EARNED VALUE MANAGEMENT
DESIGNING A TEMPLATE FOR A PROJECT MANAGEMENT SOFTWARE

3p COMPANY

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LIST OF TECHNICAL ABBREVIATIONS AND ACRONYMS

ACWP---Actual Cost of Work Performed
ANSI---American National Standards Institute
BAC---Budget at Completion
BCWP---Budgeted Cost of Work Performed
BCWS---Budgeted Cost of Work Scheduled
CAP---Control Account Plan
CPI---Cost Performance Index
CV---Cost variance
EAC---Estimate at Completion
ETC---Estimate to completion
ETTC---Estimate Time to Completion
EVA---Earned Value Analysis
EVAT---Earned Value Analysis Template
EV---Earned Value
ICB---IPMA Competence Baseline
IPMA---International Project Management Association
MS---Microsoft
OD---Ordinary Time
PMBOK---Project Management Body of Knowledge
PMI---Project Management Institute
PM---Project Manager
SPI---Schedule Performance Index
SV---Schedule Variance
TCCPI---The ‘To-Complete Cost performance index
TCPI---The To-Complete Performance Index
TCSPI ---The To-complete Schedule performance index
VAC---Variance at Completion
WBS---Work Breakdown Structure

Other Abbreviations

Etc---etcetera
i.e. --- id est. - meaning that is
e.g. --- exempli gratia - for example
Et al. --- et alii - and others
Fig. ---- Figure
pp. --- pages
p. --- page
vol. --- volume
ABSTRACT
Earned Value Management is currently becoming popular as project managers are beginning to understand its purpose and use in managing projects. The content of this thesis covers Earned Value Management with emphasis on designing an Earned Value Management template in Microsoft Excel.

The aim of designing this template is for its integration into a project management software (3p). This sophisticated, but easy to understand and use software, guides project managers through the main stages in a project, hence the need for Earned Value analysis to be integrated to track the performance of projects.

The EVA template is mainly made up of two sections. That is:

- The input section where the basic EVA parameters (BCWS, BCWP and ACWP) are entered. It also includes the BAC and the original time for the calculation of the ETTC;
- the output section- this where the figures entered in the input section are processed into meaningful information for determining the health of a project and are presented in graphs and also shown through the traffic light principle the position of the project.

For easy referencing of terminologies and formulars a glossary and a tool tip containing these are also included the template.

A thorough description of the EVA template was also put in this document where a demonstration of it with the careful assumption of figures reflecting a typical project was inputted. The results produced thereafter were coherently interpreted to reflect a real project situation.
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1.0 CHAPTER ONE - BACKGROUND TO THESIS
This chapter introduces the thesis by giving a background to it. These two sections, are the general introduction to the whole thesis including the objectives, problem statement, scope of thesis etc. The second section contains a review of related studies in the field of EVA and with regards to EVA analysis template by which this thesis was inspired.

1.1 INTRODUCTION
For every Project Manager (PM) of any project, whether complex, medium or small scale, it is paramount for him/her to get the best performance out the project. Project managers are suppose make periodic reports to steering committees, project owners or sponsors. The question that normally comes to their minds would probably be, is the project going to finish within our budget or is it going to conclude successfully within the time scheduled?

All these questions come to mind because additional cost would be incurred if the project doesn’t perform well, hence within budget and time scheduled to finish. So now, how does one track the performance of a project? This might seem to be a boggling issue which would need great mathematicians to do this. The answer to this question is the use of Earned Value Management Techniques. Earned value management (EVM) seems complex, but it has a simple foundation, (Kendrick, 2004). The answer to this question is the use of earned value management techniques in tracking the performance of a project. This uses simple arithmetic to do the various calculations.

This technique was developed by the U.S Department of Defence (DoD), which became very relevant in the early 1990, (Webb 2003). This technique as at the time it evolved is practised generally only in some few countries across the globe, namely U.S.A, Sweden, U.K, Canada, Japan, and Australia, McCauley (2001)

Earned Value calculations are founded on only three basic parameters namely the Actual cost of work performed (ACWP), Budgeted cost of work Performed (BCWP),
Budgeted cost of work scheduled (BCWS). Respectively, ACWP represents the amount of that has been spent to date, BCWP represents the value that has created which is derived from multiplying the baseline cost by the percentage complete at the report point, and finally BCWS represents the amount of work that should have been done at the report point or budget allocated for an activity or the month.

This thesis seeks to take a look at earned value management, of which a model for making earned value calculations is designed. Further, this template is also integrated into 3p project management model, an interactive project management model (software) which can be used either on Internet or on intranet, which would be described in the next section in detail.

1.2 What is 3p?

3p is an interactive project model which can be used both in Internet and intranet. 3p as a whole is a software which serves as a skeleton which direct users through four stages of managing a project. These stages are project initiation, project planning, project implementation and project completion, which serve as the main stages to successful project management.

Moreover, 3p have five decision points as designated in the figure 1 and labelled BP1 through to BP5, which are the gates to the various phases of a project. The 3P model is designed to conform to the Project Management Institutes Standards (PMI), which is the world’s biggest project leading origination. Also 3p’s phases and processes are based on the Swedish project leading standard, ISO10006:1997. Hence, 3p conforms to quality standards.

Figure 1 Processes in the 3p Project Management Software

Source: www.3p-i.com
1.2.1 Decision Points

The 3p project management model has various decision points where the project group takes a decision to proceed to the next stage of the process. These decisions points are designated with colours. It is red when no decision has been made or when the current process is incomplete. It changes to green which gives the user the signal to proceed to the next stage of the process.

- **Initiate**
  Activities including seeking, describing, choosing alternatives, judging the value of the project idea and the viable of the project.

- **Planning**
  This phase deals with putting together all the necessary inputs for executing the project. Main activities done under this phase are scope planning, defining activities, resource planning, organisational planning, quality plans, risk management planning, communications planning and procurement planning.

- **Implementing**
  This phase involves implementing all the plans in the proceeding phase (planning). These include project plan execution, quality assurance, team development, information distribution, solicitation, source selection and contract administration (PMBOK®, 2000).

- **Complete**
  This is the final phase of the project life cycle. The main activities performed here are contract closeout and administrative closure (PMBOK®, 2000).

Source: [www.3p-i.com](http://www.3p-i.com)

1.2.2 Special features of the 3p Software

- **Available/Versatility** – 3p could be installed locally off line or be used through the Internet.

- **Easy/User friendly** – 3p is easy to understand and use through the clickable graphic buttons.
• **Dynamic** – 3p is scalable: as a user you could add own phases, processes and documents.

