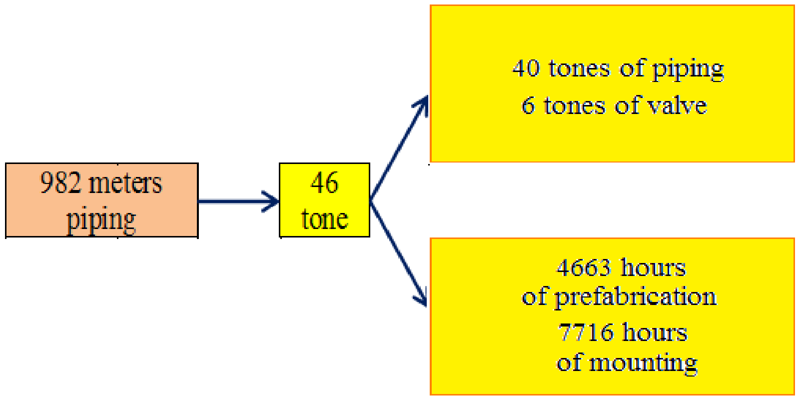

Figure 3. The estimated duration of the project

The figure 3 represents the estimated consumption of 100% by the staff at the planning.

The project budget is 3291102 euro which includes the cost of manufacture, assembly, materials, labor, production, valves and employees.

Table 3. The activities of the fabrication and mounting

	Block	Process	Start data	Finish data	Budgeted (euro)
A	Piping Block 1	Prefab. Ballast system piping block 1	28 Oct. 14	10 Jun. 15	235064.6
B		Mounting ballast system piping block 1	6 Jan. 15	29 Jun. 15	234766.6
C	Piping Block 2	Prefab. Ballast system piping block 2	18 Aug.14	1 Jul. 15	234689.6
D		Mounting ballast system piping block 2	15 Dec.14	12 Aug.15	235108.6
E	Piping Block 3	Prefab. Ballast system piping block 3	21 Aug.14	8 Jun. 1	235455.6
F		Mounting ballast system piping block 3	18 Dec.14	13 Jun. 15	236377.6
G	Piping Block 4	Prefab. Ballast system piping block 4	12 Nov.14	10 Jun. 15	235229.6

H		Mounting ballast system piping block 4	6 Jan.15	10 Jul. 15	235877.6
I	Piping Block 5	Prefab. Ballast system piping block 5	30 Nov.14	8 Jun. 15	234047.6
J		Mounting ballast system piping block 5	9 Jan. 15	29 Jun. 15	234169.6

(*) all dependencies are assumed to be FS – Finish to Start

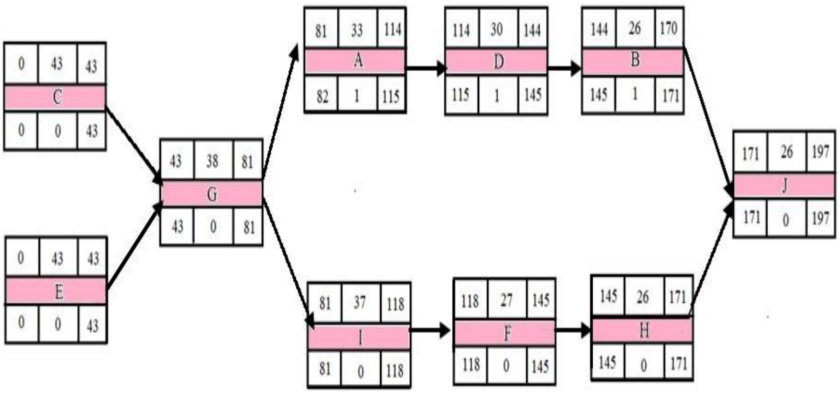

Figure 4. The network of the project

Figure 5. Gantt chart of the initial planning

Table 4. The duration and the predecessors of the activities

Activity	Immediate predecessor (*)	Duration (weeks)	Start data in the week
A	G	33	44
B	D, F	26	2
C	-	43	34
D	A, I	30	50
E	-	43	34
F	A, I	27	50
G	C, E	38	44
H	D, F	26	2
I	G	37	44
J	B, H	26	2

