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Using the Earned Value Approach for CONTROLLING OVERHEAD COST in Construction Projects

SHLOMO GLOBERSON
• Dean of School of Engineering, Ruppin Academic Center
• Emeritus at the School of Business Administration, Tel Aviv University
• *shlomog@ruppin.ac.il*

• ABSTRACT •

Direct Overhead Cost (DOC) includes all support infrastructure required to complete a construction project. Although it is a dominant factor in every project, very little has been published about ways to manage it. This paper presents an Earned Value approach used for overhead control. It is based on the project's desired profit and the notion that the Earned Value of the money spent on overhead should be proportional to the volume of completed work packages, out of the amount of completed work planned. Using this notion of earned value helps to better control and manage overhead expenses.

INTRODUCTION

A construction company's competitiveness depends on its ability to complete projects on time, within the assigned budget, and according to all agreed upon specifications. A company's ability to successfully complete projects is highly correlated to its internal ability to properly manage the above three criteria. The highly competitive construction industry is mainly controlled by prices since the technological know-whow is shared by all throughout the industry, with slow changes. As such, companies have to continuously seek ways to reduce their project costs, of which overhead cost is a major part. The focus of this article is on proper management of the overhead costs and their control.

Project's costs are typically divided into direct costs and overhead costs. Direct costs result from expenses tied directly to the performance of work packages, which have tangible deliverables at the end of their execution. Overhead costs are divided into Direct Overhead Costs (DOC) and Organizational Overhead Costs. DOC result from infrastructure expenses required to support the execution of the work packages. Organizational Overhead Costs, result from the overall support that the project obtains from organizational units, such as accounting, computer and the legal ones.

In order to successfully complete a project, both direct and overhead costs should be properly managed. This study concentrates on the management of DOC, which represent a significant portion of the entire project cost. Therefore, its proper estimation, execution, and control have a significant impact on the project's cost.

When estimating the DOC for projects, companies typically use either a volume based allocation method or resource-based costing. Volume-based allocation is a method in which overhead costs are allocated to work packages in accordance with the volume of direct labor hours, direct labor costs, or contract amount. Resource based costing is a method in which resources required for the project infrastructure are estimated and then converted to their financial value. This approach is similar to the notion of Level of Efforts (LOE) used by Project Management Institute (2013) and is defined as "an activity that does not produce definitive end products and is measured by the passage of time." LOE is typically used as long as a certain hammock of work packages is under execution, yet have not been completed, and supporting resources are needed. The need for LOE lasts as long as the project has not been completed.

For example, a project manager is required as long as the project has not been completed. Or, a forklift is needed as long as objects must be moved around the project site. Since infrastructure support is required up until the project has been completed, a delay in completing a project requires further employment of the infrastructure support and its related DOC. In other words, one of the reasons for cost overrun when project delays occur is the additional budget required for maintaining the needed infrastructure support, since it is required as long as the project is under construction.

A typical approach to estimating overhead cost in construction projects is by adding a selected rate as a percent of direct cost. This estimate is then used for evaluating the performance of the project's execution. Therefore, if the estimate is poor, its use for evaluating the execution of the project will be poor as well.

In an effort to improve the accuracy of overhead cost estimation, Chan (2012) studied the variables and the factors affecting project overhead cost. In his study, he identified eight major factors that can aid estimators to improve the accuracy of their cost estimates and project budgets. In general, companies use different internal processes for generating data banks from which an overhead estimate is generated. Based on a construction firm's cost data, Li-Chung Chao (2010) developed an improved approach for estimating overhead cost using a Decision Support System (DSS) and using a neural network model for mapping the overhead rates of project attributes.

Typically, the main contractor of a construction project employs subcontractors for large scale deliverables such as ground work, structures, floors, electrical, and plumbing. Therefore, a significant portion of the total direct work is performed by the subcontractor, leaving the main contractor responsible for the execution of relatively small portion of the direct work. However, it leaves the main contractor with the responsibility of providing most of the required infrastructure support, which is financially converted into DOC. That is, the ability of the main contractor to properly manage and control the overhead cost is of great importance, as it is under his direct control.