• **Reliable** - 3p are based on PMI’s PMBOK and uses ISO- and ANSI certified processes and methods.

• **Constraining** – 3p uses decisions points or tollgates that the user have to pass through before a phase could be finished.

**Source:** [www.3p-i.com](http://www.3p-i.com)

• **Portfolio management**- Ability to manage related and unrelated projects at the same time with ease.

### 1.3 Problem Statement

The 3p project management model which is unique of its kind, used to organise and to manage a project or several related and unrelated projects, lacked a tool within it to track the status of a project. To make the 3p project management model whole, it was imperative to integrate an earned value tool within it to check the health of a project or projects being managed by it (3p). Also, it is evident that, even though EVA is not used by mostly but some project managers, especially in the developing world, it is gaining a lot of popularity in most developed countries. According to Cable et al., a survey conducted by the International Council for Project Management Advancement, 75.3% of the respondents felt that EVM was suitable as a Standard for project performance measurement (table 1). This shows how relevant an EVA model should be attached to the 3p project management model to make it substantial by embracing all aspects of project management. Further the statistics shows that in the near future project managers would be embracing the use of earned value management in managing their projects. In a conclusion statement by Ph.D. Christensen (1999), he pointed out that the use of earned value is accelerating worldwide. This called for an integration of an EVA template into the 3p software or model.
1.4 Objectives of Study
The main object of this study is to design a simple user friendly project earned value management template, which would be incorporated into the 3p project management model.

1.5 Scope of Study
The scope of this thesis is centred on the 3p AB with focus on the design of an earned value Project Management template using MS excel.

1.6 Organisation of Study
This thesis is made up of four chapters. Chapter one contains two sections. That is the introduction and a general background to the thesis, and a review of some selected literature on EVA templates. The second chapter contains the EVA terms and methodologies implemented in the template designed in this thesis. The third chapter describes the various sections of the template designed. Finally, the fourth chapter contains the discussions and conclusions.

1.7 Limitation of Study
- The scarcity of literature related to this topic with emphasis on the design of a template.
1.8 Literature Review

Since the hub of this thesis is on earned value management, it would be worthwhile to review literatures related to this topic. This review is divided into three sections, which are a review of the importance of EVA, EVA parameters, EVA metrics and finally a review of some templates on the market. Some selected literatures were reviewed to motivate this thesis.

1.8.1 Importance of EVA

According to the IPMA\(^1\) competence baseline\(^2\) (1999) “the continuous measurement of project status is vital for effective time and cost control.” The PMBOK\(^3\) (2000) is of the view that “disseminating performance information provides stakeholders\(^4\) with information about how resources are being used to achieve project objectives.” These two views suggest that regular reporting of the projects status is imperative to the knowledge of stakeholders hence for them (stakeholders) to know whether the project has created value for the money invested. It is of this view that EVA which is used to check the health of a project has been included to the 3p project management model. This would make the model comprehensive regarding all aspects of project management. BIA (2006) in his project management binder pointed out some vital reasons why EVA should be used. Most importantly he pointed out that it provides an early warning signal for early recovery. Further, McCauley (2001) outlined some valuable points why EVA should be used. These are similar to BIA’s (2006) view which is providing early and accurate identification of trends and problems, accurate

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\(^1\) International Project Management Association (IPMA) is a non-profit, Swiss registered organisation, whose function is to be the prime promoter of project management internationally (ICB, 1999)

\(^2\) The IPMA competence Baseline (ICB) contains basic terms, tasks, practices, skills, functions, management processes, methods, techniques and tools that are commonly used in project management, as well as specialist knowledge, where appropriate, of innovative and advanced practices used in more limited situations (ICB, 1999)

\(^3\) The project Management Body of Knowledge (PMBOK) is an inclusive term that describes the sum of knowledge within the profession of project management. As with other professionals such as law, medicine, and accounting, the body of knowledge rests with the practitioners and academics that apply and advance it (PMBOK, 2000)

\(^4\) Project stakeholders are individuals and organisations that are actively involved in the project, or whose interests may be positively or negatively affected as a result of project execution or project completion; they may also exert influence over the project and its results. (PMBOK, 2004)
picture of project status, basis for correction etc. Webb (2003) in his book, A Project Manager’s Guide, also provides similar views which states that EVA provides:

- 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.

EVA was added to 3p project management because of the above outlined points which would provide confidence in the users of the product in respect to running their projects to know whether they are on or not on track.

1.8.2 Review of some EVA models/templates

After a review of the importance of EVA presented by some authors it would be worthwhile to review some models and templates in EVA based on their inputs, outputs and other feathers of it that makes it appealing for the user.

1.8.3 Template inputs

In some books they refer to the basic parameters of EVA in a different way depending on the country. In most literatures they name three basic parameters as Budgeted cost of work scheduled (BCWS), Actual Cost of Work Performed (ACWP) and Budgeted Cost of Work Performed (BCWP). However, in other literatures they refer to them as Planned Cost (PC), Actual Cost (AC) and Earned Value (EV) respectively. These differences do not change anything at all but it is just the naming that changes. The PMBOK, 2003 and ICB, 2002 uses the former. Dimitrova (2005), in her template for Sonny Eriksson used the naming for the three parameters based on the latter. Also, Amevor and Borzikowsky (2005), in their EVA template presented the inputs according to the latter.
However, in the Earned Value calculator\textsuperscript{5} the inputs were based on the former. In this template, to be designed for the 3p project management model, the three parameters are based on the former, which are widely used and used by the PMI on whose standards the 3p model is based.

### 1.8.4 Template outputs

Dimitrova (2005) in her pursuit to create an EVA template for Sonny Eriksson used only the basic earned value calculations. Amevor and Borzikowsky (2005) also used only the basic EVA calculations in their template. In the contrary the template designed for the 3p model would have additional calculations that would help the project manager in determining the status of his/her project. Some of these additional formulars adopted are The “to-complete Cost performance Index” for budgeted cost (TCCPI) as well as for schedule (TCSPI), Cost Schedule Index, Schedule variance as a percentage of schedule achievement, Cost variance as a percentage of earned value, percentage complete at the report point and finally percentage spent at the report point. All these output calculations are also presented on graphs and pie charts in the 3p EVA model for analysis.