(*) all dependencies are assumed to be FS – Finish to Start

Table 5. The costs from the earned value system

PV	EV	AC	week
1567191,79	1567191,79	1567191,79	0
2350787,34	2045184,99	1820214,64	8
2507506,45	2382131,13	2120096,71	15
2664225,56	2451087,52	2205978,76	20
2820944,67	2595269,1	2439835,05	28
2977663,78	–	–	36
3291102	–	–	48

Calculation for the graphic of the earned value system

To apply the earned value method in the control and monitoring of project costs it is considered that the progress report is drawn up after the first 28 weeks from the start of the project, as is presented in Figure 6.

It considers that of the ballast plant execution project has a duration of 48 weeks and a project budget PB= 3291102 euro.

CV=EV-AC=2595269,1-2439835,05 = 155434 euro (economii faţă de bugetul iniţial)

SV=EV-PV=2595269,1-2820944,67= -225675 euro (lucrări rămase în urmă faţă de planificarea iniţiala)

The Schedule Variance SV indicates how much the project is ahead or behind than the initial planning.

In this case it has resulted from the calculations that the value of SV is negative which means that the project are behind the initial planning.

To determine the estimated completion date ECD is necessary to consider two alternatives:

1. If it is assuming that all the remaining work will be performed in the rhythm indicated by the initial planning, then ECD will be:

$ECD_I = ECD_0 + 28/17 = 48 + 28/17 = 50$ weeks

2. If it is assuming that the remaining work will be performed by maintaining the gap of left behind of the works.

$$ECD_{II} = ECD_0 \text{ X } 28/17 = 48 \text{ X } 28/17 = 79 \text{ weeks}$$

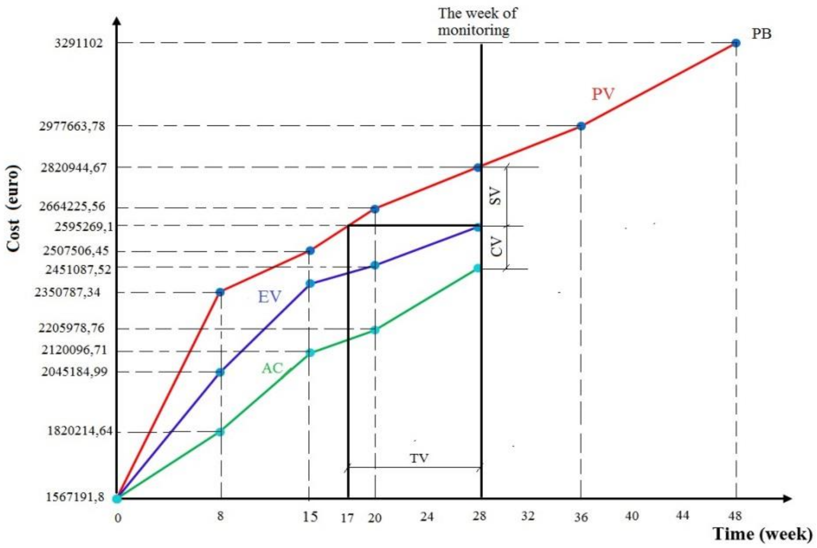

Figure 6. The curves of the Earned Value System

After the analyzing of the progress report of the project (after 28 weeks), it find out that it has been spent less than estimated in the budget for the activities undertaken up to the moment (AC <EV), but also the activities have remained as provided behind to the initial programming (EV <PV).

4. Conclusions

To use this tool called EVM, is necessary to plan resources, time and cost, to analyze the performance with which they are made. It has been demonstrated that the earned value concept is an effective technique in the project management. It permits the project managers to receive early warning signals to modify the ultimate direction of the project.

The major objectives of applying the Earned Value are to encourage the contractors to use effective internal technical cost and schedule management control systems.

EVM allows a better and more effective management decision minimizing the adverse impacts to the project.

Among the main advantages in using the earned value are:

a) The accuracy in the achievement of the reporting.

b) The early warning that provides a tool to project managers, allowing them to take the necessary corrective actions if the project is spending more money than it was physically planned.

