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Earned Value Project Management
A model for project performance valuation in Ericsson AB

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Master Thesis No 2005:7
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ABSTRACT

Recently, companies increase the usage of projects in their businesses, thus corporations are facing the issue of project valuation. Multiple techniques are dealing with this problem, however, it is questioned which one provides with the best results. This thesis examines the earned value method for project performance valuation. The main purpose of the present study is to evaluate the earned value method, as well as to design a guide of the theory and practice behind earned value method. Additionally, a template model of the earned value is provided. The model is tailor made for the needs of Ericsson AB, but is also designed to suit all types of projects within profit organizations. Theoretical results indicate that the earned value is a technique that provides with the most realistic and complete picture of the health of the project. Even though, theory supports the statement that the earned value is the best method for project performance valuation, it discloses a number of costs associated with the discussed technique. The empirical part of the study provides with a model, through which a solution to some of the problems connected with the method is suggested.

Key words: project valuation, earned value

ACNOWLEDGEMENTS

This master thesis was performed with the help of many people. However, there are two persons that put their soles in the study.

Before everybody else I acknowledge Stefan Sjögren and Katarina Lundin for their assistance throughout the working process. PhD Stefan Sjögren, who is a lecturer at Gothenburg University, has been of enormous help when solving theoretical, and practical issues of the master thesis, and Katarina Lundin, who is a project manager at Ericsson AB, was deeply involved in the empirical part of the study.

Thanks, to all the personnel at Ericsson AB that created a nice working atmosphere and helped solving numerous issues.

Marina Dimitrova

Gothenburg, January 2006

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1 BACKGROUND

This first part will provide introduction to the thesis, continued with problem discussion. Subsequently, the purpose and outline of the study are presented.

1.1 Introduction

In today's highly competitive worldwide markets, the future of all companies depends upon their ability to undertake correct financial decisions. Many international corporations deal with projects on an every day basis, which makes it a major part of their businesses. Thus, one can foresee the need of making the right financial decision when the issue of undertaking and executing a project is in question.

The present situation in Ericsson AB, is that like many other corporations, it deals with projects of different nature. The Global Services, a department within Ericsson AB, in which this master thesis is performed, is constantly working with various projects. Hence, an important part of the work there is to professionally manage projects. (See appendix I providing with an overview of the organization, and appendix II is discussing project management). One can question the meaning of professionally managed project. The good managed project is seen as a project that is constantly under control, undertaking corrective actions, when it is noticed that such are necessary. Thus, another issue appears, namely what indicates that the project is not running well and corrections are necessary to be made. Project leaders use different tools that indicate the health of the project. Such a tool is the earned value method. In their work, employees at Ericsson use among others, MS project – a tool for scheduling and controlling a project, excel spreadsheet – a tool for detailed project planning and follow up, for purchase, invoice, and resource plan. In the near future periods, for their competence centre in Gothenburg, the company intends to use only one common tool for project control, namely the earned value (EV) method.

The earned value method is a method for project performance valuation. It can also be seen as a method for cost and schedule control, as well as a project-monitoring tool. One typical description of the EV is that it is used for project in their ongoing phase. Flemming & Kopleman (1998) state that the method provides the project managers with an early warning, which can be received after the project is 15 per cent accomplished. The method forecasts the

final required funds needed to finish the job within a narrow range of values. Important point to be understood is that the earned value does not provide with suggestions of how to improve the project performance, it is rather a tool that gives a warning signal when the health of the project is worse than planned. Moreover, the earned value is a tool that enables project managers to monitor their projects.

The earned value has recently become the most common tool for measuring the project performance under the condition that the project is in its ongoing phase. The technique of earned value can be recognized under multiple other names, however, it is often referred to the same method for project performance valuation.

This thesis is subject to the earned value method. An in-depth study of the earned value method is executed. To do so, a comparison between the discussed method and its predecessor is made. Along with this, a valuation of the method is executed, by discovering the advantages and disadvantages of using it. Additionally, suggestions for how to overcome some of the disadvantages of the tool are provided. Finally, a model tailor made, to serve the needs of project managers when valuing their projects is designed.

1.2 Problem Discussion

In his studies Hertz (1964, 1968, & 1976) stresses out that project valuation remains as one of the most important issues for financial managers. The importance to value projects has been recognised in the literature for many years (Montalván (2003)). However, there had been various proposals for project valuation techniques, each one having its strong and weak sides.

The current master thesis is designed to deal with issues of project valuation. In order to specify the problem of the study multiple papers have been examined, and thus it shows that there are several ways of examining the project based on the project phase one find herself in (Brown (1985), Anbari (2003)). The phases that are of particular interest are the starting phase, or before a decision for running a project has been made and the ongoing phase, when the decision of undertaking the project is made and the project is already in its ongoing phase.

No matter in which stage the project is, in order to be successful it has to be constantly monitored and valuated.

Grembergen (2001) takes a closer look to the reasons for a project to be valuated. He underlines that the in order to undertake corrective courses of action, it is necessary to value the project. Legge (1984) talks that the summative evaluation is concerned with the ex ante selection of one course of action, or design, from a number of available alternatives. It is

pointed out that formative evaluation is concerned with ex post feedback by evaluating an existing system, or one recently developed/ implemented. Here the concern is with a rational approach to resource allocation and the achievement of predefined objectives. Other purposes of evaluation are much more political, as it has been used to gain commitment before starting a project or as a disengagement device for developers at the end of a project.

Important question to be discussed according to Grembergen (2001) is exactly what, in a project needs to be evaluated. This is concerned with drawing boundaries around the evaluation, as a total evaluation of a project is practically impossible. In this regard, the evaluation could focus on the schedule, cost, quality, risk, and multiple other factors that affect a project. This thesis will focus on the cost and schedule control and valuation. Ones one has decided exactly what will be the input variables for the project valuation (in the case of the thesis those are the cost and schedule), it is required to find a proper way of valuation.

Grembergen (2001) is concerned with the problem of how to evaluate projects. He proposes that a well-defined methodological framework is of big necessity. Today, there is a wide range of methodologies available to examine projects (e. g., cost benefit analysis, return on equity (ROI), net present value (NPV), etc.,). It is stated that the choice of method is based on what kind of evaluation is going to be performed. Along with this the valuation tool has to also be examined. This could be done by weighting the advantages and disadvantages of the particular method. It has also been noticed that most of the methodologies available for project valuation make a big emphasis on the cost of capital. In order to decide on the valuation method, one has to examine the projects that need to be valuated, the reason for their valuation, and what features from the project have to be valuated. Often the nature of the projects depends on the organization they are preformed in.

The organization, in which the thesis is employed, is a global organization with traditions in working on projects. The company is working on small projects as well as on big projects, which include significant amount of resources. For Ericsson AB, of major importance is to control both time and cost. The department, for which the thesis is designed, (Global Services) is continuously working on projects with multiple changes. To meet the customer's needs Ericsson is adjusting the projects parameters based on the changed desires of the customer. This issue has to be taken into consideration when choosing the right tool for project control and evaluation. Hence, a tool for cost and time control, suitable for Ericsson, will be the one with which it will be possible to constantly change parameters.

Westney (1997) proposes that for a project to be successful it is very important to control its costs. It is underlined that projects are under control only if four basic elements are under

control. Those are the schedules, progress, budgets, and incurred costs[1]. One possible tool to control projects is the earned value method. This concept integrates cost and schedule for measuring over-all project performance in their ongoing phase. It requires computerization, which helps to deal with the additional data elements that are required. The basic fundamentals are relatively simple. However, in order to use the earned value method major system acquisitions are required to fulfill the need for very detailed and formal instructions and documentation.

Again, the company that the thesis is employed in is equipped with a system for data integration. This makes the information flow go rapidly from one point of the organization to another.[2] Thus, it creates the perfect environment for implementing the earned value method for project performance control.

The organization, in which the thesis is employed, has shown particular interest in the earned value method. The Global Services department has made a decision of implementing the technique for its projects monitoring and control. Thus, it is crucial to value the technique itself in order to see if it is appropriate for Ericsson. A further desire of the company is to design a tool of easy implementation of the method of earned value. This second issue, however, will only be undertaken if it is discovered that the earned value is an appropriate technique for project valuation within Ericsson. Thus, based on the organization two central issues are to be dealt with in the current thesis. The first is the valuation of the earned value method and the second is designing a model for easy implementation of the discussed method. In order to solve the first problem it is chosen to find the costs and benefits of the earned value method, and further find out if the found costs can be dealt with.

According to the PMBOK® Guide[3] the earned value method enables organizations to employ a single technique of project performance measurement. However, it could only be implemented after the crucial decision that a project is going to be undertaken. The same source provides information about additional advantages of the method. It is said that the earned value provides with accurate measures for the project cost and time schedule, given the

[1] *Schedules* are time scaled plans for the execution of a project.
Progress is the measure of headway made when carrying out these plans.
Budgets are a quantity of funds allocated for the performance of a specified amount of work.
Incurred cost deals with the measurement of the consumption of these funds.

[2] As it is mentioned further in the study, one exception could be the actual costs data. To acquire this kind of data, a period of one month is needed. This kind of delay, however, is not due to the system for data acquisition.

[3] Project Management Institute, 2000, *A Guide to the Project Management Body of Knowledge* (PMBOK® Guide), Newtown Square, Pa.: Project Management Institute

planned value and time to completion. The earned value can also function as an early warning with its accurate forecasts for costs and time performance.

It is questioned if the earned value method is a good technique to be implemented for project performance valuation. Fleming & Koppelman (2000) publish for the first time the ten benefits of using the earned value method. The benefits show that the earned value method is a technique that emphasise on aspects that are left behind by other project performance techniques. Thus it is a better technique for project valuation. The ten benefits of using the earned value are further examined in the study.

Among others, Brandon (1998), Christensen (1998), Fleming & Koppelman (2004), Howes (2000), and Ruskin (2004) are examining the disadvantages from using the earned value. Some of the above authors are even suggesting ways of overcoming those problems. Thus, it is proved that, even though the earned value method bears disadvantages, it is possible to overcome them, which makes a good technique for project performance valuation. The costs of using the earned value method, together with ways of overcoming them, are further discussed in the study.

Problems, with the technique, that are present in the organization are to be discussed. A contribution to the research area is the problem of the cost of capital in the earned value method. One can wonder how does the cost of capital fit in the picture of the earned value method.

The master thesis is designed to meet the needs of the company it is employed in. Thus the problems solved in the paper are mainly focused and connected to problems and requirements of the organization.

In this paper several issues are to be illuminated: First, the advantages and disadvantages of the method are to be stated and discussed. Possible ways of overcoming the disadvantages are to be mentioned. Second, based on the finding when examining the first issues, a model for easy implementation of the earned value method could to be built. This may be done by the use of excel tools, and will be meant to provide project managers with better understanding of the method. Additionally, a guideline for understanding the results of the model could be made.

1.3 Purpose and Outline

The purpose of this study is to find out if the earned value is a reliable technique for project valuation. This could be done by finding the costs and benefits form using the discussed

method. It is intended to find solutions for the problems associated with the earned value. Another possible purpose, which is dependent on the outcome of the first issue of the paper, is to provide the company with a tool that is based on the earned value and can be used by the project managers when evaluating projects. Hence, along with the empirical part of the thesis, a goal is to design a unique template for project evaluation that will suits all kind of projects within profit organizations.

The outline of the paper is as follows: The master thesis starts with a background, followed by a discussion of the method used, and a discussion of the theoretical aspects of the earned value. Next in the paper is a chapter subject to a discussion of the earned value, followed by a section of the designed model, and analysis. Finally, the general conclusions are stated.

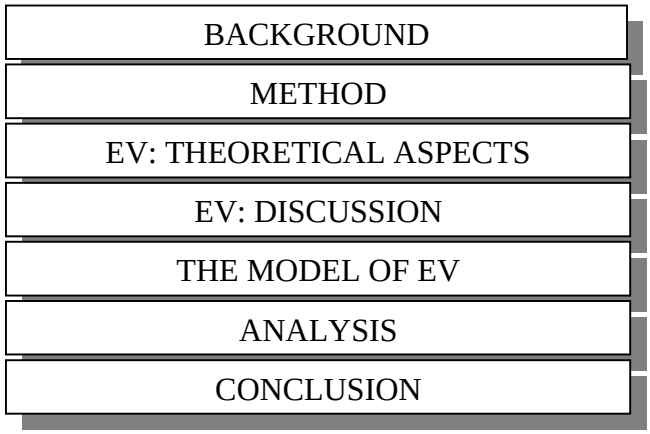


Figure 1 General outline of the master thesis

Next, the method of the study is disclosed.

2 METHOD

Under this chapter the method used to solve the problem of this study is presented.

The method of this master thesis is unique and unusual. It varied depending on the stage of the study. Several stages of this study are recognized.

In the earliest stage of the thesis, it was it was not clear what the subject of the study would be. However, a decision of writing a study on project valuation within a company had already been made. Thus in this first, very early stage of the study, the method required finding a company that will have issues when valuing projects and at the same time would be willing to share its data. It did not take long time until such company was found. The PhD Stefan Sjögren, had already received a request from a company that desired to invent a new method for project valuation. Thus Ericsson AB, and the department of Global Services, became the environment in which this master thesis is performed. Thus, in this early stage of the thesis, primary data in a form of discussion with the university supervisor was obtained.

During the next, second stage of the study, one had familiarised to the problems within the organization. The very first step was to familiarize with the methods for project valuation that were used in the company. Further information on the particular requests for examining objectives was gathered. This was done by collecting primary data[4]. The data was received in a form of electronic mails from one of the project managers. The main desire of the company was to perform a study on based on the earned value method. Thus, the company supervisor, Katarina Lundin, provided with information on projects within the organization, and specified the objectives in which the company was interested. Those objectives became the drivers of the whole study.

Since the main subject of the thesis is the earned value method, it was necessary to familiarise with the method. It was done by examining secondary data, in a form of published data collected for previous research purposes. The main sources of data were books subject to

[4] According to Kinnear & Taylor (1996), the primary data is collected especially for the research and objective in question. Primary data can be obtained by using either observation methods or questioning methods. When using the observation methods the researcher observes processes that one is interested in and follows how they develop. The question methods, according to Lekvall & Whalbin (1993), include three main types of communication; mail questionnaires, telephone interviews or personal interviews. Internet and e-mail interviews can also be considered.

project management, and the earned value. Articles, subject to project valuation were examined as well.

In the third stage of the process the earned value method was examined. Starting from this stage, and until the completion of the study, the thesis was performed in the environment of the company. This means that the access to primary data was extremely simplified. One had to only step to the desks of the projects managers and ask for information. Online, e-mail communication was not excluded. Thus, along with face-to-face discussions, online interviews were executed as well. Moreover, by executing the study in the environment of Ericsson, problems such as information delays, were avoided. One received the primary data at the moment of necessity.

To examine the earned value method, multiple articles, books were examined. Published books or articles about the project management, project valuation, project performance valuation, etc., are applied in the projected study. Nowadays, the Internet provides with brilliant opportunities for using the latest findings and various options about different research areas. For the purposes of the research multiple Internet sources have been used. The homepage of the company is updated with various types of information, which was useful when getting to know the Ericsson policies and organizational structure. Online lexicons were helpful when searching for the simplest explanation of the earned value and other terms. Recently, Internet databases store a great amount of books in the form of soft copies. Such were used through the entire period of writing the thesis. Additionally, the online database of the “Gothenburg University” library was used when examining articles subject to project valuation, and earned value method. Significant part of the literature of the study is subject to the advantages and disadvantages of the earned value method.

During the described stage the theoretical part of the study was in process.

The next, fourth stage of the study dealt with both finding the advantages and disadvantages of the earned value, together with making attempts of solving for the existing disadvantages of the discussed method. This was done by using secondary sources of data, such as books and articles subject to the costs and benefits of using the earned value, and ways of overcoming the costs of the method. Along with the secondary data, primary data, gathered from project managers and other employees at Ericsson was used. The interviewees, shared their problems when and if implementing the method, and in some of the cases even suggested ways of overcoming the problems associated with the discussed method. Thus some of the suggestions for overcoming the costs of the earned value were taken from existing literature, some were suggestions of the employees and the rest are acknowledge as

own contribution to the research area. Similar statement can be made for the suggestions of costs and benefits of the earned value method. One difference here is that the own contribution to the research area is significantly smaller, then the contribution that was made in respect to solving for the costs of the earned value.

The following, fifth, stage of the process was building the model for easy implementation of the earned value. The fifth stage was present as during the previous stages, it was proved that the earned value is a reliable technique for project valuation, suitable to be implemented during the ongoing phase of the projects executed at Ericsson AB. Hence, the fifth stage had several sub stages, some of which were already executed during other stages of the project. The *first* sub stage was to gain understanding of the concept of earned value. This was done throughout all previously discussed stages. The major source for this sub stage was the secondary data, in the form of books and articles subject to the concept of earned value. The *second* sub stage was to familiarise to previously existing tools for project valuation. Those are secondary data in the form of templates (based on earned value) previously used in the company for project valuation. Some valuable ideas for the designed, in this thesis, model of project valuation were taken from those templates. The *third* sub stage was to build the model of earned value. The main tool for doing this was the excel software. Unfortunately, the functions of the excel software were not always sufficient to express for the functions of the model. Thus, in order to obtain the desired outcome, the Visual Basics for Application (VBA) software was used. The final, *fourth* sub stage was to test the model. This was done by using secondary data, in the form of historical data from previous projects within the organization. The performed tests have shown high reliability of the model[5]. It is said that the built model proves high reliability as it provides similar results for a project valuation as other techniques do.

The process of building and examining the model was tightly supervised by a number of project managers. In that way, one could make sure that the model will be highly reliable to its future users (since the future users of the model are the project managers themselves).

[5] According to Kinnear & Taylor (1996), research's reliability means that the research model will give reliable and stable results. If a research has a high reliability it should lead to exactly the same results if repeated independently. The method should be independent of the researcher and of units. Also the measurement instruments should deliver stable and trustworthy results. Eriksson & Wiedersheim (1999) state that if the researcher aims to be able to generalise from the collected information, it is necessary to achieve high reliability. A research is reliable if it is repeatable with the same outcome, hence it can resist random influence. In general, low reliability is a result of an imprecise defined research model.

The final, sixth stage of the process was the analysis of both the model and the method of earned value. This stage took place was parallel to nearly all stages of the process[6]. During this stage both primary and secondary data was used. Because of this final stage of the study it was possible to draw conclusions.

The following chapter includes a discussion of theories that are applied in when building the model of earned value.

[6] The only exception is the first stage.

3 EARNED VALUE: THEORETICAL ASPECTS

This chapter contains theories relevant for the master thesis. The chapter starts with a discussion on Project Valuation, followed by the Cost and Time Control of a Project. Finally the Earned Value theory is disclosed.

3.1 Project Valuation

One major question of the current master thesis to consider, is the question of why does one evaluate projects. Thus a possible answer could be: in order for the corporations, which undertake projects to be successful. Recently, most of the activities of a company are being interpreted as undertaking a project. "These projects may be as simple as upgrading equipment, or as complex as a new product or service that enters the corporation into an entirely new market"[7]. Before investments are made or projects undertaken, the costs and benefits have to be weighted, in order to decide if the project will add value to the corporation, and therefore undertake the project (Boer (2003)). Lewis et. al. (2004) propose that a company develops a strategy for selecting projects. One important aspect is to consider the importance of the potential project so that the corporation's resources can be directed to the most important projects[8]. There are also circumstances under which a project valuation does not need to be completed. Such cases are when the company must complete the project in order to stay in business.

Aitken (2000) states that throughout a project there should be continuous evaluation at each stage (See appendix II, dealing with issues of project management, and project management processes). It is advised to value the project at each stage of its development. The proposed valuation is a financial valuation. Depending on the value, a decision of whether or not to proceed with the project is made.

The literature on corporate finance contains a large number of apparently rivalling methods for the valuation of projects (Gustafsson (2005)). Some of the most popular models for project valuations are the decision tree analysis (Hespos & Strassman (1965), Raiffa 1968), the risk adjusted NPV (Brealey & Myers (2000)), real options (Dixit & Pindyck (1994), Trigeorgis (1996)), return on investment, discounted cash flows, payback time (Aitken (2000)). The

[7] Sourse: http://www.mtholyoke.edu/~aahirsch/whyvalueproject.html - 2005-12-3
[8] Sourse: http://www.mtholyoke.edu/~aahirsch/whyvalueproject.html - 2005-12-3

traditional approach for project valuation, which is applied in most of the ongoing stages of the project deals with monitoring the time and cost consumed throughout the projects (Flemming & Koppleman (2000)). This approach is universal for all types of projects, and widely used among corporations. The main objective with the traditional approach for valuation of ongoing projects is to monitor costs and time. More resent approach for monitoring and evaluating ongoing projects is the earned value method, which is the central discussion of the current study.