### 1.8.5 Template Design

Designing the template is also a crucial aspect which makes the template appealing to the user. It should be designed in such a way that the user should have a considerable amount of convenience, not complicated and must provide enough information for the user. Dimitrovo (2005) designed her template with an input and output columns. On the contrary there is no clear distinction between the input and the out areas of the template. Further, the template was customised for Sonny Ericson only, hence making it almost impossible for other users to make good of it. Amevor and Borzikowsky (2005), on the other hand designed a more simple to understand template. The template has three sections namely the input area, output area and the project status. However, these sections were not defined on the template which will make it difficult for a layman to use. This was designed using only three excel sheets

\textsuperscript{5} http://www.engin.umd.umich.edu/CIS/course.des/cis525/js/f00/tejal/form.htm
namely the definition, source data and analysis as depicted on figure 3. Dimitrovo (2005) rather had each input and output fields on separate sheets making her use many excel worksheets, which in my opinion would be inconvenient for the user. Amevor and Borzikowsky (2005) have on a separate sheet the explanations of the terms and formulars used in their template. In a similar vein, the earned value calculator also has a help function that defines the terms and but gives very succinct information to the user. Also, in a different format, the earned value calculator,\(^6\) an internet based programme also has an input and an output area, which is well defined, but the output section has very limited information for analysis to control cost and time. This is depicted in figures 4 and 5. Lastly the earned value calculator has no trend analysis which would be crucial for management to base their decisions on in steering a project.

**Figure 3 the design Interface of Amevor and Borzikowsky’s (2005) EVA Template**

![Figure 3](http://www.engin.umd.umich.edu/CIS/course.des/cis525/js/f00/tejal/form.htm)

Source:

\(^6\) [http://www.engin.umd.umich.edu/CIS/course.des/cis525/js/f00/tejal/form.htm](http://www.engin.umd.umich.edu/CIS/course.des/cis525/js/f00/tejal/form.htm)
Figure 4 Input interface of the Earned Value Calculator

![Input Interface](http://www.engin.umd.umich.edu/CIS/course.des/cis525/js/f00/tejal/form.htm)

Source: [http://www.engin.umd.umich.edu/CIS/course.des/cis525/js/f00/tejal/form.htm](http://www.engin.umd.umich.edu/CIS/course.des/cis525/js/f00/tejal/form.htm)

Figure 5 Output interface of the Earned Value Calculator

![Output Interface](http://www.engin.umd.umich.edu/CIS/course.des/cis525/js/f00/tejal/form.htm)

Source: [http://www.engin.umd.umich.edu/CIS/course.des/cis525/js/f00/tejal/form.htm](http://www.engin.umd.umich.edu/CIS/course.des/cis525/js/f00/tejal/form.htm)
In conclusion the limitations and gaps in the templates reviewed above were enhanced and implemented in the 3p project management model. A summary of those limitations and gaps implemented in addition to 3p EVA model are as follows:

- Well defined sections
- Adding more output fields for a comprehensive EVA analysis
- Adding more project status to warn user based on the TCPI (BAC), TCPI(OD), CSI, CPI and SPI.
- A glossary that would provide the user with information about the terms
- A tool tip to would serve as a quick reference to all terms in each field
- The use of the traffic light functions at the project status section of the template.

After a review of some related literature, in this section, the next chapter describes the methodology used in the design of the EVA template.
2.0 CHAPTER TWO – TERMINOLOGY AND METHODS
Before using Earned Value to analyse your project there are certain calculations that must be performed in order to achieve this. In this regard, this chapter seeks to introduce and explain all the EVA terms and how they are calculated, and which have been implemented in EVAT. Also containing in this chapter are the methods used for their implementation in the template.

2.1 EVA terms Implemented in Template
Earned Value Management is a method for integrating work scope, schedule, and budget and for measuring project performance. It compares the amount of work that was planned with what was actually accomplished to determine if cost and schedule performance were achieved as planned. (Solomon, 2002)

The principles of an EVM system include the following:

Break down the program work scope into finite pieces, called work packages, that can be assigned to a responsible person or organization for control of technical, schedule, and cost objectives.

Integrate program work scope, schedule, and cost objectives into a performance measurement baseline against which accomplishments can be measured.

客观ly assess accomplishments at the work package level.
(Solomon, 2002)

2.1.1 The Basic Earned Value Data
In every earned value calculations only three basic figures are used. These are Budgeted cost of Work Scheduled (BCWS), Budgeted Cost of Work Performed (BCWP) and Actual Cost of Performed (ACWP). It is from these three basic data that nearly all the other Earned Value data may be derived. (Christensen PhD, 1999). Even though on the template there are other two input data (Ordinary time and Budget at Completion, which would be explained later in this chapter) these three basic data forms the main input data upon which the other data in the output section are derived.
2.1.1.1 Budgeted Cost of Work Scheduled (BCWS)

This is the budget for work scheduled to be completed. (Christensen PhD, 1999). It is also the sum of all planned cost in the project, or any given part of

![Figure 6: A graphical presentation of the Basic EVA inputs](http://office.microsoft.com/en-gb/assistance/HA010211791033.aspx)

- The vertical y-axis shows the projected cumulative cost for a project.
- The horizontal x-axis shows time.
- The planned budget for this project shows a steady expenditure over the lifetime of the project. This line represents the cumulative baseline cost.

After work on the project has begun, a chart of the key values of earned value analysis may look like this:

![Chart of key values of earned value analysis](http://office.microsoft.com/en-gb/assistance/HA010211791033.aspx)


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the project, up to the reporting date. (Webb, 2003) BCWS can also be monthly or cumulative. As a monthly amount it represents the amount of work scheduled to be completed for a particular month. As a cumulative amount, it represents the amount of work scheduled to be completed to date (Christensen PhD, 1999). In some countries like Sweden BCWS can be referred to as Planned Value (PV).

2.1.1.2 Budgeted Cost of Work Performed (BCWP)

This is the cost of all the planned progress achieved on the project, or part of the project, up to the reporting date expressed in terms of the planned costs originally set out in the initial estimate. It represents what has been earned, not simply what has been spent (Webb, 2003).

2.1.1.3 Actual Cost of Work Performed

This represents the actual cost incurred in accomplishing the work within a given time period. This includes both direct and indirect cost (Christensen PhD, 1999 pp 5). It is the sum of what has actually been spent irrespective of what has been planned or achieved Webb 2003)

Figure 7 The Basics of Earned Value as Shown on an S-curve

The project as a whole is divided into convenient work packages or activities. Each work package or activity is assigned a budget in terms of hours, currency or other measurable units. By summing their budgets, a time-phased budgetary baseline for the entire project is defined. This base line, known as the Performance Measurement Baseline (PMB), represents the standard or plan against which the performance (BCWP) and the cost (ACWP) of the project are compared (Christensen PhD, 1999). Figure 6 shows the relationship of the three basic parameters.