Regardless of the method used for overhead cost estimation, insufficient attention is paid by management to overhead planning and control. Willems & Vanhoucke (2015) embarked on an intensive and comprehensive review of 187 articles dealing with project control and "Earned Value" management. In only one article was the notion of "overhead" mentioned in the title, though it was not a major issue studied in that article. In other words, in-spite of the great importance of managing and controlling project overhead, very little has been published about it.

The importance of DOC depends on its proportion of the total project cost. A study by Assaf et al (2001) investigated project overhead costs of 61 large building construction companies in Saudi Arabia. They found that company overhead costs as a percentage of project direct costs were 14.3%. Siskina et al (2009), surveyed 30 construction companies in Lithuania and estimated the average project overhead costs to be around 10% of total costs and the average overhead administration costs to be around 8% of total costs. Another study by Chan (2006) of 20 construction projects found that overhead costs account for 11%-19% of total project costs. The U.S. Army Corps of Engineers (June 2013) recognized the importance and impact of overhead costs on total project cost. As a result, they developed a specific process to build overhead costs into projects. As part of the control procedure, the Corps tracks overhead costs separately from other project costs in its financial management system, using specific overhead accounting codes.

If projects are completed on time, then DOC will not be as important. However, there are quite a few studies that found that projects are typically not completed on time. For example, Jin-Kyung Lee (2008) analyzed 161 transportation projects and found that on average, projects took twice as long as originally planned. Ram (2015) reported on a study where statistics of 894 projects were collected and analyzed. The mean percent of duration delay was 79% and the mean percent of cost overrun was 15%. There were very few projects with just cost overrun without duration overrun.

Chow (2010) developed a model, based on a data set of 173 projects, to predict overhead cost as a function of project duration. Analysis of the data shows that for each project size, there is an optimal duration with a minimum overhead rate. As the duration either lengthens or shortens, the estimated overhead rate increases. This result supports the result obtained when applying a classical cost-duration model to a project's plan.

Chan (2006) looked at a breakdown of cost structure for project overhead and identified twenty one overhead items. The 12 most relevant are listed in **Exhibit 1**.

That is, out of the 21 listed overhead items, the 12 items listed in **Exhibit 1** cover 97.4% of the total overhead cost, of which the first 7 items are responsible for around 80% of it.

No.	Item	% cost
1	Site management (project manager, office support)	35.9
2	Equipment (crane, supervisor office, tractors, vehicles)	12.4
3	Cleaning and removal of rubbish	10.0
4	Insurance	7.4
5	Preparing the site	6.2
6	Temporary help around the site	5.9
7	Scaffolding	5.9
8	Power	4.5
9	Site offices	3.2
10	Fees and levies	2.5
11	Guarding the area	2.5
12	Water	1.0
	Total	97.4

EXHIBIT 01. Major Project Overhead Items and their relative cost

CONTROLLING THE PROJECT

Since the main contractor is typically responsible for managing the execution of most, if not all, of the infrastructure activities and related overhead costs, it is of utmost importance that he has the relevant knowhow to properly control them. A typical control system compares actual performance to expected performance and initiates corrective actions to reduce deviations from expected performance. With regard to cost control, actual performance takes the amount spent for the completed work and compares it to the expected cost established during the planning stage. It is very common for work packages to apply the above concepts to project control. Project Management Institute (2013) outlined the following notations and equations in using the "Earned Value Management" concept:

EV - Earned Value, The measured value of work performed, expressed in terms of the budget authorized for that portion of work which had been completed.

AC - Actual Cost, The realized cost incurred for the work performed on an activity during a specific time period.

PV - Planned Value, The authorized budget assigned to scheduled work.

CV - Cost Variance, The amount of budget deficit or surplus at a given point in time, expressed as the difference between the earned value and the actual cost.

The following example demonstrates the way that the above concepts are used for control. A specific work package is scheduled to be completed within 10 weeks and with a planned budget of PV = 160K.