3.2 Cost and Time Control

The time or schedule control is about the schedule baseline and the changes that might occur. The PMBOK® Guide describes the schedule baseline as the original approved project schedule, which is the standard used to measure schedule performance. The guide suggests that the baseline should never be changed without a proper review and approval. Changes may either extent or accelerate the schedule, and they nearly always are related to increase in the project cost. The technique that is most popular for schedule control is the variance analysis. It revises the value, which is the difference between planned and actual time. This value is called the schedule variance and is one of the parameters calculated by the earned value technique.

According to the PMBOK® Guide, the cost control deals with the factors that create changes to the cost baseline. It ensures that changes are agreed on and determines whether cost baseline has changed, along with managing the changes when they occur. Under the control phase one has to determine what causes the cost variances, (which is the difference between earned value and actual cost) and decide if the variance identifies the necessity of corrective actions. The cost variance is one of the parameters calculated by the earned value technique.

As it was mentioned, both cost and schedule control require calculations performed by the earned value method. The earned value method itself is a technique for controlling project cost and schedule performance. Further in the study follows a description of the earned value model.

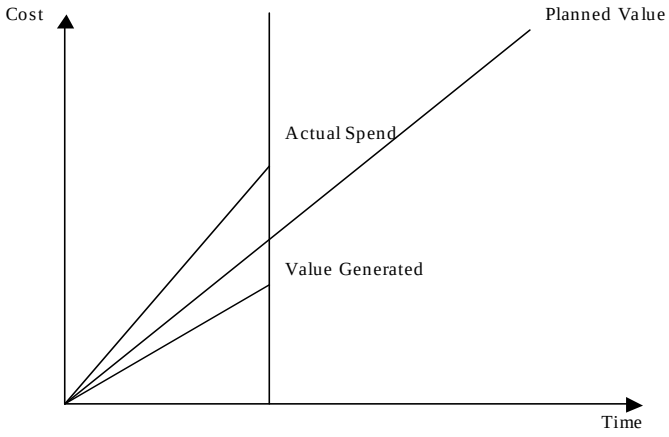
3.3 Earned Value

The concept of earned value is focused on the accurate measurement of physical performance against the detailed plan to allow for the accurate prediction of the final costs and schedule results for a given project (Fleming & Koppelman (2000)).

It is often used in complex projects where it is required to predict final costs and times at completion. By using the EV, project managers are able to control the costs for a given task, which occur with the progress of the project and compare them with the budget for the same task. The concept is widely used as it is relatively simple and brings time and cost performance elements into monetary quantity. Fleming & Koppelman (2000) state that the focus of EV is on the performance obtained in comparison to what was spent in order to achieve it.

In his explanation of earned value Webb (2003) illuminates that the concept deals with three numbers, which are the basic of the earned value method. The numbers show:

1.) how much value should have been achieved according the plan (Planned Value);
2.) how much value has been created according to the work done (Value Generated); and
3.) how much money has actually been spent (Actual Spend) .



Source: Web (2003), pp.18

Figure 2 Three quantities: the basis of the earned value performance measurement

The disposed in the above figure variables are the basis of the earned value method. Although simple in concept, the practice is much more complex because it is most often applied to projects that were very complex. Webb (2003) identifies the types of projects that are suitable for using the earned value method. The author mentions that in practice all projects with a structured plan of work, a cost structure and a suitable data-gathering system can make use of the earned value method. Appendix III illuminates the characteristics of a project that is well suited to EV method. Once it is proven that a particular project will suit the earned value method, another examination has to be done.

In order to undertake the decision to use the earned value method when monitoring and controlling a project one has to first find out what can be gained by applying that method.

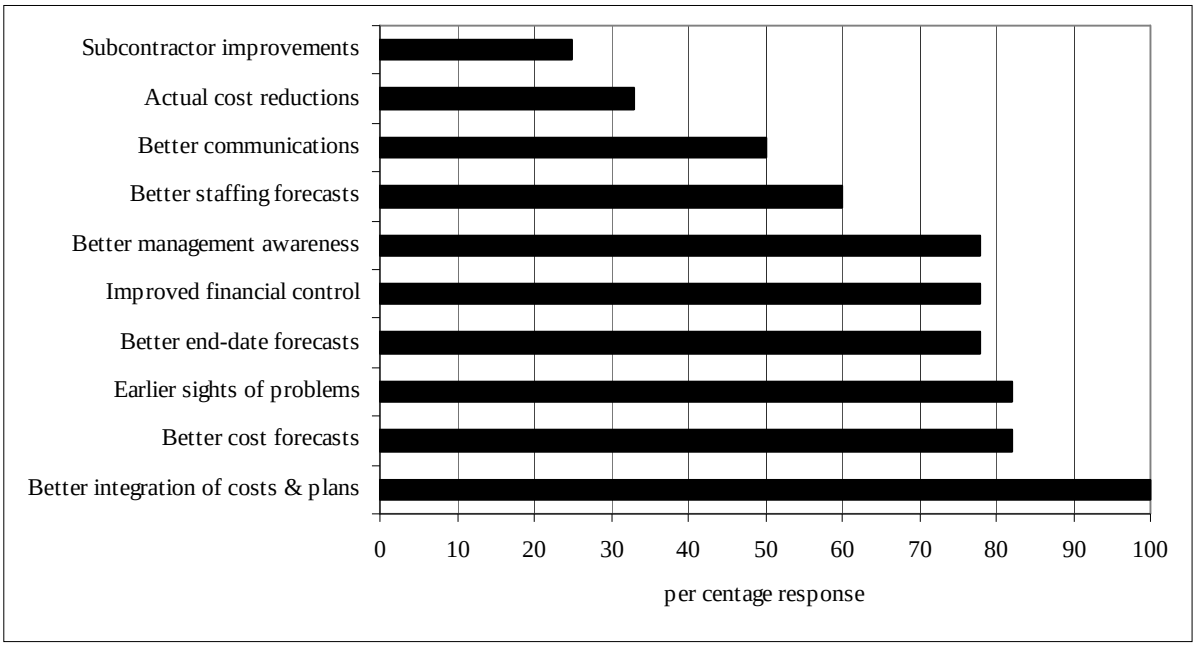
In his study Webb (2003) highlights some standpoints, which are the basic expectations from the earned value concept. The earned value is applied when there is a necessity of better insight into the progress of the projects from both a cost and a schedule perspective. The importance of the earned value over time has only increased and as the importance of having a clear view of how well a project is doing and where it is heading is large. Through the earned value it is possible to acquire:

- Early warning of a deteriorating situation creates an opportunity to do something about it before it is too late.
- Accurate forecasting allows better decisions to be made about the course of the project.
- Accurate forecasting allows better decisions to be made about matters outside the project, which may be influenced by the progress of the project.
- An open and verifiable view of progress improves sponsor confidence.

The above are some reasons why earned value performance measurement is an important project management technique, however other reasons can be important as well.

According to Webb (2003), the earned value methods demand effective planning, costing and monitoring systems. Hence the emphasis placed on these aspects can improve overall project management through the discipline they bring.

In 1994, a survey researching the benefits from the earned value was carried out in the United Kingdom among users of earned value methods. The figure below demonstrates the outcome of the survey.



Source: Webb (2003), pp.22

Figure 3 Benefits associated with earned value methods as seen in a British survey

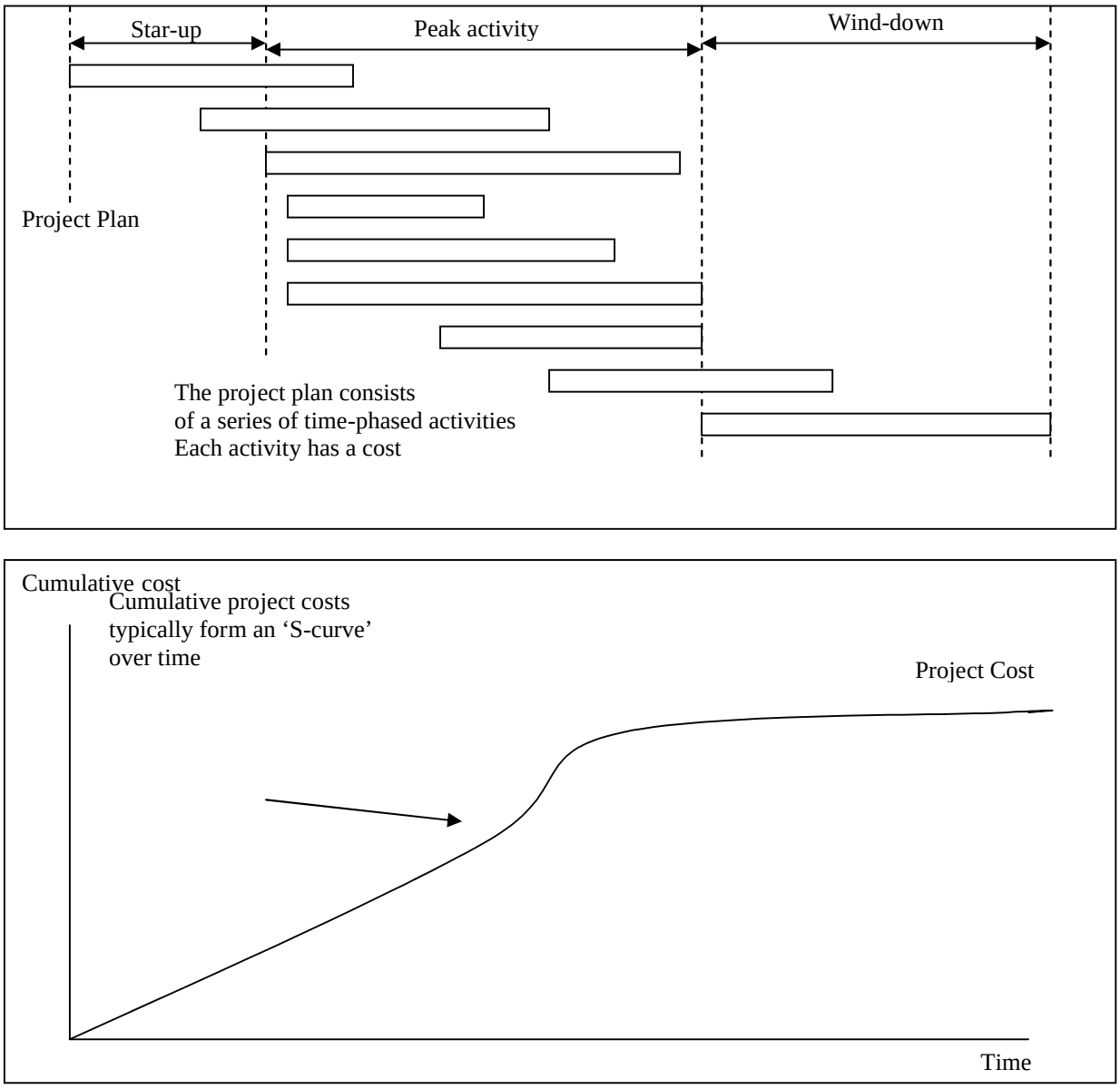
All participants in the survey claim to have seen much better integration of costs and plans, more than 80 per cent also see improved cost forecasting and earlier sight of problems. About 75 per cent point out better financial control and, most importantly, better overall management awareness of the project situation. An overall project cost reduction through the use of earned value is admitted by only 33 per cent of the interviewed. This however, can be relative as it is difficult to compare with cost that might have arisen if the earned value has not been implemented.

Webb (2003) mentions that, even though it is proved that the benefits of using the earned value are more than the costs, one should not underestimate the difficulties that come along with this concept. One significant shortage of introducing the earned value method is that it could be seen significantly more complicated in comparison to the "old" techniques used for running a project. Along with the introduction of earned value, a number of changes in the operating practices (e.g. producing new reports, tightening the planning discipline, installing new software etc.) have to be made.

A survey examining companies that implement the earned value shows that all firms were satisfied with the new technique and think that once the initial problems were overcome, the experience encouraged some of the organizations to make more widespread use of the technique.

3.3.1 Earned Value in Practice

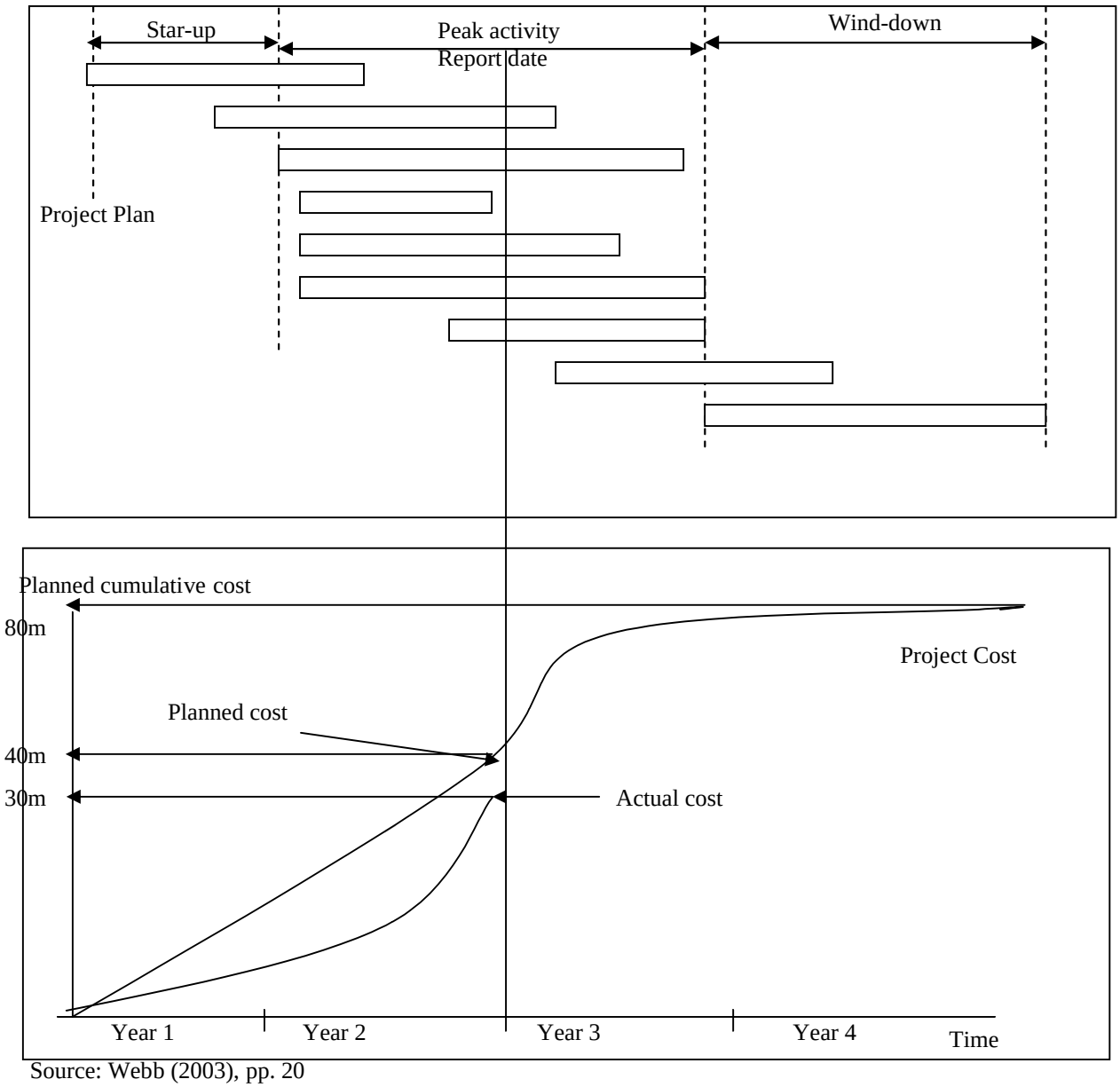
In order to explain the concept of the earned value an example suggested by Webb (2003) will be introduced. In the beginning some assumptions have to be made. A four-year lifespan project is considered. Its costs follow an S-curve as it is shown in the figure below.



Source: Webb (2003), pp. 19

Figure 4 The relationship between the plan and the costs over time

The budget for this project is set to be 80 million, and in the middle of the project lifespan the planned cumulative values are estimated to be 40 million, while in reality the project turns to use only 30 million during the mentioned period. The described situation can be viewed as a picture in the figure below.



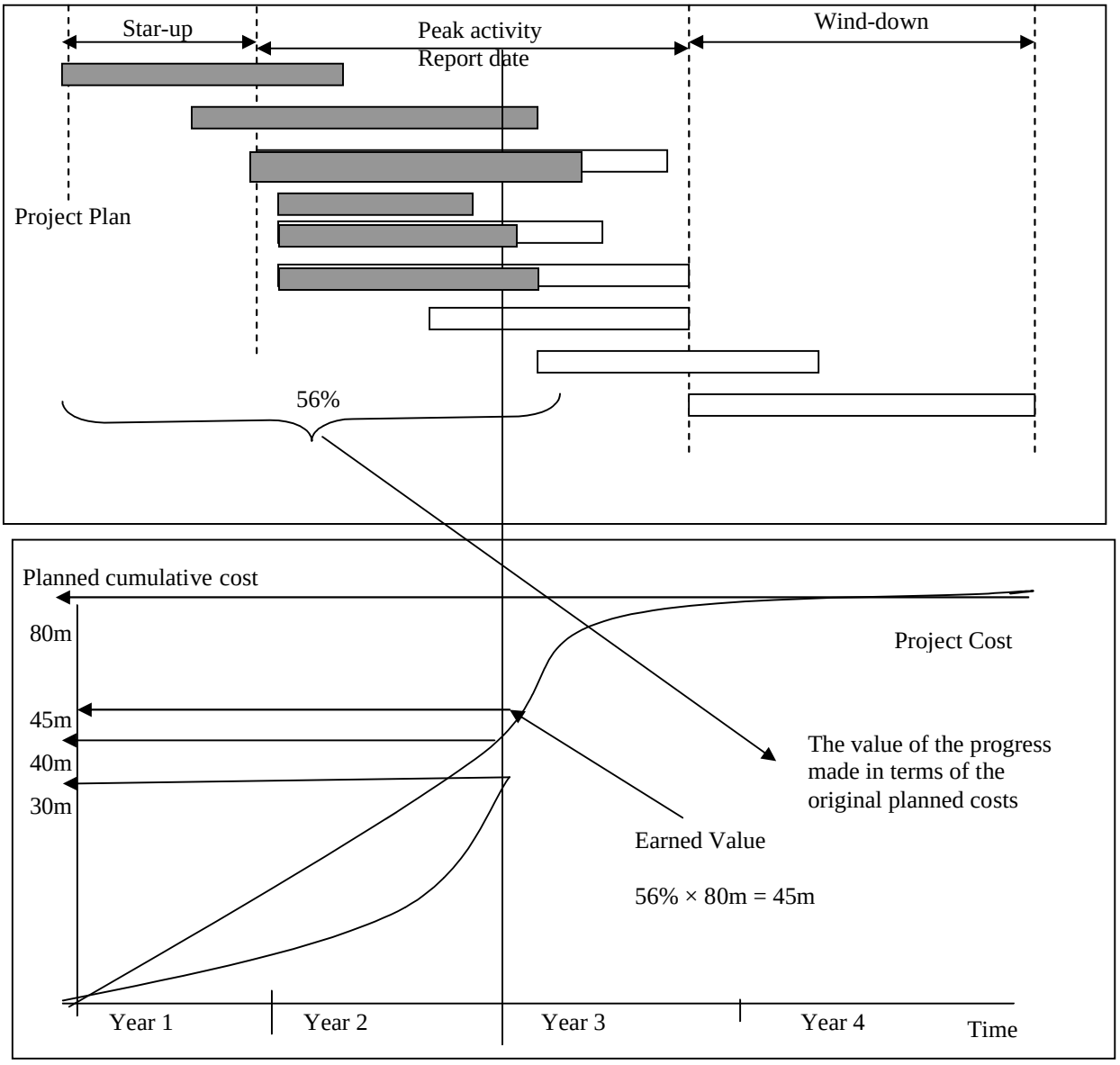
Source: Webb (2003), pp. 20

Figure 5 Planned and actual expenditure for a project at the mid-point of its life

A typical concern for the project managers is how well is the project doing at a particular standpoint, which might be useful for a prediction of the final outcome of the project. Depending on the perspective from which one looks different answers can be obtained. The planned budget for the period of two years is 40 million while the actual cost is only 30 million. One can say that the project is well behind the planned performance, or on the other hand it might be good to have spent less than it was planned. In practice the actual performance of the project cannot be evaluated when only looking at this data. Further clarifications of the work achieved are necessary in order to make a statement for how well in fact the project is doing.

Suppose that the below figure is a picture of the actual assessment of progress. The shaded area, which represents the achievements, equals 56 per cent of the total work content at the reporting date.

Fifty-six per cent of the total budget of 80 million is 45 million. This figure represents the value that is being earned at this point of work progress. When comparing the above figure with both budgeted 40 million and actual cost of 30million, it becomes obvious that the project is doing very well. The figure shows that a work that is worth 45 million is being accomplishes at the cost of 30 million. One can also forecast that if nothing changes, the project will be completed at earlier than scheduled time and at a cost below the budgeted.