2.1.1.4 Budget at Completion (BAC)

The BAC I will say serves also as an input figure as displayed on EVAT. As explained by Newell (2003), it is the total operating budget allocated for the project. The BAC is used in conjunction with other EV metrics to derive other formulas for further calculations. For example, the BAC is used with the product(s) of other derived formulas to predict the future of a project. Newell (2003) further explained that in the earned value reporting system, the BAC is a point that is at the end of the BCWS or PV line on the chart (see Figure 7). Since the BCWS line is a plot of the budget for each task in the project over time, the point at the end of the line is over the point in time when the project is scheduled to be complete and the point on the vertical axis corresponding to the end of the line is the total project budget.

2.1.2 The EVA calculations

Based on the above data in section 2.1.1 which are the basic data upon which the various EV calculations are made, and also serves as the input for the template, this section seeks to present the various calculations for EVA and which serves as the output for the template.

2.1.2.1 Variances

After establishing the earned value (BCWP) the numerical difference between it and the other two values (BCWS and ACWP) gives two different products. The Schedule variance (SV) and the Cost variance respectively (CV). The SV indicates whether the project is behind schedule or on schedule. A negative SV represents a slippage which is unfavourable for the project because the project is spending more hours than expected to perform a specific task. On the other hand, a negative CV means the
project is spending more money on a particular activity or at a particular report period than what was budgeted.

The formulas for deriving these two variances are:

- **Schedule Variance (SV)** = BCWP - BCWS
- **Cost Variance (CV)** = BCWP - ACWP

Cost and Schedule Variances can be calculated on either cumulative data or periodic (typically monthly) data (Webb 2003). Webb (2003) advised that variances should be computed at the lowest level of detail established within a project and progressively summed through the various levels of the project. This he said would make it possible to see where the cost and schedule variance problems occur and to take the appropriate actions or measures against their reoccurrence.

### 2.1.2.3 Performance Indices

Ascertaining figures for the two variances are very simple to do. It is just a basic arithmetic (subtraction of two variables) but reflects an important decision making tool in a projects lifetime. However, further numerical calculations can be derived which may be even more helpful (Webb 2003). These are the Cost performance Index (CPI) and the Schedule Performance Index (SPI). When these two index numbers are calculated it gives an instant measure of performance against both the cost plan and the schedule (Webb 2003).

- **Cost Performance Index**

  This is defined as the ratio of value created to the amount spent at a point in time (Webb 2003). In more simple terms, PhD Christensen (1999) defines CPI as a measure of the budgeted cost of completed work against the actual cost. In this definition, the completed work refers to the value created (BCWP). The deriving formula for this index is:

  \[
  CPI = \frac{BCWP}{ACWP}
  \]
If the CPI is less than one, an unfavourable cost variance is indicated (Christensen 1999). For example, if a CPI is SEK 0.85 it means that for every Kronor spent, only SEK 0.85 of work has been completed.

**Schedule Performance Index (SPI)**

Webb (2003) defines SPI as the earned value created to the amount of value planned to be created at a point in time on the project. An SPI less than one indicate an unfavourable schedule variance. (PhD Christensen, 1999). Christensen (1999) further discussed that an unfavourable SPI does not necessarily mean that the project is behind schedule. For example, an SPI of SEK0.85 means that for every Kronor of work scheduled to be completed, only SEK0.85 has been achieve at the report point. Christensen (1999) pointed out that, an unfavourable SPI may be predictive of cost overrun, because schedule problems may require additional cost in the months preceding the report point, to make adjustments. The formula to derive the SPI is as follows:

$$SPI = \frac{BCWP}{BCWS}$$

**The To-Complete Schedule Performance Index (TCSPI)**

As depicted by its name the TCSPI indicates the level of schedule performance required to finish on time from the report point (Webb, 2003). That is a TCCPI of 1.2 means that the project must perform on a SPI of 1.2 from the report point to completion of the project. As explained by Newell (2003), there is a contrast here in the sense that the TCSPI is an index and hence should reflect favourable conditions when greater than one. On the contrary the TCSPI becomes unfavourable when it is greater than one. In this case, the further the SPI is from the TCSPI the more doubtful that the project is going to complete at the Estimate at Completion (which would be discussed later). The formula for deriving the TCSPI is as follows:

$$TCCPI = \frac{BAC – BCWP}{BAC - BCWS}$$
• **The To-Complete Cost Performance Index (TCCPI)**

Analogous to the TCSPPI this index indicates the level of cost performance that will be necessary to complete the project within budget from the report point. A TCCPI of 1.5 means that the project has to perform with a CPI of 1.5 to complete successfully within the original budget stipulated. Like, the TCSPPI it is also not accurate. The reason being that, when the CPI is less than one the, which indicates an unfavourable performance, the TCCPI on the other hand becomes greater than one, which is not reflective of a typical index.

According to Newell (2003) these indexes are rarely used due to its complications, but gives an idea as to what performance is needed to finish within budget and to finish on time. This made it an important factor to implement these two “controversial” but important indexes in EVAT. The formula for deriving the TCCPI is as follows:

\[
TCCPI = \frac{BAC - BCWP}{BAC - ACWP}
\]

• **Cost Schedule Index (CSI)**

The Cost Schedule Index determines whether a project can be continued or not. The further a project's CSI is less than 1.0 the more difficult it is for the project to be recovered. The formula for the CSI is as follows:

\[
CSI = SPI \times CPI
\]

2.1.2.4 Predictive Formulas

These are EVA formulas used in predicting the condition that a project would be in from the report date. The common formulas used here are the Estimate To Completion (ETC), Estimate At Completion and the Estimate Time To Completion (ETTC)
• **Estimate To Completion**
  
  This is an estimate of the additional money that would be necessary to complete the project (Newell, 2003). Newell (2003), explains that using the ETC predicts that the project will overrun or under run its budget at the end of the project and that it is a good thing to inform stakeholders and managers informed of danger, but not practical to get extra money for the project. The deriving formula is as follows:

\[
ETC = EAC - ACWP
\]

• **Estimate At Completion (EAC)**
  
  As described by Newell (2003), it is the forecast value of the project when the project is complete. The EAC shows the total schedule or projected cost. The formula for deriving the EAC is as follows:

\[
EAC = ACWP + (BAC-BCWP)/CPI
\]

• **Estimate Time To Completion (ETTC)**
  
  This indicates the overall duration of the project (Webb, 2003). The formula for deriving it is as follows:

\[
ETTC = OD / SPI
\]

2.1.2.4 Other EVA metrics

• **Variance at Completion (VAC)**
  
  VAC is the difference between the BAC and the EAC. A negative VAC indicates an unfavourable variance and a positive VAC indicates favourable variance. The formula for the VAC is as follows:

\[
VAC = BAC - EAC
\]
• **Percent complete**

The Percent complete is the amount of work that has been completed over the budget at completion. This gives the formula:

\[
\% \text{ Complete} = \frac{BCWP}{BAC} \times 100
\]

Newell (2003) pointed out that the percent complete can never be greater than 100. This is because the BAC is the sum of the budget in the project. The difference between the BCWS and The BCWP for an activity is whether or not the activity has been completed, at the end of the project the sum of all of the budgets must equal the sum of all the BCWP. If an activity has not claimed its BCWP, the project is not yet completed. As soon as all of the activities in the project have claimed their BCWP, the project is said to be completed.