At the end of 5 weeks, the actual cost for the work performed was AC = 90K, and the earned value of the work completed was estimated to be 45%, or EV = 160 * 0.45 = 72K. That is, 90K was spent on a portion of work with a planned value of just 72K. Therefore, the extra cost spent was CV = 90 - 72 = 18K. The Cost Performance Index (CPI), which is calculated by the ratio CPI = EV:AC, obtains the value of 72:90 = 0.8. It has the following intuitive explanation: the Earned Value for every single dollar spent on this work package, is just 0.8 dollars. Using the above information, the PV of work remaining to be completed is 160 – 72 = 88K. Assuming that the same performance level will continue, as expressed by CPI, then the expected actual cost for completing the rest of the work is 88:0.8 = 110K. Therefore, total expected cost to complete the whole work is 90K + 110K = 200K.

The Earned Value approach, demonstrated in the above example, is typically used for the cost control of work packages which generate deliverable products. This approach has not been used before for overhead cost control, since overhead activities do not have specific, measurable deliverables. The objective of the remainder of this article is to present an expanded Earned Value approach, which can be used for overhead control as well.

For simplicity, let us assume that infrastructure support for a project will remain constant during its execution. Furthermore, we assume that a fixed amount of dollars will be required per unit of time until the project is completed. The following example will be used for illustration.

A company signed a contract for a construction project for the amount of $8.1 million. Project direct costs are estimated to be $6 million. Using company's historical data on similar projects, it was decided that 15% should be added for DOC. That is, DOC = 0.15 * $6,000,000 = $0.9 million.

The total direct budget for the project, without organizational overhead, is then 6 + 0.9 = 6.9 and the expected operational profit is 8.1 - 6.9 = 1.2, or 1.2 * 100/6.9 = 17%.

If the planned construction period is 18 months, then the expected overhead cost per month is OH = 0.9/18 = $0.05 million, or $50,000 per month.

The actual construction of the project lasted 34 months due to a shortage of a critical resource. At the beginning of the project no cost overruns were detected, since an earned value analysis was performed on work packages, and the earned value of work completed was around its actual cost. However, when the project was completed, due to the 16 months delay in completing the project, an additional amount of $50,000 * 16 = $800,000 was required to cover the additional infrastructure costs. Thus, profit dropped from $1,200,000 to $400,000. That is, actual profit dropped to 5.8% rather than the planned 17%.

The proposed control approach calls for calculating the Earned Value of the money spent on overhead, based on the actual progress of work completed, and comparing it to the actual amount spent on overhead. The logic of the approach goes as follows: DOC dollars support the infrastructure that is required to execute a project's work packages. If all work packages were completed during the designated time, then the amount paid for overhead justified its purpose. On the other hand, if overhead dollars were spent during a period in which no project progress was made, the Earned Value of the overhead dollars is zero. That is, the Earned Value of the overhead should be proportional to the volume of work completed, in relation to the work planned. The concept is demonstrated by expanding the above example.

Let us assume that the status of the project after three months is as follows:

Actual cost of work performed:	**AC = $560,000**
Planned Value of work scheduled to be completed:	**PV = $1,000,000**
Value of work completed	**EV = $530,000**
Actual overhead spent during that period	**AO = $150,000**

Progress on executing work packages was not as expected: the value that was planned to be completed during that period was PV = $1,000,000. Only a value of EV = $530,000 was completed, but the amount paid for the completed work was $560,000.

Using the classical Earned Value methodology, the Cost Performance Index (CPI) on executing work packages is CPI = EV/AC = $530k/$560k = 0.95. This is an indication that the total actual cost for completing all work packages will increase to 6/.95 = 6.315 million dollars, which is $315,000 above the planned budget for all work packages.

Let us now analyze the situation with regard to the amount spent on overhead. During the planning phase, the assumption was that the same effort is required for every period. Therefore, the budget for the overhead was assigned linearly throughout the life cycle of the project. However, the overhead budget assigned for the first three months was supposed to support work value of $1,000,000 rather than just the $530,000 that was completed. That is, too much overhead support was spent for too little value of completed work. The Overhead Performance Index (OPI) is just OPI = 530,000/1,000,000 = 0.53. It means that every dollar spent on overhead generated a value of overhead support of just $0.53. In other words, if the same issue which caused the delay persists, then one may expect that total overhead cost will increase to 800,000/0.53 = $1,510,000. This means that expected total overhead will be $710,000 above the planned overhead budget.