Source: Webb (2003), pp. 23

Figure 6 Earned value assessment for a project that is running ahead of schedule

In his study, Webb (2003) highlights that when calculating the earned value at a reporting date and later plotting it against the planned value and actual cost curves allows analysts to see the precise position of the project in terms of both its costs and its progress. The described process is said to be the basis of the earned value method. The author considers two aspects as the most important for the earned value. The first is to consider the fixed relationship between the plan and the costs and the second, is the ability to make an accurate assessment of progress. According to Webb (2003), important feature of the approach is the distinction between the sum that has been spent and the value that has been created or 'earned', as opposed to being planned or scheduled.

3.3.2 Earned Value Terminology

Department of Defense Instruction DODI 7000.2 defined a series of terms that have become synonymous with the earned value method of performance estimation. Those terms become standard terms, are widely used, and are likely to remain in use for the foreseeable future. Some of the most common terms are described below:

- **Actual Cost of Work Performed (ACWP) (Actual cost)** – This is the total of all expenditure on the project, or part of the project, up to the reporting date; it is the sum of what has actually been spent irrespective of what has been planned or achieved (Fleming & Koppelman (2002)).
- **Budgeted Cost for Work Performed (BCWP) (Earned value)** – This is the cost of all the progress achieved on the project, or part of the project, up to the reporting date and expressed in terms of the planned value originally set out in the initial estimate; it is also called the 'Earned Value' as it represents what has been earned, not simply what has been spent (Anbari(2003))
- **Budgeted Cost for Work Scheduled (BCWS) (Planned value)** – This is the sum of all the planned costs in the project, or any given part of the project, up to the reporting date (Kim & Ballard (2002)).
- **Cost Variance (CV)** – This is the numerical difference between the earned value and the actual cost at the reporting point $(CV = BCWP - ACWP)$[9]

[9] DODI 7000.2

- **Earned Value Management System (EVMS) criteria**.[10] It defines the attributes that management control systems must possess for earned value to be used effectively. Currently, there exist 32 EVMS criteria which are systemized into five categories that are attached to major project management activities: (1) organization, (2) planning and budgeting, (3) accounting, (4) analysis, and (5) revisions. Each criterion addresses a major principle necessary for effective management of large, flexibly priced defense projects.
- **Schedule Variance (SV)** – This is the numerical difference between the earned value and the planned expenditure at the reporting point ($SV = BCWP - BCWS$) (Branch (2004))
- **Work breakdown structure (WBS)** – PMBOK® Guide, pp.209, defines the WBS as "a deliverable-oriented grouping of project elements that organizes and defines the total work scope of the project. Each descending level represents an increasingly detailed definition of the project work". Tausworthe (1980) defines the WBS as an enumeration of all work activities in hierarchic refinement of detail, which organizes work to be done into short manageable tasks with quantifiable inputs, outputs, schedules, and assigned responsibilities. Some of the characteristics and benefits of the WBS are reviewed, and ways in which these can be developed and applied in software implementation projects are discussed. Although the material is oriented principally toward new-software production tasks, many of the concepts are applicable to continuing maintenance and operations tasks.

3.3.3 Methods for Measuring the Earned Value

In order to measure the earned value, one has to apply a particular method that will functions as a measurement rule. According to Kerzner (2003), there are several techniques that are known as rules for measuring the earned value. A brief description of those is provided.

One of the most commonly used technique is the 50/50 rule, which indicates that "half of the budget for each element is recorded at the time that the work is scheduled to begin, and the other half at the other half at the time that the work is schedules to be completed." (Kerzner

[10] Since 1967, the department of defence (DOD) has required contractors to comply with Cost/schedule Control System Criteria (C/SCSC) on "significant" DOD contracts. These criteria now termed Earned Value Management System Criteria, are nothing more than standards intended to ensure that contractors use sound business practices. Reports from criteria-complaint contractors provide insight to the cost, schedule, and technical progress of the contract. (Source: Cole & Fussel (1997) pp. 1)

(2003), pp.588) The author mentions that this technique is not applicable for projects with large amount of elements involved.

The 0/100 approach is applied to projects that involve work packages with small duration. It indicates that no value is earned until the task is completed. (Vargas (2005))

Projects with long work packages use the milestones approach, which states that value is earned when the milestone is accomplished. (Fleming (1992))

The per cent complete rule is usually invoked for projects with long duration work packages where milestones cannot be identified. The earned value is reported as a per cent of the budget. The cost formula method, also known as the 80/20 method is a variation of per cent complete for long duration work packages. (Kerzner (2003))

A discussion subject on, which method should be used to measure the earned value was held. PhD Sjögren[11] doubted if the method is a tool for cost control or for project monitoring. It is believed, however, that the method does both functions. For instance, if one uses the milestones method, it could be interpreted that the earned value is a method for project monitoring, as one is not only interested on the completion of the tasks but also on the wellbeing of the whole project. Contrarily, if one sets the per cent complete method, the earned value could be interpreted as a driver for cost control. This may be so as with the per cent complete the project manager controls mostly the right resource usage and activities completion, rather than the completion of the "critical activities"[12]. It should be recognized, however, that given that the project correctly planned, by following the plan one also makes sure that the "critical activities" are accomplished on time and the health of the project is good.

A personal standpoint is that there is not big difference if one uses the milestones or the per cent complete. What is of great importance is that the project is well planned.

Next the earned value calculations are disclosed.

3.3.4 Earned Value Calculations

Webb (2003) suggests that there are three types of calculations that are known as the most common calculations within the earned value technique. The first, and the simplest is the calculation of the variances, the second is the calculation of the indices, and the last is the

[11] The discussion was held with PhD Stefan Sjögren on December 16, 2005.

[12] Referring to the critical part method, there are activities (A) predecessors to other activities (B), meaning that if the activity A is not accomplished it is not possible to start with activity B. Thus a delay in activity A will lead to delay in activity B, and possibly to delay in the whole project process.

calculation of the estimated time and cost at completion. Below the three types of calculations are presented.

Variances

As it is mentioned in previous section two variances are acknowledged as significant for the implementation of the earned value technique. Those are as the cost variance and the schedule variance. Again the cost variance is the difference between the earned value and the actual cost at the reporting point, while the schedule variance is the difference between the earned value and the planned expenditure at the reporting point (Webb (2003)).

A way of implementing the meaning the variances is to look at their value. For simplicity the variances are supposed to be either negative or positive without taking a particular numerical value. Thus, a common rule is that whenever the cost or schedule variances are negative, the project is in a bad position, and opposite when the variances imply positive values the project is in favourable position compared to the planned values (Webb (2003), Kerzner (2003), PMBOK® Guide, Mayor (2003), Fleming & Kopplman (2000)).

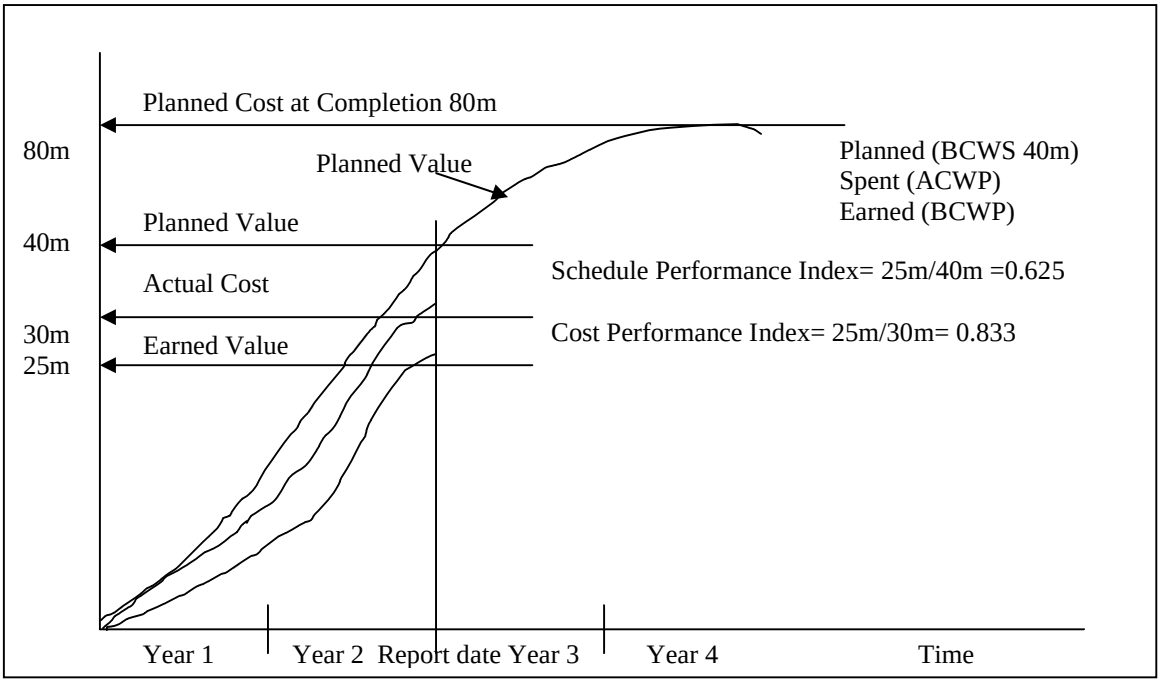
The distinction between cost and schedule variances is one of the advantages of the earned value method compared to other methods.

The data used for calculating the variances is either periodic or cumulative. If the variances are calculated, starting from the earliest stage of the project, the project manager will obtain information, which might show problems in either cost or schedule performance, and thus be able to take appropriate actions.

When comparing the two variances, the cost variance takes stronger positions as the practice shows that it gives a more reliable value. This statement is supported with the fact that the cost variance is estimated by only actual values (earned value and actual cost), while when estimating the schedule variance both actual and planned values are used (earned value and planned value), and the planned value is often inaccurate.

Indices

Webb (2003) displays two types of indexes that have a meaning for the earned value method. One of them shows the cost efficiency and the other is an indicator for the schedule efficiency. Those are respectively the cost performance index and the schedule performance index.



Source: Webb (2003), pp.26

Figure 7 The Cost and Schedule Performance Indices

- Cost Performance Index - (CPI) (Cost efficiency) The ratio of the value created to the amount spent at a point in time in the project

$$CPI = \frac{BCWP}{ACWP} = \frac{Earned\ Value}{Actual\ Cost}$$

- Schedule Performance Index - (SPI) (Schedule efficiency) – The ratio of the earned value created to the amount of value planned to be created at a point in time in the project

$$SPI = \frac{BCWP}{BCWS} = \frac{Earned\ Value}{Planned\ Value}$$

The step after estimating the ratios of the indices is the most essential one, and namely the interpretation of the cost and schedule performance indices. Among others, Fleming & Koppelman (2000), Mayor (2003), Kerzner (2003), interpret the mentioned indices as it follows. If the index values are greater than one, it can be stated that the actual performance is better than the planned. Contrarily, if the index values are less than one, the performance is worse than planned. Comparing the two indices, the cost performance index is said to be more

useful from the two as it indicates the real worth being created by the project. For instance, if the obtained value of CPI is 80 per cent, one can interpret that for each euro spent, only 80 cent worth of value is being created on the basis of the original budget.

Among others, Kim & Ballard (2002), show that the schedule performance index is less precise, since it uses monetary terms as an analogue of time, which is not always correct[13]. However, both indices are very valuable indicators of the project performance to date and are used to forecast the performance in the future if nothing is changed. If for instance, in some mid point of a project, both index values are calculated to be less than one, one can be almost certain that the performance at the end point of the project will be worse than what it is initially planned. Thus, if a trend is being established, it is much more likely that it will hold the same or even worsen until the end of the project than that it will improve with time.

Often the planned value is over or underestimated, and since it is just an estimation, there is always a risk that the value will not be correct. The actual value, though, being time or cost is more precise, and if there are no errors in the reporting, one can say that the actual value is more exact[14]. Thus, when comparing the cost and schedule performance indices, one can certainly say that the cost performance index gives more accurate information, as it includes only precise actual costs, while the schedule performance index might contain errors based on imprecise estimation of the budgeted values.

One may wonder how do we measure the budgeted, earned and planned values. Based on experience it can be said that there are two ways of measuring. Either the time or the cost can be used as input data. Thus the variables in question will be budgeted/planned time, actual time, and earned time value, or budgeted/planned value, actual cost, and earned cost value. To project managers it is recommended to use both time and cost estimates, and when calculating the indices compare the values. If doing so two values for each cost and schedule performance index will be obtained. Those values, however, must be very similar as they bear the same meaning. It has been observed that the cost performance index estimated from cost data and the schedule performance index estimated by schedule data are more precise.

Estimates at completion

There are two significant forecasting numbers for the project management that could be estimated. The first is the estimated cost at completion and the second is the estimated time at completion. These numbers are usually calculated on a regular basis during the lifespan of the

[13] It is not completely agreed with this argument. It is also possible to use schedule data input in order to calculate SPI, and then the index will use schedule to express time.

[14] Further in the paper a discussion about the accuracy of the actual cost will be held.

project. Webb (2003) reports that the formula of the estimated cost at completion is made up of two parts, namely the cost, which is already spent, and the estimate of the future cost, under the assumption that nothing in the project is changed and it follows the existing trends.

- Estimated Cost At Completion (EAC) – The estimated end cost when the project is completed is calculated by the formula:

$$EAC = ACWP + \frac{BAC - BCWP}{CPI}$$

, where BAC is the budgeted cost at completion

A research carried out on a big number of projects in the United States shows that the EAC most likely gives optimistic prognosis of the cost of completion.

According to Webb (2003) the formula of the estimated time to completion consists as well of two parts, which are the time spend until the estimating point and the estimated additional time necessary to complete the project.

- Estimated Time To Completion (ETTC) – The estimated duration of the project is completed is calculated by the formula:

$$ETTC = ATE + \frac{OD - ATE \times SPI}{SPI}$$

, where ATE is the actual time expended, and OD is the original duration

Webb (2003) states that it could be seen that a "straight line is drawn from the actual cost value to the predicted end conditions. This is because these expressions say nothing about the shape of the cost curve, they are simply point functions and simple linear relationships." In most of the cases the cost curve takes the shape of an S-curve, however the shape of the curve may vary from one project to another. Thus, one cannot say with certainty what shape the curve will take.

One can develop further the above equation:

$$EAC = ACWP + \frac{BAC - BCWP}{CPI}$$

, where $CPI = \frac{BCWP}{ACWP}$

Therefore one can substitute:

$$EAC = ACWP + \frac{(BAC - BCWP) \times ACWP}{BCWP}$$

Next the expression can be brought to common denominator, and thus:

$$EAC = \frac{ACWP \times BCWP + BAC \times ACWP - BCWP \times ACWP}{BCWP}$$

$$EAC = \frac{BAC \times ACWP}{BCWP}$$

Since $CPI = \frac{BCWP}{ACWP}$

It is obtained that: $EAC = \frac{BAC}{CPI}$

The above expression bears the meaning that the estimated cost at completion is the original budgeted cost at completion divided by the cost performance index.

Next the estimated time to completion (ETTC) is taken into consideration. Its formula consists of two parts, the actual time spent and the estimated future time needed to complete the project.

$$ETTC = ATE + \frac{OD - ATE \times SPI}{SPI}$$

The above is brought into common denominator, thus

$$ETTC = \frac{ATE \times SPI}{SPI} + \frac{OD - ATE \times SPI}{SPI} = \frac{ATE \times SPI + OD - ATE \times SPI}{SPI}$$

$$ETTC = \frac{OD}{SPI}$$

The above expression bears the meaning that the estimated time to completion equals the original planned duration divided by the schedule performance index.

To sum up, two important formulas have been derived:

$EAC = \frac{BAC}{CPI}$ and $ETTC = \frac{OD}{SPI}$, both of them showing estimates to completion.

When analysing the above expressions it comes to the attention that the estimated cost to completion is more probable to give exact results than the estimated time to completion. It is so as the EAC is the budgeted cost divided by the cost performance index. Errors could be made when estimating the cost planned, but as it was mentioned before the cost performance index bears an accurate value. The estimated time to complete is the planned time divided by the schedule performance index. Here both values are probable to contain errors. Hence, the degree of accuracy is higher in the estimated cost at completion as only one of its contents can include errors.

- To Complete Performance Index (TCPI)

Fleming & Koppleman (2000) discloses one additional method to monitor projects earned value performance. “It is a display that tells management precisely what performance factor

must be achieved on the remaining work in order to stay within the financial goals set by the management."(Fleming & Koppleman (2000), pp. 137)

The to complete performance index is calculated by the formula:

$$TCPI = \frac{Work\ \mathrm{Re}maining}{Funds\ \mathrm{Re}maining} = \frac{Original\ Budget - Earned\ Value}{Original\ Budget - Actual\ Cost}$$

In addition to the theoretical formulas for calculating the earned value, the study presents a case where the calculations of the earned value are preformed with actual data. The case is considered to be an easy example of the earned value in practice, and is placed in appendix IV.

In order to highlight the importance of the earned value approach, it is compared to another, similar approach for project valuation. Additionally, the earned value is examined by finding advantages and disadvantages of using it.

4 EARNED VALUE: DISCUSSION

In this chapter, a critical discussion about the earned value method is executed. The chapter aims at evaluating the earned value method. Two aspects of evaluation are covered. Firstly, the latest evolution of the method is disclosed, together with comparing the earned value as it is now to its latest predecessor- the traditional cost management method. Secondly, the advantages and disadvantages of using the method are stated. Most of the chapter is based on previous researches, when weighting the advantages and disadvantages, however, in addition to the previous researches, some experienced facts are taken into consideration.

4.1 Earned Value Evolution

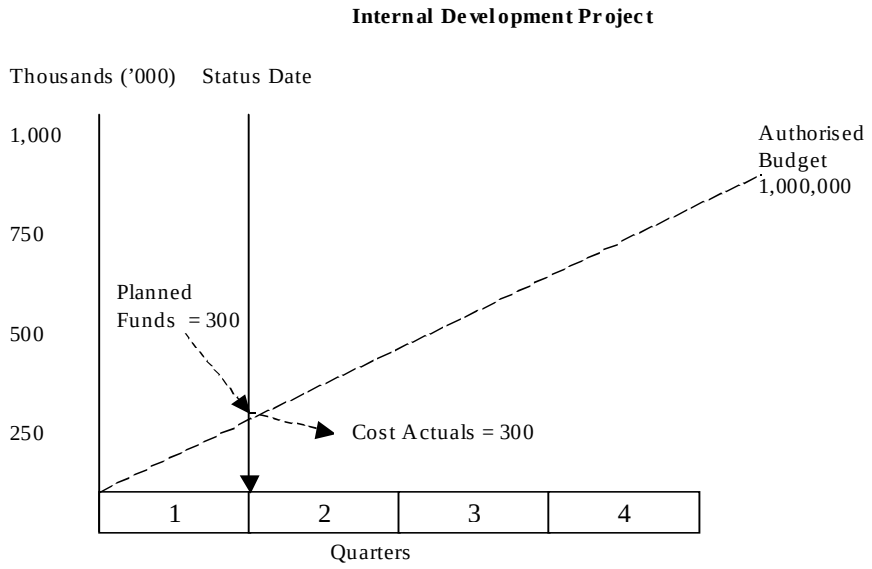
With this section it is aimed to gain an insight of the evolution of the earned value concept. It is desired to examine the earned value, and find out if according to the literature used if this method is the most appropriate for project valuation.

According to Fleming & Koppelman (2000), the concept of earned value has been around for over a hundred years. Depending on the time period, it changed various names, including industrial factory standards, earned value management, performance measurement, the Planned Value of Work Accomplished (PVWA), the Budgeted Cost s of Work Performed (BCWP), the Cost/ Schedule Control System Criteria (C/SCSC), the Cost/Schedule Planning Control Specification (C/SPCS), the criteria, Program Evaluation Review Technique (PERT)/ cost, and other titles. In addition to this statement, it should be said that a number of the above mentioned techniques are still in use. It is believed that the earned value has taken some of the features of the discussed techniques, in order to remain the shape it is now in.

The company, in which this thesis is employed uses in its daily work one of the predecessors of the earned value. The technique is called, by Ericsson, and by Fleming & Koppelman (2000): The Traditional Cost Management.

Below the traditional cost management approach is discussed.

Assume a project cost-expenditure plan such as the one shown in the figure below.