The efficiency of the costs control system and the schedules is improved by presenting on the same graph of the curves EV, AC and PV. They indicate the way in which evolving the project in financial terms (by the relative positions of the curves AC and EV) and which is the situation in terms of framing the results obtained in the work schedule (the relative positions of the curves EV and PV). In this way, it is demonstrated that the Earned Value Management (EVM) is a management concept that integrates the technical performance requirements, resource planning, schedules, while the risk is taken into consideration.

5. References

Abba, W. (1997). Earned Value Management-Reconciling Government and Commercial Practices. *Program Manager*, 26, pp. 58-63.

Abba, W. (2000). How Earned Value Got to Primetime: A Short Look Back and A Glance Ahead. In *Project Management Institute Seminars and Symposium in Houston, TX*.

Archibald, R.D. (2003). *Managing High-Technology Programs and Projects*. John Wiley & Sons, Chichester.

Anbari, F. (2003). Earned Value Project Management Method & Extensions. *Project Management Journal*, 34(4), pp. 12-23.

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

EunHong, K.; William, G.; Wells, Jr. & Michael, R. Duffey. (2003). A Model for Effective Implementation of Earn Value Management Methodology. *International Journal Of Project Management,* 21, pp. 375-382.

Fleming, Quentin W. & Koppelman, Joel M. (2000). *Earned Value Project Management*. Publisher Project Management Institute, pp. 212. *Web page*. Retrieved from: http://www.ebay.com/ctg/earned-value-project-management-joel-m-koppelman-and-quentin-w-fleming-2000-hardcover-/1773678.

Gasparotti, C. (2014). Application of the earned value method in monitoring of the project cost. *Review of Management and Economic Engineering,* Vol. 13, no. 3 (53), pp. 574-588.

Gasparotti, C. & Rusu, E. (2012). Methods for the risk assessment in maritime transportation in the Black Sea basin. *Journal of Environmental Protection and Ecology* 13(3-A), pp. 1751-1759.

Gasparotti, C.; Rusu, E. & Dragomir, S. (2013). The impact of anthropogenic activities on the water quality in the Danube River Basin. *Proceedings Ecology, Economics, Education and Legislation*, vol. I, pp. 987-994, *Conference Albena, Bulgaria,* June, 2013. DOI: 10.5593/sgem2013. *Web page*. Retrieved from: http://sgem.org/SGEMLIB/spip.php?article3381&debut_articles_rubrique=75.

Ivan, A.; Gasparotti, C. & Rusu, E. (2012). Influence of the interactions between waves and currents on the navigation at the entrance of the Danube Delta. *Journal of Environmental Protection and Ecology,* 13, pp. 1673-1682.

Kerzner, H. (1984). *Project Management: a systems approach to planning, scheduling and controlling.* New York: Van Nostrand Reinhold.

Kim, E.; Wells, Jr. W. & Duffey, M. (2003). A model for effective implementation of Earned Value Management methodology. *International Journal of Project Management*, 21(5), pp. 375-382.

Kuehn, U. (2007). EVM. 05 Earned Value Analysis–Why am I forced to do it?. *AACE International Transactions.*

Kwak, Y. & Anbari, F. (2012). History, practices, and future of earned value management in government: Perspectives from NASA. *Project Management Journal*, 43(1), pp. 77-90.

Mohammad, A. Rajabi. (2010). *Introduction to Earned Value Method*, *Web page*. Retrieved from: http://www.marajabi.com.

Pajares, J. & Lopez-Parades, A. (2010). An extension of the EVM analysis for project monitoring: The Cost Control Index and the Schedule Control Index Science Direct. *International Journal Of Project Management*.

Suketu, Nagrecha (2002). *An introduction to Earned Value Analysis*, *Web page*. Retrieved from: http://www.pmiglc.org/COMM/Articles/0410_nagrecha_eva-3.pdf.

Vandevoorde, S. & Vanhoucke, M. (2006). A Comparison of different project duration forecasting methods using Earned Value Metrics Science Direct. *International Journal of Project Management* 24, pp. 289-302.

Wesselius, J. & Ververs, F. (1990). Some elementary questions on software quality control. *Software Engineering Journal,* Vol.5, No.6, pp. 319-330.