• **Percent spent**

This is simply the amount of the project budget that has been spent to date. It is computed by dividing the ACWP by the BAC. The formula is as follows:

\[
\% \text{ Spent} = \frac{ACWP}{BAC} \times 100
\]

• **Percentage of Project Schedule to be achieved at a Report Point**

This is also a simple EVA calculation. It indicates the percentage of the schedule that has been achieved at the report point. It is calculated by dividing the BCWS by the BAC.

\[
\% \text{ of Project Schedule to be achieved at Report Point} = \frac{BCWS}{BAC} \times 100
\]
2.2 Method
The method used in implementing these terms was Microsoft Excel using both simple and advance MS excel logical formulas. These formulas are displayed in Appendix 1. In implementing the “traffic light” principles the conditional formatting in excel was used.

Figure 8 Selecting Conditional Formatting in Excel

This begins by selecting the conditional formatting command as displayed in figure 8. Firstly, you click on the dropdown menu in which is displayed “Cell value is” to select one of the conditions. In designing the project status for the CPI and SPI the second format (“Formula is”) was used. This is displayed in figure 9. At this point, you enter the formula that the format should follow (figure 6).

Figure 9 Selecting a formatting method

In this case the formula is saying that “if the value of cell 22 is less than 0.85, then the cell should change to the format that you specify.”

Secondly, you select the format button of which a new dialogue box would be displayed (figure 12). Here, you choose the colour, fonts and borders that you want to
be displayed according to the formula stated. You can add up to a maximum of three conditions per cell. You do this by clicking on the add button. This will display an additional formatting window (figure 13)

**Figure 10** A selected formatting method

**Figure 11** Entering the condition

**Figure 12** formatting the cells to depict the formula
In figure 8, the conditions set can be explained as follows.

- First condition – “if cell 24 is less than 0.85, then the colour of the cell should be red.
- Second condition – “if cell 24 is less than 1, then the colour of the cell should be yellow”
- Third condition – “if cell 24 is greater than 1, then the colour of the cell should be green”

In designing the “traffic light” for the TCCPI, TCSP and the CSI the second formatting principle (“Cell value is”) was used (figure 9). After selecting this principle you then click on the dropdown menu which displays a default “between”. There you choose the suitable condition and follow the same procedure as the first one to format the cells. With this one too you have a limit of three conditions per cell.
In figure 15, the conditions set can be interpreted as follows:

- Condition one – “if current cell displays “watch out”, then the colour of cell should be orange.”
- Condition two – “if current cell displays “warning”, then the colour of cell should be red.”
- Condition three – “if current cell displays “danger”, then the colour of cell should be red.”

It should be noted here that the displayed wordings (watch out, warning and danger) are string formulas from which the conditions for formatting are referenced.
3.0 CHAPTER THREE – DESCRIPTION OF TEMPLATE

Chapter three introduces the Earned Value Analysis Template (EVAT) designed for the 3p project management model. It explains all the various sections of the template which includes the input, output, project status, graphical analysis sections etc. of the template.

3.1 Introduction

The EVA model as a whole is made up of two major parts, namely the input data area and the output area. The input data area (circled in blue in fig. 16) receives raw data, namely the Budgeted cost of work scheduled, Actual cost of work performed, Budgeted cost of work scheduled, which are the foundations to earned value calculations, and are then processed into useful information at the output area for various analysis in respect to a project’s advancement. In addition to the input area is the Budget at Completion (BAC) which is used to make further calculations.

Further, the output area is made up of three components. These are the main output information area (Circled in green in fig. 16), trend analyses and the project status (Circled in red in fig. 16), which is the intelligence part. Also, a glossary has been included to serve as a quick reference for the user on the meaning of and EVA terms and formulas involved. To use the glossary check on the last sheet tab on which it is written “glossary”

3.2 Input Area

The input data area is the mouth of the template where EVA data known as BCWS, BCWP and ACWP are entered for the template to process these data into the various EVA calculations and immediately you will know the status of your project, whether it’s performing favourably or not. Other inputs added are the BAC and OD which are used for further calculations in conjunction with the EVA metrics calculated. These names serve as labels for the input fields and are seen on the left hand side corner of the input section of the template. On the right hand side on the input section are the cells in which you enter the figures for each input field and are labelled from period one to twelve. All the fields (BCWS, BCWP and ACWP) can be monthly or cumulative, Christensen (1999).
3. 3 Output Area

The output (fig. 18) area displays the processed data entered in the input area for analysing your project. It displays the various EVA metrics in tracking the performance of a project. These are grouped under main headings at the output area as variances, performance indices, and estimate of a project’s future and other calculations. This has been grouped in this way for convenience as calculations under each heading is related and collectively can be compared with each other to analyse their trends.
As already pointed out in the introduction, the output area is three fold, that is the output area where the results of the various calculations are displayed (circled in green, fig. 16), the output area where these figures are put on graphs to analyse trends and lastly, based on the figures presented you immediately know your position with regards to your project, and this area of the template is known as the project status area.