Source: Fleming & Koppelman (2000), pp.18

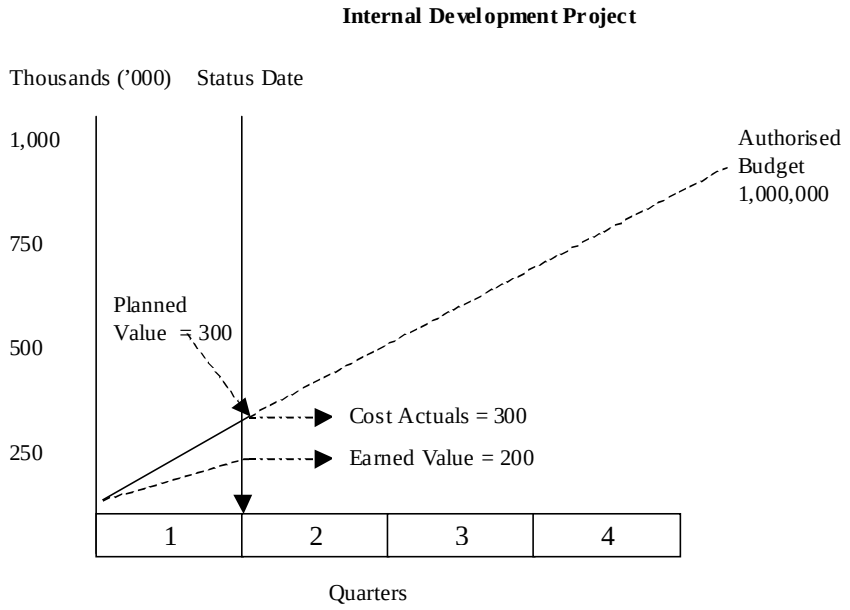
Figure 8 Traditional Cost Management: Plan versus Actual Costs

The figure shows one million- project with duration of one year. After the end of the first quarter, the forecasted cost equals 300,000. The project manager is expected to monitor the performance of the one-year project and stay within the budget limits of 1 million.

When applying the traditional approach after the first quarter, the project manager will realise that the approved spend plan of 300,000 is fulfilled, meaning that under the period of 3 months, or one quarter the whole budget has been spent. The described situation may call for a perfect cost performance. However, a more realistic picture of the performance can be drawn.

Fleming & Koppelman (2000) report that in order to determine the actual project performance it is necessary to consider the schedule status alongside of the costs' status. Problems can occur if the project's cost support organization has developed their displays using one technique (e.g breakout of costs by function), and the scheduling department developed their charts applying another approach (e.g reflecting work tasks). As a result, it will be impossible to relate the true cost and schedule status when those two key functional groups develop their respective plans using different assumptions. However, it is fairly common practice to do so.

To avoid such problems the traditional cost management evolutes to the earned value method. The figure below provides an overview of the earned value method.



Source: Fleming & Koppelman (2000), pp.19

Figure 9 Earned Value Project Management: Three Dimensions

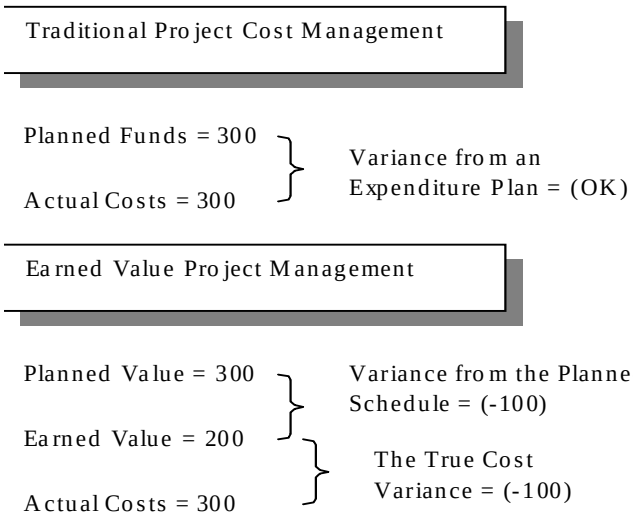
With the above figure Fleming & Koppelman (2000) show the actual physical earned value of only 200 against the planned value of 300. From this, it can easily be seen that the project is running behind the planned work to be done in the first quarter. The difference between planned versus accomplished is 100, and it is said that the project is running negative 100 schedule variance. Another interpretation of the above figure is that the project has spent 300 while the achieved work is only 200 worth of earned value. This condition is called "overrun". The project is running negative 100 cost variance.

The earned value approach can give an accurate prognosis of the final cost of the project.

To sum, it can be said that the project is not running well. However, it is difficult to discern that condition using the traditional cost management approach.

4.1.1 Traditional Cost Management versus Earned Value

In their findings Fleming & Koppelman (2000) point out that there is an important distinction between the data available when using the traditional cost-control approach and for using the earned value technique. The differences in the data can be observed in the below figure.



Source: Fleming & Koppelman (2000), pp.20

Figure 10 The fundamental differences

Looking at the top of the figure (Traditional Project Cost Management) one gets the data for planned values and actual costs. Using only this information it is practically impossible to find out how much of the physical work of the project has been accomplished. Since the difference between the two measures is zero, one makes the conclusion that there are perfect results against the original spending plan. However, it is only possible to make conclusions about the funding, not the cost performance.

In contrast the earned value technique displays three dimensions of variables: the planned value, actual costs, and the earned value. Thus two critical variances can be ascertained. The first is the variance from planned value, which shows how much of the planned work has not been accomplished (when the variance is negative) in the time frame being measured. The variance from the planned schedule is the difference between the earned value and planned value.

The second variance, the true cost variance, is often considered to be of greater importance, since it indicates the relationship between the actual costs and the earned value. This variance shows what is the relation of the cost of the work done and the worthiness of the work accomplished. It is calculated as the difference between the earned value and the actual costs. A negative variance indicates cost overrun. The above figure illustrates that a total of 300 was expended to accomplish only 200 worth work, which indicates a negative variance of 100.

At present, the majority of the project managers in the Global Services department of Ericsson AB use the traditional cost management for valuing and monitoring their projects. According to the above discussion, this means that only conclusions about the funding of a given project

can be made. Thus the personal standpoint is that at present the project manager are rather monitoring than controlling the project.
Next the costs and benefits from using the earned value are to be discussed.

4.2 Costs and Benefits from Using the Earned Value

When valuing a certain tool, it is not only needed to compare it to other tools of similar kind (the traditional cost management). Ones, one knows that among others, the earned value is a better method for project valuation, it is necessary value the method internally by listing the advantages and disadvantages from using it.

4.2.1 Ten Benefits of Using the Earned Value Method

Fleming & Koppelman have first published a book regarding the earned value in 1996, and devoted a chapter describing the benefits from using the earned value methods. Ever since the concept of the ten benefits from earned value management become very popular. Below the ten benefits are briefly described.

1. A single management control system providing reliable data
2. The integration of work, schedule, and cost using a Work Breakdown Structure
3. A database of completed projects useful for comparative analysis
4. The cumulative Cost Performance Index as an early warning signal
5. The Schedule Performance Index as an early warning signal
6. The Cost Performance Index as a predictor for the final cost of the project
7. An index-based method to forecast the final cost of the project
8. The To-complete performance index to evaluate the forecasted final cost
9. The periodic (e.g., weekly or monthly) Cost Performance Index as a benchmark
10. The management by exception principle can reduce information overload

Source: Christensen (1998), pp. 10

Table 1 Ten benefits from the EV management

Benefit 1. The earned value is a technique that reflects a precise picture on both the cost and schedule (time) performance. It is an advantage to use a single tool to measuring the performance of all projects in a company despite their size and variability. That way the performance comparison gives more realistic results (Cole & Fussell (1997)).

Benefit 2. With the use of work breakdown structure, all critical functions will be expected to work within an integrated project plan. The WBS ensures a proper integration of work, schedule, and cost (Schulte (2005)).

Benefit 3. A part of the earned value management is the continuously reporting of the results obtained in various projects. All these data can be used for a comparative analysis with respect to the new coming projects.

Benefit 4. The cost performance index is calculated as the earned value divided by the actual cost. These values can be obtained in an early stage of the project and thus the value of the CPI can also be seen in this early stage of the project. Having the CPI one gets a picture of the cost performance, and has the opportunity to make changes. If no changes are made, Christensen & Heise (1993) observe that in most cases the CPI only worsens.

Benefit 5. The schedule performance index is calculated as the earned value divided by the planned value. The SPI can be obtained in an early stage of the project and if it indicates problems, it is possible to adjust. The schedule problems are often resolved by additional spending, therefore the SPI can also indicate a predictive of later cost problems (Schulte (2005)).

Benefit 6. Fleming & Koppelman (2000) point out that the cumulative CPI is used for determining a lower limit for the estimated final cost of a contract, which is useful for planning and control purposes.

Benefit 7. According to Fleming & Koppelman (2000), the combination of both cumulative CPI and SPI provided the ability for forecast the final cost result of the project. This technique is considered as finding the “most likely” or the “high end” in the range of statistical possibilities.

Benefit 8. Christensen (1994) shows that the To-complete Performance Index (TCPI), is useful for evaluating the reasonableness of the contractor's EAC or other financial goals.

The TCPI is the ratio of the remaining work to the remaining financial resources. It indicates the level of performance that the contractor must achieve to reach a financial goal. Thus, this earned value metric can help the project manager assess the reasonableness of critical financial goals, such as completing the remaining work within the targeted cost.

Benefit 9. In their studies Fleming & Koppelman (2000) find that the periodic CPI (usually weekly or monthly) CPIs are useful for cost performance trends at the detailed levels of the WBS.

Benefit 10. Last but maybe the most ultimate according to Fleming & Koppelman (2000) is that by using the EVM, the management do not necessarily has to follow each task in order to

oversee the performance of the authorized work. Rather, by focusing on only those exceptions to the authorized plans in accordance with specified variance thresholds, management can effectively monitor all critical aspects of performance against the project.

4.2.2 Costs of Using the Earned Value Method

In their study Fleming & Koppelman (2004) point out some of the cost of the earned value method, and more precisely they give explanations of why the earned value is not used in all the projects. The first reason is that "the EVM advocates often speak in a foreign tongue". It is explained that when using the EV a number of terms (such as BCWP, ACWP, WBS) complicated for untrained personnel are used. Thus, often when reporting the position of a given project it is difficult to understand without a special tutorial. In the year of 2000, the PMBOK® Guide to a certain degree found a solution to this problem. Currently, instead of using references such as BCWS and BCWP more simple and understandable references are used, which are respectively Planned Value and Earned Value. The second reason provided by the study is "because initially the United Stated Department of Defence (DOD) defined EVM to acquire 'major systems'". This means that in the past the method was associated with big and complicated projects as well as with a complicated technique. However, in fact the technique of EV is not complicated, but in order to achieve efficiency it has to be applied to projects with longer time span. The third and last reason mentioned in the study is "because sometimes management...doesn't really want to know the full cost!" Even though on the first sight this sounds ridiculous, Fleming & Koppelman (2004) explain that project managers are "optimistic in their nature", and if the EV indicates that the project is in cost overrun and should be closed down, it will be difficult to reject that notion, as the EV method gives a precise results on a early stage of the project. Sometimes management would not either like to know the predicted final costs of a project, since they might get bonuses based on their (cost) performance. Having known that the cost of a project will be more than planned the performance of the managers will drop and so will their bonuses.

Brandon (1998) draws the attention to four problems associated to the EV method.

The first problem is that the " commercial awareness of earned value is minimal; corporate training courses rarely discuss earned value, and there is relatively little in commercial print on the subject." Second, since the method is tightly involved to the calculation of predicted final costs and time of completion, detailed data acquisition is required. The process of data collection, however, in most of the cases is too costly and time consuming. The third reason

according to the author is that the reporting of the EV is not being “handled in an easily implemented manner”. The fourth and last problem discussed in the paper by Brandon (1998), is that there are major employee and contractor resistance issues when trying to put earned value into practice. In conjunction to Brandons’ second problem, an article by Vargas (2003), states that the earned value method for project performance valuation is nearly as popular as the net PERT/CPM. A survey with 400 professionals showed that the earned value analysis is used by 41 per cent of the people who worked with projects.

Howes (2000) mentions that the estimated cost to completion is based on past performance and this may not always be a correct estimation, as the future of the project could be unrelated to the past performance, and therefore the assumption that the future performance will be the same as the past will appear to be wrong. As it was stated before the schedule variance is the difference between the earned and planned values. Thus, if these values are based on costs as input, the schedule variance will only relates to cost performance, where the time as it relates to the completion of project activities in their logical sequence is abandoned. Howes et al. (1993), recognizes this as a serious problem, because cost is not always proportional to time. It is, therefore, reasonable to assume that the predicted project duration must be treated with extreme caution (Sparrow & Wrisley (1999)). Thus, one own contribution is the recommendation to use cost data when estimating cost variance and schedule data when estimating the schedule variance

Howes (2000), General Accounting Office (1996), state that in its basics, the earned value method does not account for changes in the project (in the form of additions and omissions of activities). Hence, this must be taken into consideration when determining the performance indicators used to calculate project cost and time predictions.

In his article Ruskin (2004), finds two problems when using the earned value measurements. Those are the treatment of the partly completed work, and the level of product oriented work breakdown structure, at which measurements should be made. The article proposes that the earned value measurements should be made at the earliest stage of the project and 0/100 approach should be used. With this, it is desired to evaluate the project at the earliest stage, so that a decision for implement or abandon can be made. As a researcher, the validity of the above proposition is questioned. It is agreed that measurement should be made along the project lifetime, starting from the earliest stage, however, it is disagreed that the 0/100 approach is a best measuring tool. As mentioned in further sections, the 0/100 approach is considered to give very rough earned value estimates, which are not satisfactory for project

valuation. Hatfield (2004) suggests that the 0/100 approach should be only used for activities with very short duration.

Thamhain (1998) states that the earned value technique has a little applicability, which is a result of different barriers. As mentioned in among others, the above source, the barriers are: "Lack of comprehension of how the technique works; Anxiety concerning the adequate use of the tool; Use of the tool requiring a lot of work and time consumption; Tools trimming creativity in the use of other strategies; Inconsistency of the tool in managerial procedures/business processes; Method of control as a threat, concerning the freedom of the team; Vague and inaccurate purpose and its benefit; High cost of its implementation; Unsuccessful prior experience in the use of other techniques; Low familiarity with the technique" (Vargas (2003) pp. 1)

4.2.3 Overcoming the Costs of Using the Earned Value Method

In this section, based on existing literature and own experience, different ways of overcoming the problems associated with the use of the earned value method are suggested.

4.2.3.1 Overcoming the Data Acquisition Problems

Brandon (1998) suggests a way for overcoming data acquisition problems by using non-intrusive methodology for data collection and yet it should provide with the necessary accuracy. Non-intrusive method is such that requires very little extra effort by project team members or project managers to provide the input data for the analysis. The author suggests that for a successful obtaining of a non-intrusive method of data collection, three key objectives have to be present. Those are setting appropriate work package size, appropriate definition of per cent complete, and appropriate basis for costing.

In case that the work packages are small, the project-involved employees will do excessive reporting paper work. If the work packages are big, the project performance will not be measured on the optimal frequency level so that corrective actions can be undertaken. In both cases there is inefficiency.

Per cent complete estimates must be provided for each work packages on a regular reporting basis. When debating the issue of an appropriate way to measure the earned value, or the percentage complete work, it became evident that not in all cases it is possible to be

absolutely exact (with accuracy of 1 per cent). Instead the interviewed suggested that it is reasonable to report 0, 25, 50, 75, or 100 per cent completion of the work package.[15]

Brandon (1998) recognises that the actual costs is a major problem in many organizations. Those cost are often not obtainable in a timely manner, meaning that the costs might be reported a month after they take place. In order to overcome the cost reporting delay, the author suggests setting up a "feed forward" cost reporting system instead of a "feed back" cost system, which usually comes off the company's general ledger. The “feed forward” cost reporting system can be organized as employees estimating the expenses for the coming month and thus reporting that value to the project managers. Thus the project managers will use the cost estimation to predict final costs and time. After the end of the month the project managers are usually accessing the exact actual cost data as then the financial department has accounted for it.

Usually in large corporations and big projects, there are many people involved in one work package. Thus the question of how to measure the per cent complete of the work package when there are more that one person working on it arises. The project manager can receive reports of work complete from all workers, but in that case she will access too detailed data, requiring extra work to sort and format the data to the shape of which it could be used. Therefore, it is suggested that in such cases, one responsible person should be appointed to sort the data and report the total percentage complete of the particular work package to the project manager.[16]

4.2.3.2 Overcoming the Reporting Problems

Usually reporting earned value is not notified as easy among project managers. Brandon (1998) discovers several reasons for that. The first one is that it appears to be difficult to get the actual costs into a project so that the real costs can be used in the system's earned value method. The second difficulty comes when trying to set an automatic interface between the corporate systems (or departmental databases) and a project management system. This action is yet not commonly accepted in companies and a standard format such as a spreadsheet for

[15] Brandon (1998) provides with the following example. “If reporting is weekly for a one-year project, and if the average work packet size is a week, then the maximum error (assuming current week's tasks estimated 50% in error, and all off in the same direction) would be (Average Packets Per Week * Average Cost Per Packet * 0.5) / (Total Cost), which reduces to (.5/52) or about 1%. Thus, if we had a project with a planned cost of $1,040,000 over a year with 520 work packets (average 10 per week), the maximum error in analysis at each month end would still only be about 1%.”

[16] This problem is also present in some of the ongoing projects in Ericsson.

doing this does not exist. The third reason is that using the earned value mechanism in these systems cannot be characterised as simple.

Brandon (1998) suggests a way to find the actual costs in order to estimate the cost variance and the cost at completion, by simply involving a database product (Access) or an excel spreadsheet.

4.2.3.3 Overcoming the Employee/Contractor Resistance Problems

Brandon (1998) draws into attention that in order to run a successful business it is necessary to adopt a performance measurement system that is accepted by all project members and is concentrating on the performance measurement of a project, not individuals. It is typical that the earned value analysis is viewed as an employee evaluation. In order to prevent that, Brandon (1998) suggests additionally employ some form of Total Quality Management (TQM) along with the earned value technique. Thus it is recommended that the management uses the earned value for exploration of project cost to complete, time to complete, defining the project weak areas, and not for the use of measuring individuals performance.

4.2.4 The Problem with the Cost of Capital

One important issue when undertaking a project is how it will be sponsored and what kind of return it will provide to the shareholders. According to the investopedia dictionary[17] the cost of capital is the required return necessary to make a capital budgeting project worthwhile. Cost of capital includes the cost of debt and the cost of equity. Thus it becomes evident that in order to make a good investment project related decision it is necessary to estimate a reasonable cost of capital that will be satisfactory for the investors. Most of the project valuation techniques are based on the cost of capital, in the earned value method, however, it is not evident what kind of cost of capital it used. Thus, one might doubt if this technique takes the cost of capital in consideration at all.

Based on the experience earned at Ericsson, it is possible to say that the cost of capital is usually included in the planned/ budgeted value. The company sets its budget so that if it is fulfilled, the return on the investment will be satisfactory. Thus, on the first sight it might seem that the earned value does not account for cost of capital, when in fact it does.

[17] http://www.investopedia.com/ - 2005-11-08

A particular problem at Ericsson is that in the system integration projects (see appendix I) multiple changes are involved, due to customers changed desires. Thus, it happens that the initial budgets are changed. Therefore, because of the multiple changes, one can experience difficulties accounting for the cost of capital every time a new budget is made.
The below table is a summary of the problems and possible solutions of the earned value method.

Problem:	**Solution:**
EV uses complicated terms, such as BCWP, ACWP (Fleming & Koppelman (2004))	Use simple terms such as EV, AC, PV
Commercial awareness is low (Brandon (1998))	
Detailed data acquisition required (Brandon (1998))	Set appropriate work package size, appropriate definition of per cent complete, and appropriate basis for costing (Brandon (1998))
AC problem (Brandon (1998))	Feed forward method
Employee contractor resistance problems (Brandon (1998))	Project managers should point out that the EV is a tool for project performance valuation, but not for measuring individual performance
Estimates to complete are based on past performance (Howes (2000))	
The basics of the earned value method does not account for changes in the project (Howes (2000), General Accounting Office (1996),)	1. Take into consideration when determining the performance indicators used to calculate project cost and time predictions (Howes (2000), General Accounting Office (1996)) 2. The detailed model of earned value
The treatment of the partly completed work (Ruskin (2004))	1. At the earliest stage of the project use 0/100 method (Ruskin (2004)) 2. Use 0, 25, 50, 75, or 100 per cent completion

Table 2 A summary to the problems and solutions of the earned value method

To sum up, the chapter began with a discussion on the evolution of the earned value method, and a comparison of the method to its predecessor, which is also currently used in the Global Services department, namely the traditional cost management. It was concluded that the earned value method is a better tool for project valuation, moreover it was stated that the traditional cost management approach is rather a tool for monitoring a project than for controlling it. The second half of the chapter dealt with the cost and benefits from using the earned value. The overall conclusion from this section is that even though the model is a better tool for project valuation it bears some costs. Some of those are summed up in the above table. From the table it is noticed that most of the problems associated with the method have solutions. Thus the actual disadvantages of the method are only few.
Next, the model of earned value, designed to meet the needs of Ericsson AB is presented. The company will be able to use the model as a tool for valuating projects.

5 THE MODEL OF EARNED VALUE

The following chapter contains a description of the model of earned value, and a guide for implementation the results of the model.

5.1 Description of the Model

The model of earned value is a relatively simple tool that is designed to help project managers in Ericsson to easily understand the concept of earned value management and be able to implement it in their daily work. The designed model is universal, however, in order to use it for a particular project justifications regarding the size and project duration will be needed.