As we can see from the above example, the major reason for the cost overrun, above the planned one, is because of an overuse of infrastructure and its related overhead expenses. This additional overhead expenditure is the result of a significant delay in the project's completion. Summing up the expected revised budget for both work packages and overhead, the total revised amount reaches 6,315,000 + 1,510,000 = $7,825,000. Considering the fact the contract was signed for 8.1 million dollars, not much ($275,000) has been left, if at all, for organizational overhead and profit.

A major reason for project cost overrun is overhead cost overrun. Therefore, a project manager has to continuously follow the overhead spent as a function of a project's progress and make sure that it is in accordance with the planned expenditure. That is, if work progress is slower than expected as presented by OPI, efforts should be made to adjust the overhead expenses to match the project's progress. The following paragraphs discuss possible ways to evaluate potential sources of overhead adjustments.

The information given in **Exhibit 1** with regard to major project overhead items and their relative costs, can be used to estimate the ability to allocate portions of infrastructure and their relative costs, to the volume of completed work, as described below in **Exhibit 2**. Let us introduce the concept of "Reduction Factor," which is expressed in percentage terms, and defined as the ability to reduce infrastructure support in a certain period and transfer it to other periods where they are needed.

A reduction factor of zero means that the specific infrastructure and its related cost is rigid and cannot be reduced to lower levels. For example, guarding the construction area has to be continued at the same intensity over the life of the project. Therefore, when a project is delayed, security should be continued at the same level as long as the project has not been completed.

There are types of infrastructure support that can be reduced to adjust them to the work volume expected to be performed. For example, until the project has been completed, a project manager is required. However, it is possible to reduce the project manager's level of involvement, from 100% to 50%, if a project's progress drops significantly. Or, site cleaning efforts can be adjusted to the accumulation of waste that has to be removed – if no waste has been accumulated then no infrastructure efforts are needed and its reduction factor can reach even 100%. That is, the resources needed can be saved for future periods when they will be needed.

There is no information about real values of the reduction factor of the different infrastructure efforts. Therefore, if it is obvious that a certain infrastructure effort can be split to match the work volume, it is assumed that its reduction factor is 0.5, which means that 50% of the infrastructure can be moved to other periods as needed.

No.	Item	% cost	Reduction Factor (%)
1	Site management (project manager, office support)	35.9	50
2	equipment (crane, supervisor office, tractors, vehicles)	12.4	0
3	Cleaning and removal of rubbish	10.0	50
4	Insurance	7.4	0
5	Preparing the site	6.2	0
6	Temporary help around the site	5.9	50
7	Scaffolding	5.9	0
8	Power	4.5	0
9	Site offices	3.2	50
10	Fees and levies	2.5	0
11	Guarding the area	2.5	0
12	Water	1.0	0
	Total	97.4	

EXHIBIT 02. Ability to adjust infrastructure support levels to direct activities efforts

Using the information in **Exhibit 2**, the total percentage of overhead cost that may be delayed can be calculated to be (35.9 + 10.0 + 5.9 + 3.2) * 0.5 = 27.5. That is, 27.5% of DOC may be moved to fit the project progress profile.

Assuming that DOC is around 15% of the total project cost, then 0.275 * 15 = 4.1% of total project costs can be saved by flexible management of project infrastructure and its related overhead cost. An increase of 4.1% to the profit means a significant addition to the overall profit. If the expected profit is 16%, then 4.1% makes up 25% of the profit.

It is the function of management control to monitor all the relevant control indicators and to initiate corrective actions when one of them reaches a level that warrants a response. A response is the delaying use of infrastructure for a later time when direct work volume justifies it. As has been said before, an expected delay in project completion is a major indicator for project cost overrun, due to the need to maintain infrastructure over a longer than planned period of time. Therefore, it is of utmost importance that management continuously monitors indicators that may be used for predicting project duration, of which OPI is one of them. Obviously a critical path analysis of the project's network is also a powerful tool to predict the project's delayed completion, although it does not indicate the volume of work which remains to be completed.