### 3.4 Project Status Area
This section of the output area displays colours, red, black, green and yellow depicting different situations in which a project is in at a report point. The first two fields, the project status based on SPI and CPI displays only three colours. These are red, green and yellow. Within these colours, it also displays certain wordings such as “watch out”, “on track”, “warning” and “danger”. These words are displayed with the colours according to the following:

When CPI or SPI is:

- $< 1$ it displays yellow with “watch out” (project moderately behind schedule or over budget)
- $< 0.85$ it displays red with” Warning” (project far over budget or schedule and needs considerable amount of attention)
- $< 0.65$ it displays also red but with “Danger” (highly behind schedule or over budget and must be treated with urgency)
- $\geq 1$ it displays the colour green with “on track”

Also, the project status based on TCCPI and TCSPi displays only two colours with only two wordings. These are red and green with the wordings unfavourable and favourable respectively. Red is displayed with unfavourable when both TCPI are greater than CPI and green with “favourable when CPI is greater than the two TCPI.
Lastly, the project recoverability status displays four colours namely red, yellow, red and green. This is the most important part because it tells you whether your project can be recovered or not. The colours displayed show the level of recovery. The following are the meaning of the colours:

When CSI is:

- < 1 it displays yellow with “watch out” (Project may be recovered with ease)
• < 0.85 it displays red with” Warning” (Project may be difficult to recover)
• < 0.65 it displays black with “Danger” (Project may not be recovered)
• >= 1 it displays the colour green with “on track”

3.5 Trend Analysis
This section of the output area displays various graphs showing trends of the various calculations for critical analysis of a project. The graphs are displayed when you click on the EVA analysis, variances and performance indices sheet bottom (figure 5). Other EVA analyses are displayed in the “other analysis” sheet bottom. Appendices 1 to 3 Displays all the various graphs in the template.

Figure 20 Trend Analysis part of EVAT

In the “EVA analysis” sheet bottom the following are trend analysis are displayed:
• Earned value trend analysis (including ACWP, BCWS, BCWP and BAC)
• Estimate to completion (ETC)
• Estimate at Completion (EAC)

For convenience, all analyses are displayed on the same sheet as displayed in figure 20.
The “variances and performance indices” sheet button displays the following:

- Variances for cost and schedule as well as variance at completion.
- The to complete Cost Performance Index and the To Complete Schedule Performance Index

In the “other analysis” sheet bottom the following are displayed:

- Percentage spent at the report point
- Percentage complete at the report point
- Percentage of project schedule to be achieved at the report point

3.6 Glossary

This section can be assessed by clicking on the glossary sheet bottom. The glossary in the template shows a summary explanation of all the terms and associated formulas used in the template. (See figure 21)

3.7 Comments/tool tips on Terms

To serve as a quick reference comments are made on each term. Just put the mouse pointer on the term and this displays the meaning of the term selected. This is demonstrated in figure 22
Now that we know the various EVA terms and how it was implemented, the next chapter will be based on discussions on how to use the template to manage a project.
4.0 CHAPTER FOUR – DISCUSSIONS AND CONCLUSIONS
This final chapter discusses how to use the figures displayed by EVAT to track the progress of a project. This is done by using an illustration with figures (imaginary) inputted into the template and the results interpreted. But before that the introduction of this chapter discusses the foundations to an EVA, which is use of Work Break Down structure. Also Contained in this chapter is the general conclusion of this master thesis and some propositions for future work on the template.

4.1 Introduction
To make EVA work in a project it should have a well planned and organised scope identifying all the various activities that would be performed in executing the project. This facilitates resource allocation to each activity hence allowing easy tracking of progress on each activity specified for the project. This requires the use of a Work Breakdown Structure (WBS) in specifying activities for a project. Even though this chapter focuses on how to use EVA to manage a project it is imperative to discuss a WBS prior to the former discussion because EVA is always preceded by a well planned and organised project.

4.2 Work Break Down Structure (WBS)
A WBS is a deliverable-oriented grouping of project components that organises and defines the total scope of the project (PMBOK, 2000). That is WBS makes out and in an orderly manner classifies the content of a project, hence all other work not included is outside the scope of the project. According to Webb (2003), the purpose of the WBS is to define discrete quantities of work so that:

- They can be uniquely identified for what they are.
- They can be seen for their contribution to the total project.
- They can be monitored and controlled from a time, cost and content standpoint.
- Responsibility for achievement and performance can be allocated.
- Meaningful historic data can be obtained at the end of the project.
Referring to figure 23 the white box represents the total project and the blue boxes are the various work activities\(^8\) (components) that would be performed within the scope of the building project. These work packages can be sub-divided into various work packages\(^9\) as illustrated in figure 24. As Yong (1997) pointed out the items at the lowest levels or leaves of the WBS are significant because each leaf defines a discrete element of work or task to be performed against which resources can be assigned and cost and schedule measured.

---

\(^8\) A deliverable at the lowest level of the work breakdown structure, when that deliverable may be assigned to another project manager to plan and execute. This may be accomplished through the use of a subproject where the work package may be further decomposed into activities. (PMBOK, 2001)

\(^9\) A deliverable at the lowest level of the work breakdown structure, when that deliverable may be assigned to another project manager to plan and to execute. This may be accomplished through the use of a subproject where the work package may be further decomposed into activities. (PMBOK, 2001)
After breaking down the work into its lowest level schedule and cost, as well as resources (Human and materials), are assigned to them. The individuals responsible for the accomplishment of each activity are also specified. This is called a work package (Yong, 1997).

As put forward in Yong (1997) document, the Cost/Schedule Control Systems Criteria Joint Implementation Guide, give the following characteristics to be typical of a work package:

- The work package) represents units of work at levels where work is performed.
- It is clearly distinguished from all other work packages.
- It is assignable to a single organizational element.
- It has scheduled start and completion dates and, as applicable, interim milestones, all of which are representative of physical accomplishment.
- It has a budget or assigned value expressed in terms of dollars, man-hours, or other measurable units.
- Its duration is limited to a relatively short span of time or it is subdivided by discrete value milestones to facilitate the objective measurement of work performed.
- It is integrated with detailed engineering, manufacturing, or other schedules.

These work packages may further be decomposed in a subproject work breakdown structure especially when a project manager assigns a scope of work to another organisation and this other organisation must plan and manage the scope of work at a more detailed level than the project manager in the main project (PMBOK, 2000)
4.3 Managing With Earned Value – an Illustration

Now that we know about the WBS, the system based on which EVA can be possibly used in a project, this section discusses with examples, and how the EVAT can be used to manage a project. With an illustration, let’s say a project with a six month duration, which is currently on the fourth period, has the following data:

Table 1 Input figures for illustration

<table>
<thead>
<tr>
<th></th>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
<th>Period 4</th>
<th>Period 5</th>
<th>Period 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>BAC</td>
<td>1600</td>
<td>1600</td>
<td>1600</td>
<td>1600</td>
<td>1600</td>
<td>1600</td>
</tr>
<tr>
<td>BWCP</td>
<td>300</td>
<td>450</td>
<td>600</td>
<td>1000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BCWS</td>
<td>300</td>
<td>500</td>
<td>700</td>
<td>900</td>
<td>1300</td>
<td>1500</td>
</tr>
<tr>
<td>ACWS</td>
<td>300</td>
<td>520</td>
<td>840</td>
<td>1100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Putting the above data in the template gave the following results up to the fourth period:

Table 2 Output figures from illustration

<table>
<thead>
<tr>
<th></th>
<th>Period 1</th>
<th>Period 2</th>
<th>Period 3</th>
<th>Period 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>CV</td>
<td>0</td>
<td>-70</td>
<td>-240</td>
<td>-100</td>
</tr>
<tr>
<td>SV</td>
<td>0</td>
<td>-50</td>
<td>-100</td>
<td>100</td>
</tr>
<tr>
<td>VAC</td>
<td>0</td>
<td>-248.89</td>
<td>-640</td>
<td>-160</td>
</tr>
<tr>
<td>CPI</td>
<td>1</td>
<td>0.87</td>
<td>0.71</td>
<td>0.91</td>
</tr>
<tr>
<td>TCCPI</td>
<td>1</td>
<td>1.06</td>
<td>1.32</td>
<td>1.20</td>
</tr>
<tr>
<td>SPI</td>
<td>1</td>
<td>0.90</td>
<td>0.86</td>
<td>1.11</td>
</tr>
<tr>
<td>TCSPi</td>
<td>1</td>
<td>1.95</td>
<td>1.11</td>
<td>0.86</td>
</tr>
<tr>
<td>CSI</td>
<td>1</td>
<td>0.78</td>
<td>0.61</td>
<td>1.01</td>
</tr>
<tr>
<td>EAC</td>
<td>1600</td>
<td>1848.89</td>
<td>2240</td>
<td>1760</td>
</tr>
<tr>
<td>ETC</td>
<td>1300</td>
<td>1328.89</td>
<td>1400</td>
<td>660</td>
</tr>
<tr>
<td>ETTC</td>
<td>6</td>
<td>6.67</td>
<td>7</td>
<td>5.40</td>
</tr>
<tr>
<td>% of project schedule to be achieved at the report point</td>
<td>18.75</td>
<td>31.25</td>
<td>43.75</td>
<td>56.25</td>
</tr>
<tr>
<td>% complete</td>
<td>18.75</td>
<td>28.13</td>
<td>37.50</td>
<td>62.50</td>
</tr>
<tr>
<td>% spent</td>
<td>18.75</td>
<td>32.50</td>
<td>52.50</td>
<td>68.75</td>
</tr>
</tbody>
</table>
4.3.1 Interpretation of the Results from the example

Figures produced the template would meaningful unless interpreted to into what they stand for. In this respect this section interprets the figures given out in the output section of EVAT in the illustration into a language that would be understandable by the ordinary person.

4.3.1.1 Interpretation of the CV

At period one, the project was scheduled to cost 300 and it has actually earned 300. Actual expenses incurred amounts to 300. The results of it are that it produces a CV of zero meaning it is neither over budget nor under budget. From periods two to four, it is showing negative variance of -70, -240 and -100 respectively, meaning that the project is over budget. As indicated in chapter two a negative variance means that the project is not performing favourably. That is more resources are used than budgeted for the period. (Refer to figure 26)

---

10 It’s important to realize that negative schedule variances can occur even if work is being accomplished on schedule or if money is being spent at the rate planned, because earned value integrates the measurement of time and costs to show the true value of the work produced to date in comparison to the expected value to date—in other words, making it a more accurate indicator of project performance than either schedule or cost information alone could possibly be. (Knutson and Joan, 2001)

11 A positive cost variance does not always mean something good. If our cost variance is positive and we have left out some of the required work it would not be such a good thing. A good rule of thumb is that any variances, whether positive or negative, should be investigated (Newell, 2003)
4.3.1.2 Interpretation of the SVs
At period one the SV is zero since the project was scheduled to cost 300 and it has earned 300. That is SV is BCWP minus BCWS. However, periods two and three show a negative schedule variance indicating that the project is behind schedule by 50 and 100 respectively. This shows an unfavourable schedule variance. At period four it shows a positive schedule variance of 100, which interprets that the project is beyond schedule and that indicates a favourable variance. That is the project has utilised the time scheduled for the period well. (Refer to figure 26)

4.3.1.3 Interpretation of the VAC
The VAC is computed by subtracting the EAC from the BAC. At period one, since the EAC is the same as the BAC there is no variance produced. From period two to four, negative variances are produced indicating an unfavourable condition. This indicates the final overrun of the project.
These three variances are depicted on a graph in the template and shown on figure 26.

Figure 26 Graphical presentation of results from variances
4.3.1.4 Interpretation of the CPI

From chapter two we learnt that the CPI measures how well the project’s budget has been spent\textsuperscript{12}. When a project is following its plan, the amount of work accomplished and the amount of money spent to accomplish it are the same, and the resulting value will be one. So, an index of one means that the project is following its project plan (Newell, 2003). This is shown on the example as on the first period the project was following its budget so it produced a CPI of one. However, on the subsequent periods the CPI was changed to 0.89, 0.71 and 0.91 at periods two, three and four respectively\textsuperscript{13}. The means that the project’s budget was not followed and indicates an unfavourable index. That is for every Kronor spent only SEK0.89, SEK0.71 and SEK0.91 of work has been completed respectively in periods two, three and four. On the product status section (fig. 25) of EVAT it indicates the yellow colour and displays the wording “watch out” in periods two and four and red with the wording “warning” in period three meaning that, even though all CPIs are unfavourable, the CPIs for period two and four are more than 0.85 but less than one and CPI for period three is less than 0.85. These limits show how bad the project is over budget and gives quick information to the project manager to take immediate actions necessary. On the graph (fig. 27) it clearly indicates the CPI is below one in all the periods except period one.

\textsuperscript{12} The cost performance index is like the cost variance discussed previously with one important difference. When we calculated the cost variance, the result was a figure in Kronor. A negative figure showed an unfavourable variance and vice versa. The problem with this method is that it is difficult to compare projects of different sizes to one another. It would be better to have a measure that gave the health of the project regardless of its size. For this purpose the performance index is used (Newell, 2003)

\textsuperscript{13} According to Christensen (1999) research on completed defence contracts shows that the cumulative CPI does not change by more than 10 percent from its value at the 20% completion point, and \textit{in most cases only worsens}. 
4.3.1.5 Interpretation of the SPI

The SPI indicates how well the project is on schedule and a SPI less than one indicates an unfavourable schedule variance\(^{14}\). It is a comparison of the project tasks that were planned to be accomplished to the work that was really accomplished (Newell 2003). From the example periods one and four indicates favourable SPI meaning that the project was on schedule showing a SPI of 1.0 in period one and even less time spent in period four showing a SPI of 1.11. (See fig. 27) However, in periods two and three an unfavourable SPIs of 0.90 and 0.86 are respectively indicated. This means that for every Kronor of work scheduled to be completed only SEK0.90 and SEK0.86 has been completed on periods two and three respectively. On the corresponding project status (fig. 25) on the template, the yellow colour is shown and displaying the word “watch out” meaning that the SPI is less than 1 but not less than 0.85.