The earned value model is build up on excel spreadsheet and is a complementary tool for project managers. Additional tools such as MS project calculations, or extensive calculations on excel will be necessary in order to fully control a project.[18] The model is a personal contribution to the research area, and it is inspired by interviews with employees of Ericsson, and previous existing template models for project valuation.

Before starting to use the model it is necessary to familiarise with the theory behind earned value, and thus be able to interpret the results. Unfortunately, the EV method can only be used as an indicator of the health of the project and do not suggest a way for improving the project performance.

Before starting to use the model one should carefully read the instructions, which are stored in the first sheet, called *"info"*. The next stage is to adjust the model, so that it fits a particular project. The size and duration of each project is individual and therefore it might be necessary to add rows or columns, else one has to delete. The model is initially designed to fit 21 work packages, and 15 dates. If the present project has more than 21 work packages and 15 control dates, it is required to add rows and columns. Among the other VBA programmes, a VBA program to produce a function in the excel sheet that will make it easier for project managers to adjust the work packages is made. In the planned value sheet ("*PV*") there are two buttons, respectively ON and OFF that connect and disconnect the sheets that can contain changes.[19] If for example the project manager controls a project that has more than 21 work packages or

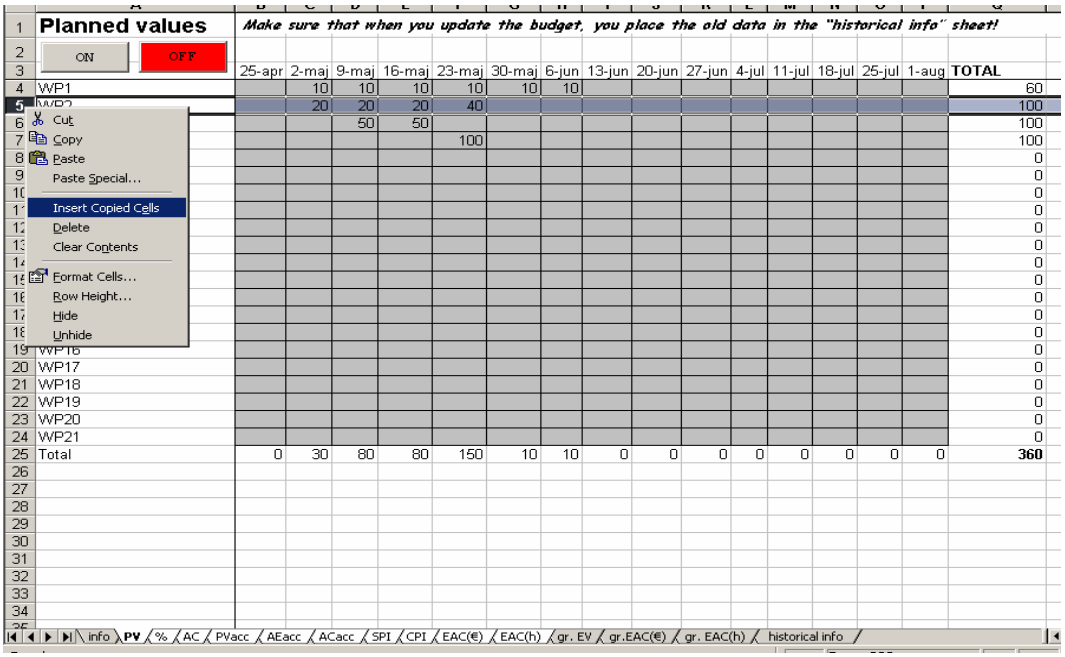
[18] Additionally, more detailed model of earned value that could be used as a single tool for project valuation is designed.

[19] It is possible to adjust the programme so that it links various combinations of excel sheets, depending on where one wants to make changes. The connect function carries that when it is "ON", all the changes made in one of the excel sheets will be also made in the rest of the connected sheets.

control dates, she will have to add rows/columns. In order to keep the inserted formulas in the "*%*", "*AC*", "*PVacc*", "*AEacc*", "*ACacc*", "*SPI,*" "*CPI*", "*EAC(€)*", and "*EAC(h)*" sheets[20], the project manager will have to first connect the sheets by clicking on the "ON" button, copy a number of rows/columns (depending on the number one has to additionally insert), and insert the copied rows/columns. Press "*enter*" and the "OFF" button after the end of the copy procedure, in order to disconnect the excel sheets. Refer to the below picture.

The data that is disclosed in the pictures is a dummy data. It is chosen not to disclose a real project data, as in the organizations' projects usually have multiple work packages, and control dates. If a real example has been shown, the earned value model example would have been much more complicated, and a danger of confusion among readers might have arisen. Thus the model displayed consists of four work packages and six weeks life span.

The next stage of using the model is to fill in the input sheets. Those are the planned vales ("*PV*"), actual cost ("*AC*"), and per cent complete ("*%*"). The areas that would be necessary to fill in are the ones that are marked in grey. See the below picture.



Picture 1 Input cells and sheets

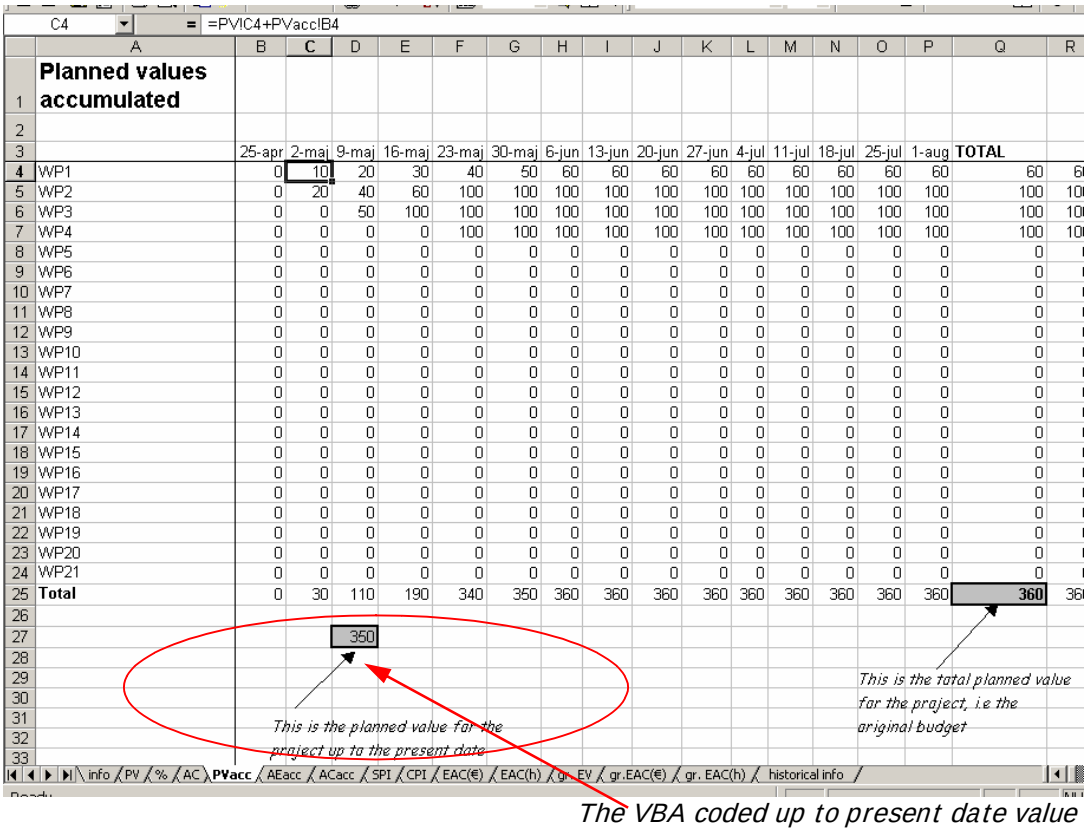
As it could be seen from the picture when input is added the bottom line called 'total' updates to be the total sum per date. Similar calculations are performed in the actual cost sheet.

[20] The sheets "*%*"and "*AC*" are input sheets and therefore do not contain formulas, however, they also have to be "connected" in the inserting process, so that one will obtain the same number of work packages in all excel sheets.

The values that are filled in can be both costs and time. However, important is to fill in data of similar kind, i.e mixtures of time and cost will provide incorrect earned value estimates.
The majority of the project managers at Ericsson use the time as an input. It is so as their main cost is the hourly cost, which is represented by a budgeted hourly cost in the organization. When using the time only, however, one will not be able to estimate the cost of the project and the total budgeted cost, which also includes variable costs such as costs for business trips, equipment tests costs, etc. For some projects the cost could be crucial and sometimes the factor for a project to be closed down. The time input, on the other hand, will provide with budgeted time and time at completion, and when those are converted to costs, the number will only contain the fixed costs. Thus one could judge the health of the project by the difference between the budgeted time and estimated time at completion. Common practice at Ericsson is to use the time in order to estimate the earned value. However, if one is interested in the total cost of the project, a precise estimate cannot be obtained. Again, a practice at Ericsson is to multiply the working hours by the hourly cost, but if doing so, one will underestimate the total cost, as it also includes other than hourly costs. As a researcher, one would wonder how accurate the cost estimate of the company is. The writer's opinion is that the obtained total cost then will give only a rough number that will in most of the cases be unsatisfactory for the performance evaluation process. Thus, in case one is interested in the costs of the project, it is strongly recommended to use the cost data as an input in the designed model.
The *"%"* sheet is both alike and different from the *"PV"* and *"AC"* sheets. It is similar, because it is an input sheet, where one has to fill in the per cent complete for each work package for each control date, and different as it contains VBA coding. The code behind this sheet carries two main functions. The first one is to fill in the *"TOTAL"* column with the last value different than zero from the referring row. If no value is filled in the *"TOTAL"* cell will remain blank. Thus the template users are not required to manually fill in the *"TOTAL"* column. The second function of the VBA code is to recognize the present standpoint date. This is necessary, in order to be able to calculate the planned value for the project up to the present date. The mentioned value is placed in *"PVacc"* sheet and used to calculate the schedule performance index, and the estimated time to complete. The planned value for the project up to the present date is the total planned accumulated value up to the date one find herself in. In order for the programme to recognize the present date, it is VBA coded that the last date, is related to the last per cent complete value. Thus the programme recognizes the last per cent complete filled in value and uses the date in which it is filled to be "present date". Thus according to this date, the total up to present date value is automatically placed in

the “PVacc” sheet. The highlighted cell below the “*Total*” column is designed to take the value of the mentioned column depending on the date one finds herself in. As it is shown in the below picture the up to date planned value of the project is 350, which also means that the present date is May, 30th, or the last per cent complete value is filled in on May, 30th. Refer to picture 2.

The next sheets of the model are designed to calculate accumulated values. Thus as it is shown in the picture below, one can observe the accumulated values for each work package for each date. The planned accumulated values are formulated from the planned values per date and accumulated values per previous date. In the “*TOTAL*” row one can observe the total planned value per work package, and the bottom cell is the total budget of the project. In the “*TOTAL*” column one finds the total planned accumulated value per date.



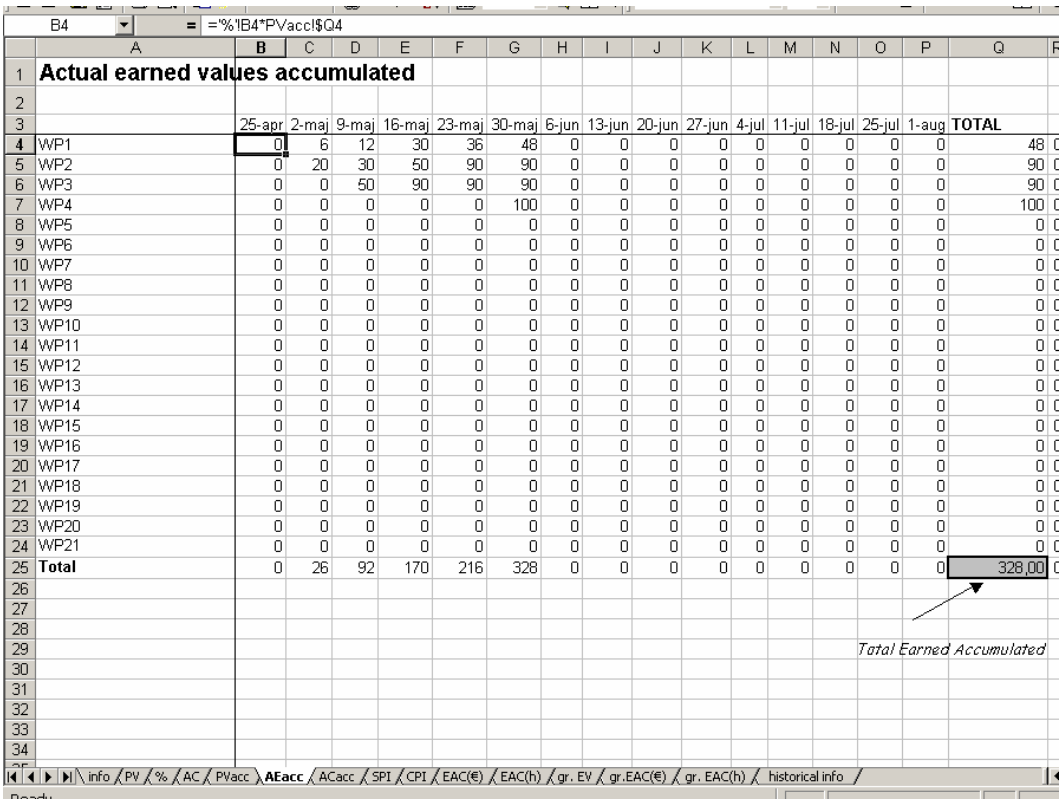
Picture 2 Planned value accumulated excel sheet

The next sheet in the model is showing the actual earned accumulated values. It includes a general formula that accumulates the earned values. The formula is as follows:

$$Actual\ Earned\ Accumulated = Per\ Cent\ Complete \times Total\ Planned\ Accumulated\ per\ Work\ Packet$$

The "*TOTAL*" row shows the total earned accumulated for a work package until the present date. It is designed to take the last accumulated value in the column, which is also the total value of a given work package at the present date standpoint.

The bottom cell highlighted in grey shows the total earned accumulated value for the project. The accuracy of this value play very important role for the further calculations. It is one of the parameters included in the calculations of the performance indices, which on their turn are included in the calculation of the estimated to complete values.



B4 = ='%'!B4*PVacc!$Q4

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q
1	**Actual earned values accumulated**																
2																	
3		25-apr	2-maj	9-maj	16-maj	23-maj	30-maj	6-jun	13-jun	20-jun	27-jun	4-jul	11-jul	18-jul	25-jul	1-aug	**TOTAL**
4	WP1	0	6	12	30	36	48	0	0	0	0	0	0	0	0	0	48
5	WP2	0	20	30	50	90	90	0	0	0	0	0	0	0	0	0	90
6	WP3	0	0	50	90	90	90	0	0	0	0	0	0	0	0	0	90
7	WP4	0	0	0	0	0	100	0	0	0	0	0	0	0	0	0	100
8	WP5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
9	WP6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
10	WP7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
11	WP8	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
12	WP9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
13	WP10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
14	WP11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
15	WP12	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
16	WP13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
17	WP14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
18	WP15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
19	WP16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
20	WP17	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
21	WP18	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
22	WP19	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
23	WP20	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
24	WP21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
25	**Total**	0	26	92	170	216	328	0	0	0	0	0	0	0	0	0	328,00
26																	
27																	
28																	
29															*Total Earned Accumulated*		
30																	
31																	
32																	
33																	
34																	

info | PV | % | AC | PVacc | **AEacc** | ACacc | SPI | CPI | EAC(€) | EAC(h) | gr. EV | gr.EAC(€) | gr. EAC(h) | historical info

Picture 3 Actual earned value accumulated excel sheet

The next excel sheet, namely the actual cost accumulated ("*ACacc*"), is very similar to the accumulated earned values sheet. It does the same functions as the previous described sheet, but with respect to the actual cost values[21]. Thus there one can observe the total actual accumulated cost for each work package, per date, as well as the overall total accumulated value.

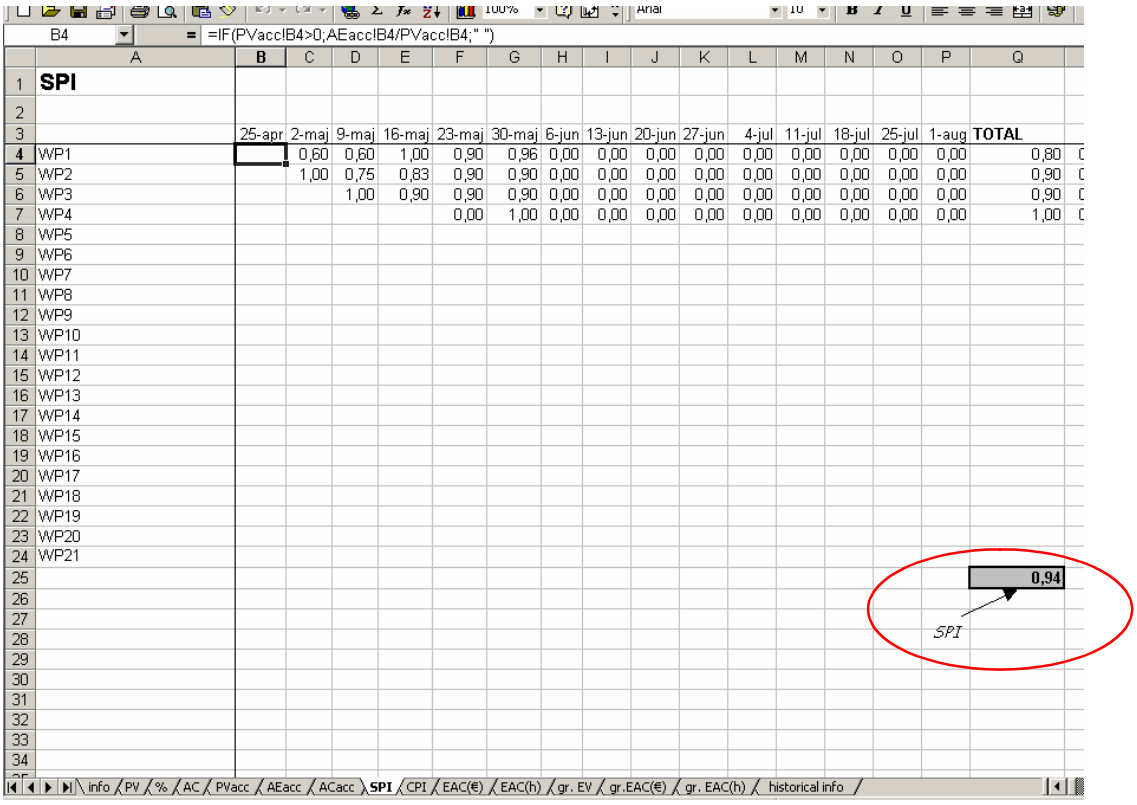
The following two excel sheets are providing with estimates of the performance indexes. It is been proved that no matter what kind of data one uses in the model, it is possible to estimate both cost performance and schedule performance index. Again, it has been proved that the

[21] When talking about cost values it is often meant either cost or time, depending on the input data one is using.

accuracy of the schedule performance index is better if schedule data is used, and respectively, the accuracy of the cost performance index is better if cost data is used. Earlier in this paper, a discussion subject to the performance indexed is held. There the researcher argues that the cost performance index is a better measure for the performance of a project. It is so, as the CPI includes only actual data such as the actual earned value and the actual cost, while the SPI includes both actual and planned values, and the planned values are only estimates that may contain errors.

The picture below shows the excel sheet adopted to calculate the schedule performance index for a project. It is as simple as the rest of the excel sheets. There one can observe the schedule performance indexes for each date and work package. The values in this sheet are obtained from the values in two other sheets, namely the values in the actual earned accumulated and planned value accumulated excel sheets.

Important row in the sheet is the "*TOTAL*" row, which shows the schedule index for the work packages. The bottom cell in this row, highlighted in grey, is the overall schedule performance index for the project until the present date. Therefore, this number is changing with the time and constantly used for the calculation of the estimated time to complete. Further in the study a discussion on the implementation of this value can be found.