As a reminder, the OPI index expresses the ratio of the cost value of cumulative work packages completed, divided by the cost value of work packages which had been planned to be completed during that period. A value of OPI > 1.0 means that work is progressing ahead of schedule. A value of OPI < 1.0 means the opposite and that we may expect potential delays in project completion, and that infrastructure support will have to be extended. Obviously, if OPI is slightly below 1.0, it does not necessarily require attention. However, low values of OPI (say, 0.5) are a strong indication that there will be a delay. Therefore, there is a need to determine the value of the OPI which warrants a response. A response may call for an immediate reduction of infrastructure in order to make use of it, in later periods. It should be noted that even when a corrective action is taken, it cannot be taken linearly since it is impossible to linearly reduce every single resource which is involved in the infrastructure.

In order to establish the value for the OPI that calls for intervention, one must first establish the sensitivity of management to the reduction in the project's profit. For example, let us assume that the project's expected profit is 12%. Is an expected drop of 0.4% of profit, from 12% to 11.6%, traceable and significant such that it warrants corrective actions, or should it be another value, say 1.5% or even 2.3%? For the purpose of this analysis, let us use the following notations:

PRD – Profit reduction due to project's delay.

OPI - The cumulative value of work packages completed, divided by the value of work packages which had been planned to be completed during that period.

DEL= (1 - OPI) – Portion of delayed work which has not been completed according to the original plan. It is used as a predictor of the expected delay of project completion.

DOC – Direct Overhead Cost. The cost of the infrastructure required to support the execution of the project's work packages

For example, if as part of project monitoring and control, OPI was calculated to be OPI = 0.8, then DEL = (1 - OPI) = (1 - 0.8) = 0.2. This means that 20% of the volume of work which was planned to be completed has not been completed, and that there is the expectation that the project may be delayed by around 20%. A project's delay calls for an extension of infrastructure support beyond the planned project completion date. If, in spite of this finding, no efforts have been initiated to postpone the use of infrastructure support, and assuming linear behavior of the need for that support, then DOC will increase by 20% and will reduce the profit accordingly. Equation 1 calculates the profit reduction as a function of the above circumstances:

PRD=(1-OPI)*DOC (1)

The initial plan estimated that infrastructure cost will be DOC = 15%. Substituting the values into equation 1 we obtain:

PRD=(1-0.8)*15%=3%

The extra cost generated by the extension of needed infrastructure is expected to reduce the profit from, say, 12% to 9%: a drastic reduction in profitability of 25%.

As can be seen from equation 1, the reduction in profit depends on both the duration of expected delay and the DOC.

Management has to establish a threshold of profit reduction that requires immediate attention and response. As a result of establishing that value, the value of the relevant OPI can be calculated and used for control. From equation 1 it is possible to present OPI as a function of PRD and DOC as follows:

OPI=(DOC-PRD)/DOC (2)

For example, let us assume that management decided that the profit threshold value is PRD = 1.2%. Substituting the values into equation 2 we obtain:

OPI=(15-1.2)/15=0.92

A value of 0.92 means that during the project control process, if OPI drops below 0.92, immediate attention should be paid to the infrastructure support pattern. Since OPI indicates that there is a high probability that the project's completion will be delayed, infrastructure should be adjusted accordingly and extended over a longer period of time, while spending as little as possible on additional cost.

CONCLUSION

Each project requires infrastructure to support its execution, generating a direct overhead cost of around 15% of the project's cost. A delay in project completion requires an extension of infrastructure support and its related costs. If both the infrastructure and its related cost are not managed effectively, they will add significant additional costs to a project's planned cost. Proper management of both calls for initiating control mechanisms through which it is possible to evaluate whether there is the proper allocation of the infrastructure used, relative to the volume of work completed. A discrepancy between the two requires management to initiate corrective actions concerning the infrastructure pattern. Typical corrections include delaying infrastructure resources to generate a better allocation to the expected pattern of work packages volumes. ◆

• AUTHOR •

SHLOMO GLOBERSON Professor Globerson earned his PhD at the department of Industrial Engineering, University of California at Berkeley, He is presently the Dean of the Engineering School at Ruppin Academic Center, in Israel. Professor Globerson is a frequent visiting scholar at different universities and establishments around the world. He is also involved in developing new programs for project managers and top executives, as well as helping companies in implementing project management know-how. He has published over eighty refereed articles and twelve books. He is a Certified Industrial Engineer in California, a member of the Project Management Institute (PMI) and a Certified Project Management Professional (PMP).

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