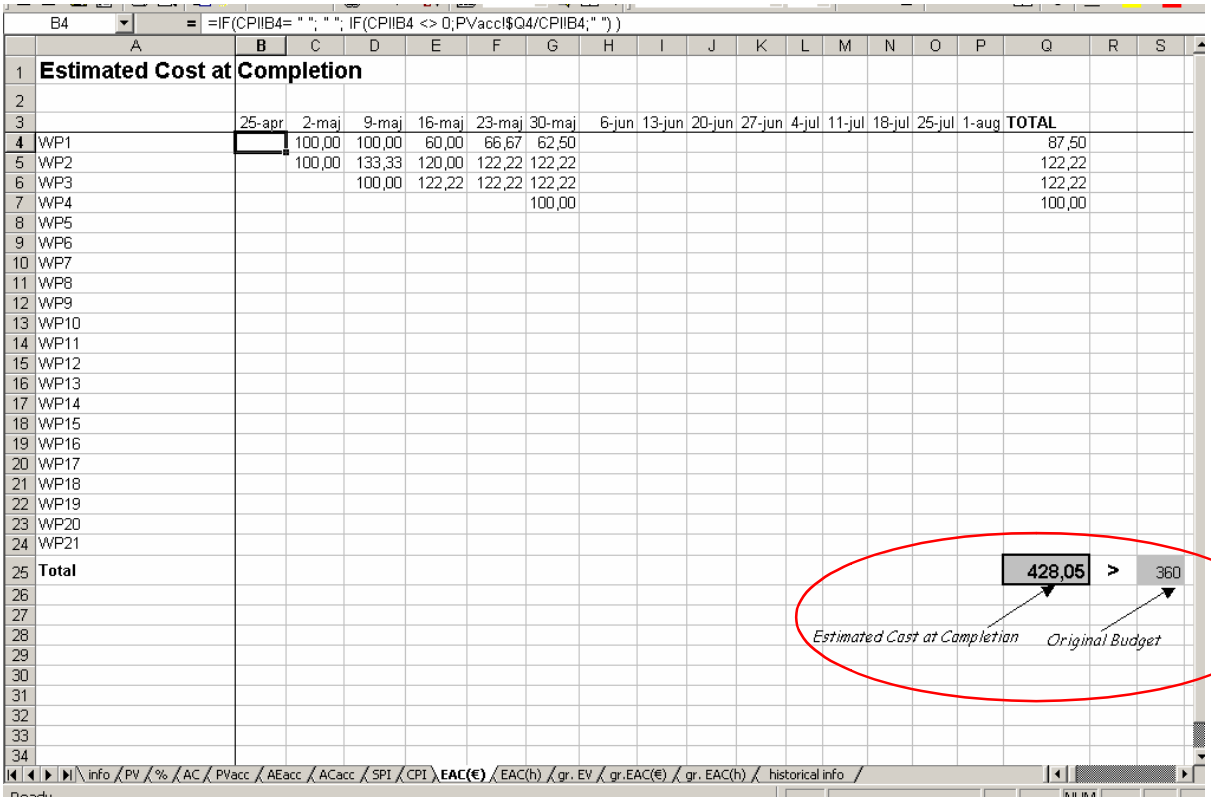


Picture 4 Schedule performance index excel sheet

The next sheet is very similar to the schedule performance sheet, but it calculates the cost performance index. As it was mentioned this index is estimated from the accumulated earned value and the accumulated actual cost, and thus the cell formulas refer to the "*AEacc"* and "*ACacc"* excel sheets. The cost performance index is one of the parameters that discloses the health of the project, and therefore it is important to analyse its value. Further in the paper a discussion of the implementation of this value can be found.

With the following two excel sheets ("*EAC(€)*" and "*EAC(h)*") one has to be very careful. Only one of them can be used for the valuation of a particular project. Which one, depends on the input data. In case that project managers are using cost data, which also is recommended to do, as it gives more realistic picture of the project development, one has to only use the estimated cost at completion excel sheet ("*EAC(€)*") and omit the estimated time to complete ("*EAC(h)*"). If a schedule input data is used, one has to take only into consideration the estimated time to complete excel sheet.

The estimated cost to completion ("*EAC(€)*") excel sheet shows the estimated cost to completion for each work package and date (which usually can be compared with the planned value for the particular packet and date), the total estimated cost at completion for each work package, and the total estimated cost at completion for the whole project. The below picture illustrates some estimated values. The row "*TOTAL"*, as before shows the estimated cost at completion for the separate work packages. The bottom cell of this row views the total estimated cost at completion for the whole project. Additionally, in this sheet the original budget value is included along with a comparison sign. By only observing the bottom cells of this sheet one is already analysing the project. Well-managed project will have smaller estimated cost of completion that the original budget is, while poor performance of the project will be indicated (as it also is the case in the picture) with estimated cost larger than the original budget.

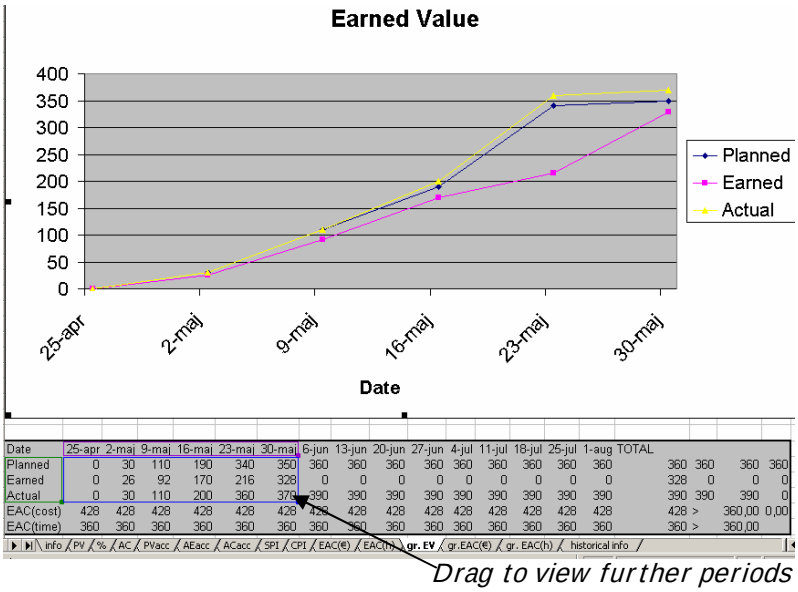


Picture 5 Estimated cost at completion excel sheet

The estimated time at completion ("*EAC(h)*") excel sheet is very similar to the estimated cost at completion. It shows nearly the same estimates based on schedule data. As a bottom line in this sheet a comparison between the estimated time at completion and originally planned total time is performed.

The next three excel sheets do not include new information on the project, rather they are useful when desiring to view the complete picture of the health of the project based on the earned value method. Additionally, one can use the graphs on those sheets when making a presentation of the project performance. The discussed sheets include graphical expressions of the earned value. The "*gr. EV*" sheet shows the three parameters that are of major importance for the project. As it is shown in the picture below, those are the planned value, the earned value, and the actual cost. The best case to which the project can end up to, is when all three lines are identical, which means that the project is perfectly planned, having the same planned, actual, and earned values for the dates in question. Unfortunately, in reality it is very seldom that a project can be that well planned and executed. Thus variances can be observed in the "Earned Value" graph. If analysis of the graph in the below picture has to be made, one can say that all three lines are very close to each other until May, 16, which indicates that until that date, the project is running relatively well. The last disposed period (16^{th}-30^{th} May)

indicates larger gaps between the three values, which signals for problems in the project. Particular problematic week is the week May 16th-23rd. There the earned value line does not follow the same trend as the other two lines, instead due to this value a gap is observed. In the following period, however, the gap is reduced and the earned value takes again similar value to the actual and planned values. When taking a closer look to the graph, it can be noticed that the actual costs are greater than the planned, and the planned values are greater than the earned. This indicates that the project is not in perfect condition and some unfavourable variances are observed. The best case is when the earned value curve is above the planned, and the planned value is above the actual. This would mean that the tasks of the project are executed with less resources or time than it was initially planned, and the efficiency is higher than it was expected when planning the project.



Date	25-apr	2-maj	9-maj	16-maj	23-maj	30-maj	6-jun	13-jun	20-jun	27-jun	4-jul	11-jul	18-jul	25-jul	1-aug	TOTAL				
Planned	0	30	110	190	340	350	360	360	360	360	360	360	360	360	360		360	360	360	360
Earned	0	26	92	170	216	328	0	0	0	0	0	0	0	0	0		328	0	0	0
Actual	0	30	110	200	360	370	390	390	390	390	390	390	390	390	390		390	390	390	0
EAC(cost)	428	428	428	428	428	428	428	428	428	428	428	428	428	428	428		428 >		360,00	0,00
EAC(time)	360	360	360	360	360	360	360	360	360	360	360	360	360	360	360		360 >		360,00	

Picture 6 Earned value graph excel sheet

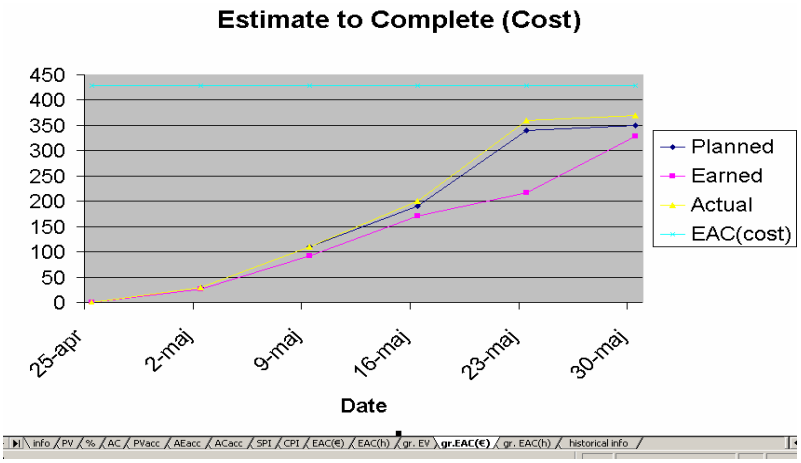
The earned value graph takes its values from the below placed table (see the above picture)

The table is includes formulas that pick the planned, earned, and actual values from respectively the *"Pvacc"*, *"AEacc"*, and *"ACacc"* sheets. The earned value for future periods is zero. Thus one will most likely view the project situation until present date(, which is also the case in the above picture). In order to view time periods after May, 30th, one has to drag the bordering line in the table below the earned value graph[22]. Refer to the above picture. Depending on what kind of input data has been used, one should either analyse the estimated cost to complete graph (*"gr.EAC(€)"*) or the estimated time to complete graph (*"gr.EAC(h)"*)

[22] The rest of the graphs (*"gr.EAC(€)"* and *"gr.EAC(€)"*) can be adjusted in a same manner.

excel sheet. If using cost data the "*gr.EAC(€)*" is to be analysed, else the *"gr.EAC(h)"* has to be taken into consideration.

The estimate to complete graphs (, which are found in the "*gr.EAC(€)*" and *"gr.EAC(h)"* excel sheets) are very similar to the earned value graph. However, they also include the estimate to complete value. This value is viewed as a parallel to the abscissa line. The estimated value is a prognosis of the final cost of the project, if nothing is changed.

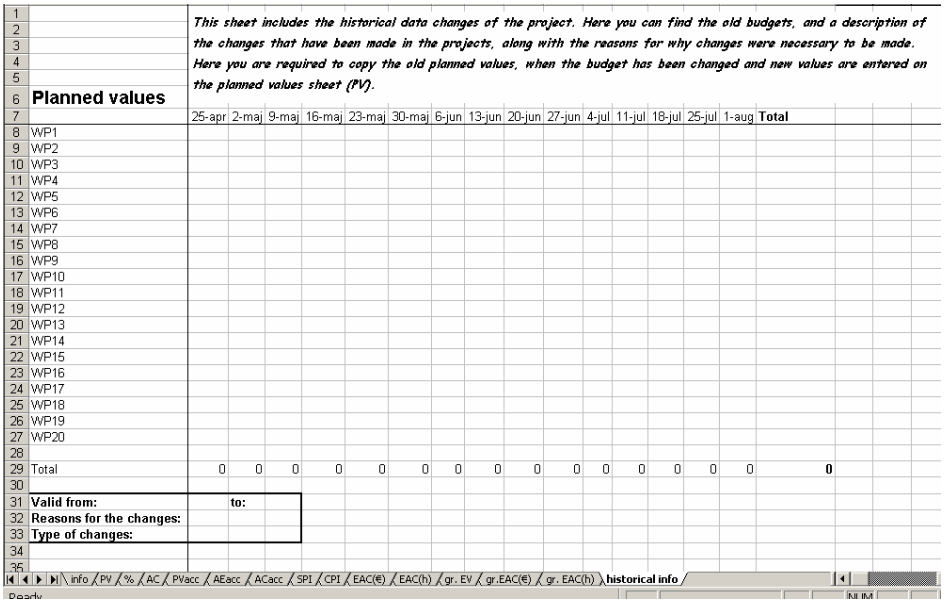


Picture 7 Estimated cost to complete graph excel sheet

The above picture shows that if no further changes in the project will be made, the final cost will be greater than the budgeted cost as the estimated at completion line is above the planned value curve. Thus, the project managers are given a signal to search for problems that cause the unfavourable effects in the project.

The estimated time to complete graph (found in the *"gr.EAC(h)"*excel sheet) is based on the same principle as the estimated cost to complete graph, with the difference that it indicates schedules and the values there are estimated from schedule input data.

The final sheet in the designed model is called "*historical info*" and serves as a file that keeps historical data on old budgets. Every time, the earned value model shows there is a problem, the project managers try to find out what this problem is, and possibly propose a new budget to sponsors.



Picture 8 Historical info excel sheet

In the "*historical info*" sheet the project managers should store the old budgets, report the period when the budget was in function, report the reasons that made her change the budget, and finally report what kind of changes were made in both the project and the budget. The above picture views the "*historical info"* excel sheet.

The next section is viewed as guide for implementation the results of the model of earned value.

5.2 Implementation of the Results

In order to control a project by using the earned value method model, it is not only necessary to be able to calculate different parameters, but also understand their meaning. With the designed model one has to only learn how to implement three types of parameters. Those are the performance indices, the estimates to complete, and the graphs.

First, in the model are calculated the cost and schedule performance indices. Their interpretation is as simple as comparing them to 100%. The below table can be used as an interpretation guide. Among others Mayor (2003), Fleming & Koppleman (2002), and Kerzner (2003) state that a perfect project performance is recorded when the indices are equal to 100 per cent. Larger than 100 per cent index determines exceptional performance, and the larger the index is, the better the performance is. On the other hand, if the performance indices are less than 100 per cent, the project managers are facing poor project performance. Thus, depending on the index value one can decide if it is necessary to search for the bottleneck.

Based on experience and common sense, it is recommended that corrective actions are undertaken when either of the indices are less than 90 to 95 per cent. If the index value is between 95 to 99 per cent, the project managers can wait until the next control period (which is usually in one week), and see what the value is. If it shows a trend to drop over the time, the project manager should take corrective actions in order to prevent further problems in the project.

	>100%	=100%	<100%
CPI SPI	Exceptional performance	Perfect performance	Poor performance

Table 3 Implementation of the performance indices

The estimated at complete value is tightly connected to the performance indices. If one has lower than 100 per cent indices, the estimated at complete value will be larger than the original budget, and vice versa. Fleming & Koppleman (2002) bring into the attention that that the cost performance index becomes more stable when at least 20 per cent of the project life has passed. Studying over 700 DoD projects also prove this fact.

The below table is used as a guide for how to implement the estimated to complete figures. The implementation of the estimated to complete figures is based on a comparison with the original budget[23]. Thus if the estimated at completion value equals the original budget, the project performance is characterised as perfect. If the estimated at complete value is less than the original budget value, the project manager is facing a project with exceptional performance. The case, when the estimated at complete value is larger than the original budget, is indicating that the project is facing troubles, and the project manager has to undertake corrective actions, if a successful ending project is desired.

	Original Budget		
	>	=	<
EAC(Cost) EAC(Time)	Poor performance	Perfect performance	Exceptional performance

Table 4 Implementation of the estimates to complete

[23] When using the term original budget, it is meant planned cost or planned time, depending on the input data.

A typical graphical expression of the earned value model is shown in picture 7. There, four curves can be observed. Those are the actual cost[24], the planned value, the earned value, and the estimated at complete value. The discussed picture has several aspects, the most significant of which are: value, distance, and order. The figure that is illustrated in picture 7 shows different values over time periods, which the four curves take. Thus, one can judge about the health of the project based on those values. The next feature that could be observed from the picture is the order of the curves, which is based on the size of the four illustrated value curves. The case in picture 7 is one of the worst cases for a project. There the estimated at complete value is above all values, which indicates that, if nothing changed, the project will run over the budgeted. The next curve is the actual cost curve, being above the planned and earned value curves. This supports the fact that at its end the project will exceed its budget, as the actual cost is more than it has initially been planned. The curve that follows is the planned value curve. It is above the earned value curve, which indicates that, the employees or machinery have not been as efficient as it has been planned, and less than the planned work has been accomplished.

The next chapter contains analysis of the earned value method.

[24] When mentioning the actual cost, it is referred to actual cost or time.

6 ANALYSIS

This chapter includes summary and analysis based on both theory and the discussions on earned value method held with, among others, project managers, project experts, etc.

When holding a discussion about the earned value, one question comes to the mind: to whom is the earned value valuable. In order to examine this, the reporting flow of the results of a given project is examined. The project is executed by the project members, who report to the project manager, who reports to the programme manager (if one is appointed), who reports to the account or key account manager[25]. The key account manager reports to the chief executive officer, responsible for the marketing areas, and finally the reporting flow ends to the chief executive officer, consolidating all Ericsson's market units. The customer is keeping close contact to the project manager, who reports the progress during the project executive phase, however it is also possible that the customer will have connection to all other executives in the organization. The figure below discloses the reporting hierarchy at Ericsson.

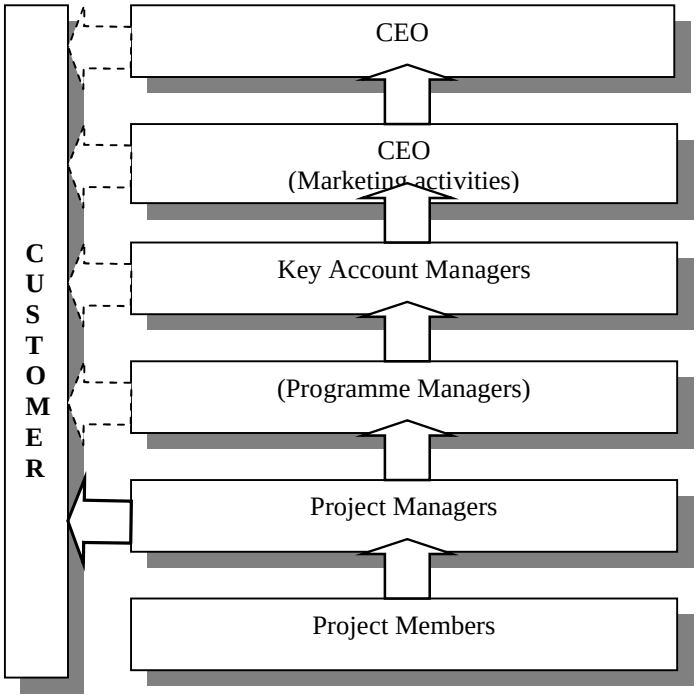


Figure 11 Reporting system at Ericsson AB

[25] In Ericsson, the account managers are responsible for different customers, while the key account manager is the head of the account managers.

Starting from the bottom of the figure, the project members might not always understand that the earned value is a valuable technique, since the method might be seen as a tool for controlling personnel. Thus a task for the project managers is to make sure that the team members understand that the EV is a tool for monitoring the health of the project, but not the human resources. It is suggested that the project managers present the earned value method as a tool for helping the project members to schedule their work in a way that it will best for the projects health. It is believed that when using the milestones method for measuring the earned value, the project members would have gain better understanding of the method, as they would be introduced to the critical activities and their crucial role for projects' health.

The project managers are the ones that might find the biggest use of the EV tool. Through the discussed technique, the project managers will have a strong tool of controlling the project, thus it is believed that the project managers will obtain better results in their work. The programme managers are those who are responsible for a given group of projects, and report to the key account managers. It is believed that both the programme manager and the key account manager can make use of the earned value method. They might find it useful in a way that it makes the performance of the project managers and the project itself better, and to prove a better performance they might even monitor the project process by the use of the EV method. The chief executive officer, responsible for the marketing areas, and the CEO responsible for the organization, are not likely to go into the details of the discussed method, however they will profit of the tool as it is likely to improve the project performance and thus the profitability of the organization. The customer, who is sponsoring the project is often interested in the progress of the project and there are cases when the customer will even like a detailed reporting on the issue of how money are spend, and how much value have been created.

One issue with the earned value can be the budgeting process. It is questioned if all costs of the project are included in the budgeted values. Thus a discussion with project managers with the subject of "how are the costs of the project estimated" is held. The biggest part of project cost consists of cost of hours. The company sets a fixed hourly cost of its personnel, which varies with the role and experience of the consultant, where labour cost, IT equipment, premises, and the overhead costs of the management are included. In the labour costs, among others the hourly salary, the health insurance are included. The IT equipment costs are the costs of leasing the computers, software, and information technology support. The premises costs are the cost of buildings rent, heating, electricity, etc. The overhead costs of the management are cost for the management. The cost of capital is included in the fixed hourly

cost. The total cost of the project is the number of working hours times the fixed hourly cost plus the variable cost. The variable costs are all costs that occur under business trips as well as the costs for environment tests.

The company, as many other consultancy companies, has worked with the above model of cost estimation for long time, it is well examined and believed that all of the costs are included in the total cost.

Another issue of the earned value method is the right choice of a measurement method. Section 3.3.3 provided with a discussion on possible ways to measure the earned value. It is been recommended to use the per cent complete method with as much accuracy as possible. It is considered reasonable to be 25 per cent accurate, meaning that the project members can report the per cent complete work using: 0, 25, 50, 75, or 100 per cent complete.

In a discussion with PhD Sjögren it was questioned if when using the per cent complete method, the project members will consider the earned value as a tool for cost control as well as labour productivity control, and when using the milestones method, the project members would see the earned value as a tool that will help them to schedule better their work. It was concluded that the choice of the measuring method is not of big importance. It is crucial, however, to present the earned value as a method for project performance valuation and support. In that case the project members will not feel threaten by the method, rather they will see it as a tool that supports their work.

It is important to set a right size of the work packages/activities[26]. It is recommended to set control dates every week. Often the work that is done under a given activity is a "black box" for the project manager. For instance, a project member, working on a given activity can report false information about the per cent complete, and the project manager can do nothing but trust the reported information. The only possibility to control the trueness of the information is at the standpoint when the reported activity is fully completed (i.e at 100 per cent completion).[27] Thus, in order to minimize the information asymmetry, one can set "appropriate" size of the work packages/activities. By appropriate size, it is meant that the work package/activity should be small enough to be able to catch if problems appear. For instance, if the control dates are set to be every week, activity with duration of two weeks can

[26] It is assumed that each work package contains of one or more activities.

[27] It is also possible to control the per cent complete in an earlier stage of the activity process. In order to do this, however, the project manager has to have special technical skills to be familiar with the work executed by the project member, and thus judge the per cent complete. In practice, it is not common that the project managers are familiar to the working tasks of all project members. Even if they were, it would take too much resources to supervise every single member of the project group.

be appropriate[28]. Thus even if the project manager receives false information in the first week of the work package/activity execution, in the second week she will receive true information. The project members can report 100 per cent completion, then the project manager will note that the project is running according to plan. The project members can also report that the work package/activity is not 100 per cent accomplished. Thus the project manager will receive a warning signal that there are problems with the discussed activity.

The analysis of the earned value includes a discussion on the costs and benefits of the method. One of the great disadvantages of the earned value method is that in first sight, project managers find it very complicated. It can be explained with the fact that behind the simple calculations of the earned value, difficult terms are used. Fleming & Koppelman (2000) state that in the literature terms, such as BCWP, ACWP, BCWS are use rather than the simple terms like earned, actual, and planned values. Using the simple terms proves that a great deal of the difficulties with the earned value method disappear. Thus in the designed model, complications by using the simple names of the variables are avoided. By doing so, it is intended to take the essence of the model, when using minimum resources. The designed model does not require special skills in order to be able to make use of it. This means that Ericsson, and the users of the model will not have to invest in special training before they could use it.

The experience shows that, even though, the model of earned value is simple, the project managers, as well as other employees, meet some complications when using the performance indexes. In order to interpret the meaning of the performance indexes, one has to be familiar to the theory behind earned value, and the practice shows that in Ericsson, only few are trained to implement this method. There are several solutions to this problem. The first suggestion is that the company trains its employees, so that they are prepared to meet the challenges of the earned value method. Even though, the technique is simple, one will have to spend some days in order to familiarise with the method, which will require additional expenditures. A dilemma is also which employees have to be trained. In case the company decides to implement the model for controlling all ongoing projects, multiple employees will need a special training. The second suggestion is that only project managers are trained to understand the concept of EV, and when it comes to reporting the health of the project, the project managers will use the estimate to complete, which proved to be easier for employees to understand. The estimate to complete includes the performance indices in a way that they

[28] One cannot make general conclusions for the right size of work packages/activities, as every project is unique and what is good for one project could be damaging for another project.

are not evident, but one can show the final estimated cost or time of the project. When comparing the predicted final value of the project with the planned value, it is easy to understand if the project is running well or not. The health of the project in most of the cases is dependent on the productivity of the personnel, thus common sense is enough to estimate the productivity of the project-involved personnel.

For the purposes of earned value calculation, it is necessary to report the per cent complete of each work package for each date. Often more than one person is involved in completing a work package. Therefore, one has to be aware of the fact that in order to estimate the correct per cent complete, the weighted average number has to be calculated. Lets assume that there are five activities in a work package and a separate person executes every activity. Each activity has different weight, and the sum of the weights is the total work package. The assigned package has to be completed in three weeks. (The described case is illustrated in the table below.) In the first week only one activity is started, and ten per cent of it are accomplished. When calculating the overall per cent complete for this work package one has to use the formula:

$$WP\%\ complete = \sum \%\ complete\ act._i \times Weight_{\ i},$$

thus in the specific case from the below picture one obtains 2 % complete for the whole work package for the given date (April, 25th):

$$2\% = 10\% \times 20\% + 0\% \times 20\% + 0\% \times 30\% + 0\% \times 25\% + 0\% \times 5\%$$

For the next two periods, the same formula is been used and total per cent complete are estimated to be 4 % and 98%.

	act. Weight	25-apr	02-maj	09-maj
act.1	20%	10%	10%	100%
act.2	20%		10%	90%
act.3	30%			100%
act.4	25%			100%
act.5	5%			100%
WP1	1	2%	4%	98%

Table 5 Weighted average of the per cent complete

One important fact illustrated in the above table grabs the attention. Activities three to five do not report any progress in the first two weeks, and all of a sudden in the last week the activities are fully accomplished. Two explanations for the observed fact are found. One possibility is that activities three, four, and five have only been executed and accomplished in the third week. Thus, it is totally correct to place 100 per cent completion in the third week row. The other possibility that comes to the mind is that the workers of those activities are

using 0/100 per cent reporting approach. They report zero per cent when the work is not completed and 100 when the activity is fully completed.

It is not recommended to use the 0/100 approach. The argument for this is that one cannot observe the real project picture, the desired feedback of the work performed is not obtained by the discussed approach, and thus one cannot know what the health of the project is in order to undertake corrective actions[29]. The time period when the project manager is assured about the project health might be too late to be able to repair possible problems occurred in the project.

A number of project managers in Ericsson have been asked about the most appropriate approach for per cent complete recording. Most of them shared that the best approach is to record the exact per cent complete of the work package. In reality, however, it is not always possible to be that precise, and therefore, the managers think that it is reasonable to report with 25% accuracy. Thus it is recommended to record the per cent complete with as big accuracy as possible.

In a big organization, such as Ericsson, the information float is not always as quick as one would desire. This especially applies to the actual costs information flow. From the moment the costs have been expended to the moment the costs are booked, there is a significant period of time. Usually there is one-month period before the consumed goods and services are accounted.

One type of input data necessary for the calculation of earned value is the actual cost data. As it was described before, the actual cost data that one accounts for is usually one month old. Thus the earned value calculations that could be performed are running one month late. And therefore, one can estimate the health of the project only for periods that are at least one month behind the present date. Unfortunately, four weeks is a significant period, especially for projects with smaller life spans, and the fact that one does not control a project for the last month, or controls is with one-month delay, could be curtail for the project. To sum up, the fact that the actual cost data is one month old, will lead to the fact that the project valuation is performed with one-month delay.

The solution to the actual cost problems is found in the examined literature (Fleming & Koppelman (2000)). Based on the literature, it is suggested that project managers fill in estimated actual costs for the periods where one has no actual cost[30]. By doing so there is a risk of making imprecise calculations, which is proved to be better than making no

[29] As it was discussed before the case shows a “black box”, meaning that the health of the project is unknown unless 100 per cent complete is reported, or a lack of 100 per cent complete is obtain at a point where the work package/activity is planned to be accomplished.

[30] This action is known as the “feed forward” method. (Brandon (1998))

calculations at all, until data is accessed. The moment that actual cost data is in place, the project managers have to remember to go back to the previous periods with estimated actual costs and replace the estimates with the actual costs.

In connection with the estimated actual cost, it is suggested that the project members do this estimate, as they are the ones that know best how much it has been expended for a particular activity. Thus, it is assumed that the project members will make the most accurate estimate of the actual costs, and in respect to this the most accurate estimate of the future final cost of the project can be done. This issue is to be discussed further in the section.

Ericsson AB is a company with traditions in working on various projects. It is using different tools for project valuation; however, it appears that the company has planned to replace the old valuation tools with the earned value model. It appears that the old tools no longer can fulfil the needs of the project managers. The department that the current thesis is employed, is working with projects, which are subject to multiple changes. This is due to the fact that in order to fulfil customer needs one has to be able to respond to changed customers' desires. Therefore, one could expect multiple changes in the planned values as well. With the most commonly used tool for project management (MS Project), it is more complicated to store old budgets, while the historical data in the current model is easily accessible.

This problem has been solved with the earned value model. A separate sheet, which stores historical budgets is designed. There, detailed old budgets are found together with the reasons for changing the budget and the exact changes that are made.

When controlling a given project, one has to keep in touch with all members involved in this project and collect data about the costs they made and the work they accomplished. Assuming that the project size is big, and there are many participants in it, it is certain that many hours will be spend for only collecting the required data. Therefore, companies would appreciate a controlling tool that will not require as many working hours for data collection as it is at present. (Refer to section 4.2.3.1 overcoming data acquisition problems, which among others includes suggestions made by Brandon (1998)).

In addition to the previously described model, a model that has similar principals for project valuation, but is made so that project members can fill in data themselves is designed. The project members will be able to fill in two types of data. They will fill in the per cent

complete, and the actual cost[31]. The following two pictures are illustrations of the excel sheets available for project members.

	% complete of WP		Fill in the percentage complete for each work package for each date; Read the comment in cell A3!!!														
2		act. Weight	25-apr	2-maj	9-maj	16-maj	23-maj	30-maj	6-jun	13-jun	20-jun	27-jun	4-jul	11-jul	18-jul	25-jul	1-aug	TOTAL
3																		
4	act.1	20%	10%	10%	100%	100%	100%											100%
5	act.2	20%		10%	90%	100%	100%											100%
6	act.3	30%			100%	100%	100%											100%
7	act.4	25%			100%	100%	100%											100%
8	act.5	5%			100%	100%	100%											100%
9	WP1	1	2%	4%	98%	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
10	act.1	20%		50%	80%	100%	100%											100,00%
11	act.2	20%		50%	80%	100%	100%											100,00%
12	act.3	30%		50%	80%	100%	100%											100,00%
13	act.4	25%		50%	80%	100%	100%											100,00%
14	act.5	5%		50%	80%	100%	100%											100,00%
15	WP2	1	0%	50%	80%	100%	100%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	100%
16	act.1	20%			20%	60%	100%											100,00%
17	act.2	20%			20%	60%	100%											100,00%
18	act.3	30%			20%	60%	100%											100,00%
19	act.4	25%			20%	60%	100%											100,00%
20	act.5	5%			20%	60%	80%											80,00%
21	WP3	1	0%	0%	20%	60%	99%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	99%
22	act.1	20%					100%											100,00%
23	act.2	20%					100%											100,00%
24	act.3	30%					100%											100,00%
25	act.4	25%					100%											100,00%
26	act.5	5%					80%											80,00%
27	WP4	1	0%	0%	0%	0%	99%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	99%
28	act.1																	
29	act.2																	
30	act.3																	
31	act.4																	
32	act.5																	
33	WP5	0	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%

info / PV / AC / % / PVacc / AEacc / ACacc / SPI / CPI / EAC(€) / EAC(h) / gr. EV / gr.EAC(€) / gr. EAC(h) / historical info /

Picture 9 Per cent complete excel sheet for project members use

The excel sheet shown in the above picture functions in a way that allows all workers employed in a given project to fill in the per cent accomplished work. Thus the total per cent complete for the work package is automatically calculated by the model in the bottom column, called WP_i (, where i is the number of the work package). This is possible, after the project manager has set the weights for each activity of the work package. The different activity weights are to be added in the "*act. Weight*" row. After the data has been filled in, the model is designed to calculate the total per cent complete for each date, activity, and work package. The total per cent complete for each date and work package is calculated by the formula:

$$WP\%\ complete = \sum \%\ complete\ act._i \times Weight_{\ i} \quad \text{(Refer to table 5)}$$

[31] The actual cost data filled by the project members is the estimated actual cost data, for the period when the project managers have no actual data. In the moment when such data is accessible, the project managers have to go back and substitute the estimated with actual data.

The row called "*TOTAL*" shows the accumulated per cent completed in the last observed period, as the cells in this row are designed to take the value of the last filled cell from the corresponding column.

The below picture is an illustration of the second excel sheet available for project members to fill in data. Before the actual cost data is accounted, there is a period in which one has to make estimates for the actual cost. Thus it is suggested that the project members make this estimate as it is believed that they will provide with the most accurate estimates. The discussed excel sheet contains several significant rows. Project managers shall fill in the row "*cost*", which presents the hourly total fixed cost. In the rows "*hours*" and "*other*", the project members will fill in respectively the hours that they have used for completing a given activity, and the variable costs[32] that are used while completing the activity[33]. The row "*Total*" is designed to calculate the total cost for each date for each activity, or work package.

The total cost equals the hours multiplied by the hourly cost plus the additional variable cost.

$$Total \ \ \cos t = hours \times hourly \ \ \cos t + other \ \ \text{var} iabe \ \ \cos t$$

1	**Actual cost**	*Fill in the actual costs for each WP for each date; Remember to update the costs if you use the FEED FORWARD method*																					
2					25-apr				2-maj				9-maj				16-maj				23-maj		
3		hours	cost	other	Total	hours	cost	other	Total	hours	cost	other	Total	hours	cost	other	Total	hours	cost	other	Total	hours	cost	o
4	act.1	1	100		100	2	100		200	2	100		200				0				0			
5	act.2	1	100		100	2	100		200	2	100		200				0				0			
6	act.3	1	100		100	2	100		200	2	100		200				0				0			
7	act.4	1	100		100	2	100		200	2	100		200				0				0			
8	act.5	1	100		100	2	100		200	2	100		200				0				0			
9	WP1	5	500	0	500	10	500	0	1000	10	500	0	1000	0	0	0	0	0	0	0	0	0	0	
10	act.1				0	2	100		200	2	100		200	2	100		200				0			
11	act.2				0	2	100		200	2	100		200	2	100		200				0			
12	act.3				0	2	100		200	2	100		200	2	100		200				0			
13	act.4				0	2	100		200	2	100		200	2	100		200				0			
14	act.5				0	2	100		200	2	100		200	2	100		200				0			
15	WP2	0	0	0	0	10	500	0	1000	10	500	0	1000	10	500	0	1000	0	0	0	0	0	0	
16	act.1				0				0	2	100		200	2	100		200	2	100		200			
17	act.2				0				0	2	100		200	2	100		200	2	100		200			
18	act.3				0				0	2	100		200	2	100		200	2	100		200			
19	act.4				0				0	2	100		200	2	100		200	2	100		200			
20	act.5				0				0	2	100		200	2	100		200	2	100		200			
21	WP3	0	0	0	0	0	0	0	0	10	500	0	1000	10	500	0	1000	10	500	0	1000	0	0	
22	act.1				0				0				0				0	3	100		300			
23	act.2				0				0				0				0	3	100		300			
24	act.3				0				0				0				0	3	100		300			
25	act.4				0				0				0				0	3	100		300			
26	act.5				0				0				0				0	3	100		300			
27	WP4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	15	500	0	1500	0	0	
28	act.1				0				0				0				0				0			
29	act.2				0				0				0				0				0			
30	act.3				0				0				0				0				0			
31	act.4				0				0				0				0				0			
32	act.5				0				0				0				0				0			
33	WP5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	
34	act.1				0				0				0				0				0			

info / PV / AC / % / PVacc / AEacc / ACacc / SPI / CPI / EAC(€) / EAC(h) / gr. EV / gr.EAC(€) / gr. EAC(h) / historical info /

Picture 10 Actual cost excel sheet for project members use

[32] In Ericsson, those are usually the cost spend for business trips, or equipment testing.

[33] The columns WP_i shall not be filled in, as they are formulated from the data filled in the *"act. "* columns.

If the project members find the earned value model too complicated and are unable to fill in data themselves, in order to save time the project manager can appoint one person that is responsible for each work package and that will gather and accumulate data. Hence, the project manager will only have to communicate with as many people as work packages when gathering data.

The following section discloses the conclusions of the executed study.

CONCLUSION

This thesis performed an evaluation of the earned value method. The comparison with the traditional approach for project valuation proved that this technique covers more aspects than the existing tool, and therefore, it is considered as a better tool. Unfortunately, even though, it is proved that the earned value is a better tool, a number of disadvantages that accompany the method are found. One major disadvantage is that behind the simple theory of the earned value, complicated terminology is used. Thus, a model that uses simple terms, such as planned, actual, and earned values is designed. Another problem associated with the discussed method is that the earned value is rarely discussed in corporate courses. It is intended to solve that problem by providing the readers with an easily understandable paper that can also be used as earned value guide. Thus, it is considered that in order to be able to use the earned value method one will only have to follow the guide (the present master thesis[34]), and use the designed template. To use the template, it is necessary to access to detailed data, which acquisition could be a problem. It is suggested that the users of the model delegate partially the work to other employees, which collect samples of data. Thus the efforts for data collection will be significantly reduced. Another suggestion is to make project members fill in data themselves. For this purpose, a special detailed template is designed. Particular problem for system integration projects at Ericsson is that they deal with multiple changes, thus the company desired to acquire a tool for project valuation that could bear the function of multiple changes, and the possibility to save old data. The model provides with additional excel sheet, which is designed to store the historical budgets, so that no data is lost. Finally, attempts to solve the problem with delayed actual cost data are made. It is suggested that estimates of the delayed actual cost data are made either by the employees (which are believed to be able to make the most accurate estimates), or by the project manager. Ones the real actual cost is available, the project managers are advised to replace the estimates with the actual costs. Hence, one can sum up that a solution to most of the disadvantages of the model can be found, which proves that the earned value is a fine method for project performance valuation.

[34] To be more precise as a guide for earned value can be used: the earned value: theoretical aspects and the model of earned value-implementation of the results sections from the current master thesis.

Contribution to the research area

Under the working process, a model that enables project valuation for projects within profit organizations is constructed. It is believed that a tool of this kind is not been created yet. Other tools for project management, based on the earned value are being examined, but those are complicated for the use of unskilled project manager or project member. Moreover, projects that constantly change their scope are difficult to control, however the designed model deals with a number of issues of the earned value, and enables changes in the scope of a project. The study presents some solutions to the earned value issues that have not been discovered before. It is believed that this study is the first to discuss the cost of capital as a component of the earned value method.

Proposition for further research

In the executed study, and in particular in the designed model, only two input data are included. Thus the model evaluates mainly the cost and time performance of a project.

For a project to be considered successful, it is also necessary to consider other parameters than cost and time. Such a parameter can for instance be the quality of the performed activities.

In a discussion with PhD Sjögren, an issue about the percent complete was considered. It was doubted what 100 percent complete means, and if the 100 per cent is the top of the completion. For instance, one activity can be fully completed, but even after the full completion there might be space for improvements in a form of improving the quality of the product.

Thus a further research, which takes into consideration the quality of the executed tasks, will be of interest. Moreover, a model that includes the quality of the performed activities as an input data will be attention grabbing.

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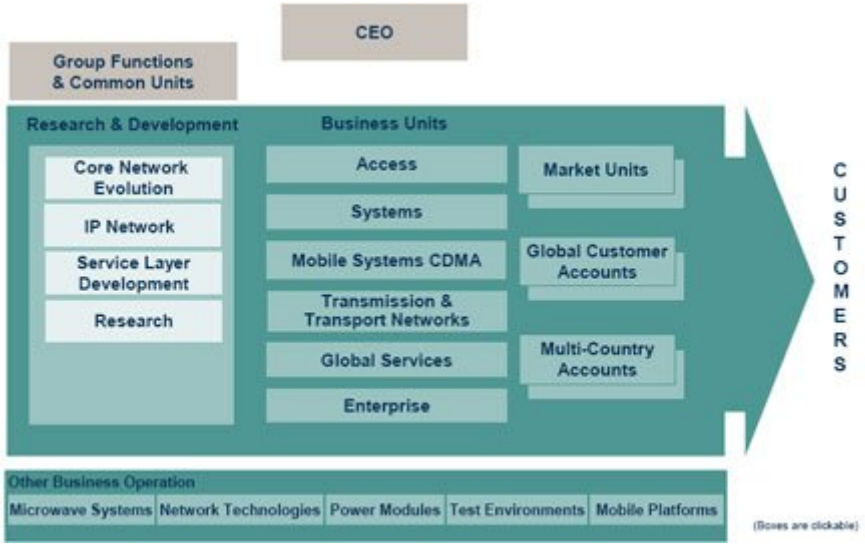
APPENDIX I : ERICSSON AB

Ericsson AB is an organization with traditions in providing telecommunications equipment and related services to mobile and fixed network operators globally. It origins in 1876. Today over 1,000 networks in 140 countries utilize its network equipment and 40 per cent of all mobile calls are made through Ericsson systems. The company is famous with its ability to provide end-to-end solutions for all major mobile communication standards.

Through Sony Ericsson Mobile Communications joint venture, a range of mobile devices, including those supporting multimedia applications and other services are offered, which allow richer communication.

The company is known as a heavy investor in R&D and actively promote open standards and systems. A goal is to hold a technological leadership in telecommunicational equipment. Ericsson has one of the industry's most comprehensive intellectual property portfolio containing over 16,000 patents with an additional 15,000 patent applications pending approval by various patent authorities. [35]

The below figure views the organizational structure of Ericsson AB. The model discussed in this paper origin from the Global Services business unit.



Source: http://www.ericsson.com/about/organiz.shtml- 2005-09-21

Figure 12 Ericssons organizational structure

[35] Source: http://www.ericsson.com/about/ - 2005-09-21

Products

Ericsson AB supplies the network equipment and services that enable telecommunications. They provide with services for network operations and revenue generation. Through Sony Ericsson Mobile Communications joint venture the company offers a range of mobile devices, including those supporting multimedia applications and other personal communication services. Moreover, it has products for special applications within defense systems, enterprise, cables, mobile platforms and power modules.

Service layer

The service layer is where applications and end-user services are enabled and managed. Ericsson has a leading complete service-layer portfolio with products, solutions and services for both fixed and mobile network operators and a particularly strong position within pre-paid, billing, intelligent networks and mobile multimedia services (MMS). Mobility World is an Ericsson initiative that develops content and applications together with industry-wide partners. Sales of Service Layer products are accounted for within either mobile networks or fixed networks depending on which type of operator is involved.

Services

The services portfolio includes expertise in consulting, systems integration, managed services, network deployment and optimization, education and technical support services. With over 15,000 dedicated Global Services professionals on the ground in 140 countries, the services sales (including network rollout) account for approximately one quarter of the Systems net sales. Some of the most comprehensive managed services capabilities within the telecom industry, covering management of day-to-day operations of a customer’s network, sometimes including a managed capacity service for an efficient network build out and on-demand capacity, as well as hosting of applications and content management are offered. The combination of local expertise, global technology leadership, business understanding, strong delivery capabilities and extensive experience in managing multi-vendor networks, makes Ericsson a leading provider of services to network operators.

The Global Services business unit includes both network rollout and professional services. Sales of network rollout services represent approximately 8 per cent of net sales and are consolidated within either mobile networks or fixed networks depending on which type of

operator is involved while professional services represents about 15 per cent of sales and are reported separately. [36]

The System Integration (SI) unit works as an integrator of the operators' applications, servers, and network components, thus Ericsson makes sure that applications work correctly together. Network complexity is a growing challenge for operators. More and more components, applications, servers, and network elements need to cooperate. Ericsson points out several characteristics of the SI department. It is said that that the SI is a local business, which is based on competence and customer trust; it is both commercially and technically complex; it is comparatively more open and competitive than the other service areas.

SI involves mainly two areas: the service layer and telecom management. The service layer includes the support systems and platforms for new services such as MMS and video. Telecom management covers all the support systems and processes for payment, activation of services in all parts of the network, quality assurance for speech and data services, and network monitoring.[37]

[36] Source: http://www.ericsson.com/about/compfacts/offering.shtml - 2005-09-21
[37] Source: http://www.ericsson.com/products/services/sys_integr.shtml - 2005-10-31

APPENDIX II: PROJECT MANAGEMENT

The project

According to the Wikipedia[38]- free encyclopedia a **project** is a temporary endeavor undertaken to create a unique product or service. Temporary means that the project has a definite beginning and end. Unique means that the project's end result is different than the results of other functions of the organization, designed to produce the same result over and over again.

The PMBOK® Guide highlights that "projects can be combined into more comprehensive programmes or broken down to smaller subprojects." For instance the health insurance department in Sweden is running a project aiming at reducing the traffic accidents on the highways. The project is called don't drink and drive, and it's purpose is to prevent people from driving after using alcohol. This project could be broken into some subprojects, such as running special campaigns for young people, which are also the biggest percentage involved in car accidents. A separate campaign for middle age people could be undertaken, and a campaign for elderly men and women, convincing them to quit driving could be undertaken as well.

Project management

In his findings Richman (2002) describes the project management as a set of principles, methods, and techniques that people use to effectively plan and control project work. It establishes a sound basis for effective planning, scheduling, resourcing, decision-making, controlling, and replanning. It is underlined that the project management principles and techniques help complete projects on schedule, within budget, and in full accordance with project specifications (Kerzner (2003)). At the same time, they help achieve the other goals of the organization, such as productivity, quality, and cost effectiveness (Cooke (2005)).

Richman (2002) defines the objective of project management as optimization of project cost, time, and quality.

The PMBOK® Guide, provides the following definition of project management: "it is the application of knowledge, skills, tools, and techniques to project activities to meet the project requirements". It is suggested that instead of taking risk the project managers should the techniques and concepts of project management. The project management helps to ensure that

[38]Source: http://en.wikipedia.org/wiki/Project - 2005-09-22

the time and resources are used in a most efficient way aiming to meet the project requirements or scope.

The Triple Constraint

One of the key aspects of the project management is the triple constraint (Lewis (2002)). It is called so as the concept contains of three parts, each one is dependent on the other two. When changing of the parts, the rest automatically are changed as well. Further, each factor of the triple constraint is described.

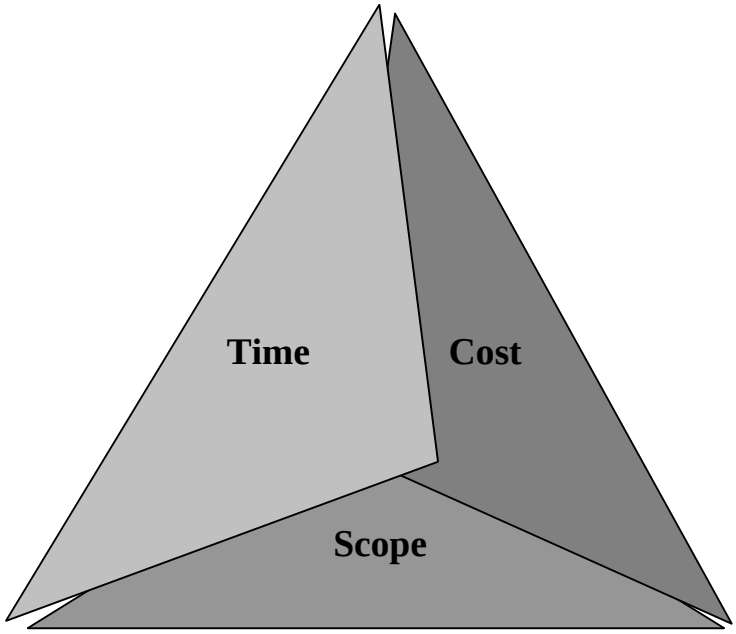


Figure 13 The Triple Constraint

According to the PMBOK® Guide the **scope** is the "sum of the products and services to be provided as a project". It could be also said that the scope of the project is the work that should be accomplished.

The money, labour, equipment, and other resources necessary to complete the project are referred to as the **cost** of the project.

The **time** refers to the schedule of the project or how long it takes to complete the project.

The constrained is how each of the three factors affects the other two. If for instance the project managers take the decision to speed up the project, or to complete the project earlier, it will bear consequences. In such as situation, it is probable that the cost of the project will increase (more resources will be needed to complete the project faster), and additionally it is possible that the scope will reduce (less work can be accomplished when the time is reduced).

Juran (1999) recommends using the concept of the triple constraint in an early planning stage of the project to understand the need to consider each factor and how it relates to the particular project. The concept could also be used in the implementation stages of the project, to deal with changes, and other issues, which possible will occur.

It is essential that from the beginning of the project, the three factors, time, cost, and scope are competing with each other. To manage a successful project the leaders must understand the concept of the triple constraint and to find the balance between the three factors (Lewis (1998)).

Influences on a Project

A range of influences has a bearing on the performance and outcome of a project. Two major groups of influences are of internal and external character. The internal influences may arise in the form of the organization's systems, structure, and culture. The external influences could be the social, environmental, and economic factor. Practically, it is impossible that a project will not be influenced by either internal or external factors.

A major part of the projects, including the one to be later examined in the paper, are performed within large organizations. The structure of the organization, its characteristics, and systems determine how projects historically were done and how they will be performed in the future. The culture and style of the organization affect the project. It normally matters if the organization is hierarchal. In that case the project managers have to go through functional managers to request assistance from another department. If the organization has a laid-back culture, it is easier to communicate between the different departments and "levels of the hierarchy".

The external factors of a social, economic, or environmental nature are usually outside the control of a project manager. Unfortunately, those can be strong enough to collapse a project. The project manager, however, must be well aware of the external project influences and be able to adjust project planning and implementation to account for external factors. (PMBOK® Guide)

Project Management processes

As a multi project organization, Ericsson develops project models to manage the projects undertaken for their clients. These project models not only serve as a work guidelines, but by having these models, Ericsson ensures fast service, high accuracy, quality, and completeness. The Global Services unit of the organization has employed two project models to follow when

executing a project. Those are the PMP model and the PROPS model. Below a short description of those models can be found.

Hereunder the PMP model used in the Global Services department of Ericsson is described.

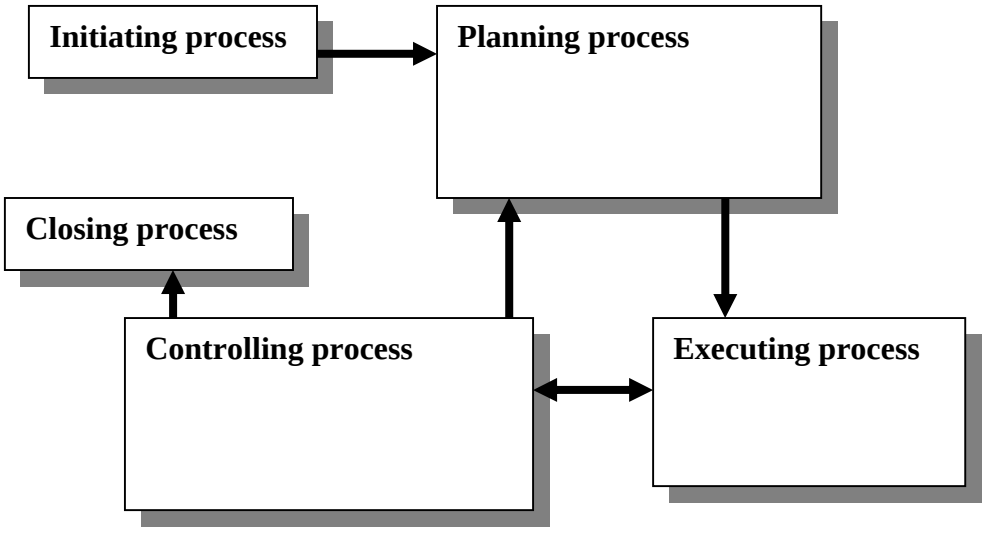
Project Management Process Model (PMP Model)

The PMBOK® Guide displays the discipline of project management in a matrix format based on nine "knowledge areas" and five "process groups". Below both, the areas and the groups are presented, starting with the nine knowledge areas.

The nine knowledge areas included in the project management matrix are:

1. Project Integration Management
2. Project Scope Management
3. Project Time Management
4. Project Cost Management
5. Project Quality Management
6. Project Human Resources Management
7. Project Communications Management
8. Project Risk Management
9. Project Procurement Management

Respectively, the five process groups or types of processes in a project are:



Source: PMBOK® Guide

Figure 14 The PM Process

In order to execute a project management process one has to follow all the stages view in the above figure. A brief descriptions of the five process groups is as follows:

1. Initiating or authorising the project means that one should recognize that a project should start.
2. Planning is the process of defining and refining possibilities, or selecting the most appropriate alternative. The PMBOK® Guide acknowledge this process as the heart of the project managers job. It establishes a workable scheme to accomplish the needs that the project is undertaken to address.
3. Executing is the coordination of labour and other resources in order to fulfil the plan.
4. Controlling is the monitoring and measuring progress, which ensures that the project objectives are met. If variances from the plan are identified, the management has to undertake corrective actions to prevent future failures.
5. Closing a project, as it is described in the PMBOK® Guide, is the action of formalizing acceptance and bringing it to an orderly end.

Even though all types of processes are active in each project and each task of the project, there are exceptions from the process types being involved in every knowledge area. For instance, the PMBOK® Guide highlights that all nine knowledge areas involve the planning process, but project scope management is the only knowledge area involved with initiating as a process.

Two aspects of the various processes involved in project management are described in the PMBOK® Guide. "First, the processes interact in complex ways and are not completed in a consistent fashion. Within each process and between processes, interactions and iterations take place. Second, projects have core and facilitating processes, where the core process is said to be the processes that depend on each other and that are usually performed in a sequential order. The facilitating processes are those that take place at different times, depending on project requirements."(PMBOK Guide pp. 33-34)

PROPS Model

The PROPS framework is seen as a set of models, rather than as a set of instructions. Thus the framework helps to realise the "competence and creativity of the individuals for the benefit of the organization."[39] The framework serves as an inspiration to people involved in projects, and it is recognized as the ideal foundation for a successful project culture.

In the model two perspectives are recognized, the business and human perspectives. The business perspective in PROPS is about aligning all efforts in the organization into the same business direction, focusing on customer satisfaction and securing maximum value from of

[39] Source: http://esealmw040-29.al.sw.ericsson.se/inside/projects/models/props_r4/props.intro.html - 2005-11-23

the entire project portfolio through an efficient use of resources. The human perspective in PROPS is about recognizing the individual employee as one of the organization's most important assets.

PROPS provides models for standardizing the project life-cycle and the project organization. The project life-cycle model in PROPS is about integrating all project efforts to reaching the project goal and successfully concluding the project. The model defines what should be done in the project and when it should be done, and by whom. In PROPS project organization model, different categories of project stakeholders are described and their roles and responsibilities are defined.

PROPS framework is generic, and possible to use in different environments and industries, for all types of projects and project portfolios. However, to give more hands-on support, adaptation of the models in the framework may be needed, for instance for specific projects types that are commonly occurring in a specific organization. A special framework for customer projects is the PROPS-C model.[40]

[40] Source: http://esealmw040-29.al.sw.ericsson.se/inside/projects/models/props_r4/props.intro.html - 2005-11-23

APPENDIX III: CHARACTERISTICS OF EV PROJECTS

According to Webb(2003), projects that are well suited to the earned value method, usually have the following characteristics:

- a clearly defined objective
- a clearly perceived route to the goal
- work taking place over an extended period
- a high labour content
- tasks of a creative nature
- a formalized management structure
- cost and time limitations.

A clearly defined objective is needed in order to be able to forecast what route the project might take or where it might end up; it may at some point focus on an objective, in which case effort will be concentrated upon it or it may lose sight of any real objective and be terminated.

A clearly perceived plan is a tool that is used as a basis for comparison for the other measures such as the actual costs.

Actual reporting time-scales are important part of the control and forecasting through earned value techniques. If a project is of short duration in respect to the reporting times the project managers will not be able to make use of the earned value method.

A high labour content is a characteristic that is necessary for a successful implementation of the earned value methods. Since the methods control the cost and schedule performance it will be difficult or even impossible to control schedule if little or no life working force is involved.

The projects of creative nature usually are more risky and include schedule and cost overrun. As the earned value method is designed to work with such problems, it will be logical to use it when working with innovative tasks.

Without a formalized management structure, there is not much point in attempting performance measurement unless one is only interested in statistics. Earned value management implies not only a well-defined plan against which performance can be measured, but that someone is going to take responsibility for implementing the plan, take note of the performance measurement results and carry out whatever actions are indicated.

Cost and time limitations should be present in order to implement the earned value methods. Since the techniques' main objective is to cost and schedule control, without any limitations in those terms, there will be no point of controlling.

APPENDIX IV: EXAMPLE OF EARNED VALUE

In order to provide with better understanding of the concept of EV, it is useful to work out an example concerning a project. For that purpose a simplified example is further on discussed.
Let us assume that a project has ten activities to be performed over a period of ten weeks. Usually when working with projects, project managers tend to set a budget for each activity, which is later compared with the costs that occur when executing the activities. An estimation of time for each activity is also being made before starting the project. In the table below times and costs are shown.

Activity	Time (in weeks)	Budget (in € '000)
1	1	5
2	1	7
3	1	6
4	1	11
5	1	12
6	1	14
7	1	13
8	1	15
9	1	11
10	1	16
Total	10	110

Table 6 Projects' budget /planned values

For simplicity it is assumed that each activity is performed sequentially. Hence the above table shows the estimated parameters of the project before it has started.
The next step takes place when the project has already started and more precisely when the project manager desires to monitor if the project is developing as expected or if the estimated time and budget match the actual ones.
Suppose the project manager checks on the project after five weeks. For that purpose she will require information about the actual cost and if the activities have been completed. It is assumed that at that time four activities have been completed and the cost for those is € 31,000. After those five weeks the initial target was to complete five activities, whereas only four have been completed. The cost that is expected after the fifth week is € 41,000 (Refer to the table below) whereas it is only being spend € 31,000.

Activity	Budget (in € '000)
1	5
2	7
3	6
4	11
5	12
Total	41

Table 7 Expected cost after the fifth week

To sum up the actual cost is € 31,000 for four activities while the estimated cost is € 41,000 for five activities (Refer to the table below).

	Actual	Estimated
Activities	4	5
Cost (in € '000)	31	41

Table 8 Overview

In order to determine the EV one has to determine the value which is earned by the completion of activities and the budget for each activity is the value that is earned. Hence the EV is the sum of the budgets for the completed activities (Mayor (2003)).
EV after completion of activities 1-4 is € 29,000 (Refer to the table below)

Activity	Budget (in € '000)
1	5
2	7
3	6
4	11
Total	29

Table 9 EV after completion of activity four

To sum up:

Actual cost: € 31,000

Planned value: € 41,000

Earned value: € 29,000

Mayor (2003) suggests that to interpret the above measures it is required to consider the cost performance and the time performance.

Cost Performance

The cost performance is considered by comparing the EV with the actual cost (Mayor (2003)). There is a difference of € 2,000 between those two measures. The earned value is less than the actual cost, which is not a good indicator. It is also said that there is a variance of € 2,000 between the mentioned measures. A second way to consider the cost performance is to provide a ratio between the above measures. This ratio is called the *Cost Performance Indicator*.

$$Cost\ Performance\ Indicator = \frac{Earned\ Value}{Actual\ Cost} = \frac{29{,}000}{31{,}000} = 0.935484$$

The interpretation of the Cost Performance Indicator is that if it is more than 100%, the project is running well, however, if the indicator is less than 100%, there are problems in the project, meaning that the project manager has to review the performance (Refer to table 5). In the particular case the indicator being 0.935484 implies that there are issues to be solved in the project

Time Performance

To estimate the time performance it is required to compare the EV with the planned value at that point of time. A variance of € 12,000 is obtained. The Earned Value is significantly less than the planned value. A second way to estimate the time performance is to provide a ratio between the above measures. This ratio is called the *Schedule Performance Indicator*.

$$Schedule\ Performance\ Indicator = \frac{Earned\ Value}{Planned\ Value} = \frac{29{,}000}{41{,}000} = 0.707317$$

The interpretation of the Schedule Performance Indicator is that if it is more than 100%, the project is running well, however, if the indicator is less than 100%, there are problems in the project, meaning that the project manager has to review the performance (Refer to table 5). In the particular case the indicator being 0.707317 implies that there are issues to be solved in the project.

	= 100%	> 100%	<100%
Cost Performance Indicator Schedule Performance Indicator	Perfect performance	Exceptional performance	Poor performance

Table 10 Performance Indicators: Interpretation

Both indicators show that there are problems in the project. Moreover, by analysing them the project manager can predict the outcome of the project as a whole. If nothing is changed, it is likely that the project will not be competed within the initial ten weeks and it is likely that the initial budget will not be sufficient in order to complete the project. Further it is possible to estimate the cost and time at completion if nothing in the project is changed.

Cost at Completion

To estimate the cost at completion it is required to use the cost performance indicator and the original project budget. Hence the cost at completion is as follows:

$$Estimated\ Cost\ at\ Completion = \frac{Original\ Budget}{Cost\ Performance\ Indicator} = \frac{110{,}000}{0.935484} = 117{,}586.2$$

The estimated cost at completion, being € 117,586.2 is € 7,586.2 more than the original budget.

Time of completion

To estimate the time of completion it is required to use the schedule performance indicator and the original time estimate. Hence the time of completion is as follows:

$$Estimated\ Time\ of\ Completion = \frac{Original\ Time\ Estimate}{Schedule\ Performance\ Indicator} = \frac{10}{0.707317} = 14.13793$$

The estimated time of completion, being 14.13793 weeks is 4.13793 weeks longer than the original time estimate.

Having the estimates of cost and time of completion the project manager is provided with a forecast for the outcome of the project if nothing is changed. Based on that forecast she can decide on appropriate action to take.