4.3.1.6 Interpretation of the TCCPI

When recalled from chapter two this performance index indicates the level of cost performance that would be necessary to complete the project from within budget. From our example here the TCCPI indicates 1.06, 1.32 and 1.20 for periods two, three and four respectively. This tells the project manager that the project has to perform

\(^{14}\) Like the CPI, the SPI is also a good tool to compare projects of various sizes.
with a CPI of 1.06, 1.32 and 1.20 to complete successfully within the original budget stipulated in periods two, three and four respectively, which is an unfavourable condition. However, since the project was performing within budget in period one the TCCPI was 1.0 which was favourable at that period. The further the TCCPI is from the CPI the more unfavourable the project becomes and hence becomes doubtful that the project would finish at EAC. From figure 28 it can be seen that the TCCPI has move away from the CPI and it moved further at period three. On the corresponding project status (fig. 25) it is indicating the red colour with the message unfavourable in periods two, three and four whiles it displays the green colour with the message favourable in period one.

Figure 28 graphical presentation of the TCCPI results

4.3.1.7 Interpretation of the TCSPI

This index acts the same way as the TCCPI only that this (TCSPI) is based on schedule and the former on cost. In the example, periods two and three produced unfavourable TCSPI with 1.95 and 1.11 respectively, which means that the project should use an SPI of 1.95 and 1.11 to complete the project from the report point on schedule. However, periods one and four performed favourably with their TCSPI

15 It can be seen that as a project’s cost performance index moves below one, the TCCPI will increase and become greater than 1. Although called an “index,” this is not really accurate since all indexes indicate something bad when they fall below one and this index indicates something bad when it is greater than one. The TCCPI gives us a rough estimate of the performance that is required for the remaining portion of the project in order for the project to be completed for the original budget. (Newell, 2003)
being at par at period one with 1.0 and period four going below the SPI with a TCSPI of 0.86. On the graph (fig. 28) you will find that at both periods two and three the TCSPI has moved away from the SPI whiles at periods one its equal to the SPI. The new thing here is that at period four, even though it has moved away from the SPI below one it, which an index would have shown to be unfavourable, with this index (TCSPI) it rather shows a favourable condition\textsuperscript{16}. On the project status section (fig. 25) it displays the green colour at periods one and four with the message favourable whiles it displays the red colour with the message unfavourable.

\textbf{Figure 29 A graphical presentation of the TCSPI results}

\textbf{4.3.1.7 Interpretation of the CSI}

It can be recalled that the CSI indicates the recoverability of the project from the report period. The further it moves away from 1 the more unlikely the project is going to be recovered. From the example it shows an unfavourable CSI of 0.78 and 0.61 at periods two and three respectively and a favourable CSI o 1.0 and 1.01 at periods one and four. From the project status is indicates green colour with the message “ok” for periods one and four. On the other hand, it shows red colour with the message

\textsuperscript{16} It can also be seen here that as a project’s schedule performance index moves below one, the TCSPI will increase and become greater than one. Although called an “index,” this is not really accurate since all indexes indicate something bad when they fall below one and this index indicates something bad when it is greater than one. (Newell, 2003)
“warning” meaning the project is nearing the danger of irrecoverability and the colour black with the message “danger” displayed meaning that the project is doubtful of being recovered.

### 4.3.1.8 Interpretation of the EAC

The EAC indicates what the project would cost at the end from the report point\(^{17}\). From the figure the project was budgeted to be completed at SEK1600 but from periods two to four, with its performance with respect to CPI, SPI, TCSPI and TCCPI produced an EAC of SEK1849.89, SEK2240 and SEK1760 respectively. Due to the very poor cost performance at period three it shows a big figure for the EAC. On the other hand the EAC was reduced at period four due to the fair cost performance with a good schedule performance. Since in period one everything was going on well with respect to schedule and cost the BAC is the same as budgeted. (See fig. 30)

![Figure 30 A presentation of the Estimate at Completion results](image)

\(^{17}\) Newell (2003) pointed out that using the estimate at completion predicts that the project will overrun or under run its budget at the end of the project. While it is a good thing to keep the stakeholders and the managers of your company informed that projects are in trouble, it is a weak support for asking that the project be given additional budget. A good project manager who wants to keep his job will take the EAC and use it as additional supporting information to show that the project budget was originally over or understated. In addition to the EAC, the project manager should have much supporting information as to why the project is in the condition that it is in.
4.3.1.9 Interpretation of the ETC

The ETC is the expected additional cost to complete the project at EAC. From the example the additional costs expected to be incurred at the various periods are SEK1300, SEK1328.89, SEK1400 and SEK660 respectively for periods one, two, three and four.

4.3.1.10 Interpretation of the ETTC

This is the estimated additional time that would be needed to complete the project from the report point. From the example, in period one to four it indicates an ETTC of 6, 6.67, 7 and 5.40 months. This means that the project is likely to be completed in these days indicated instead of four months as scheduled to be completed.

4.3.1.11 Interpretation of the percentage Complete

The percentage complete indicates the amount of work completed for a particular and expressed in percentage. In the template, in was put in a pie chart (Fig. 31) to enable the user to know the chunk of work completed at a particular period.

Figure 31 Pie chart showing the results for percentage complete

4.3.1.12 Interpretation of the percentage Spent

This indicates the amount of the budget that been spent in a particular reporting period. From the example it indicates that in period one, two, three and four 11%, 19%, 30% and 40% of the total project budget was respectively used. This is depicted in a pie chart in EVAT as seen in figure 32 While the percentage complete refers to
physical work completed the percentage spent refers to money spent within a particular period.

**4.3.1.13 Interpretation of the Percentage of project schedule to be achieved at the report point**

This represents the schedule achievement expressed in percentage at a report point. This refers to time unlike the percent complete and the percent spent. In the example it indicates 13%, 21%, 29%, and 37% of schedule achievement respectively at periods one, two, three and four. (See fig. 33)

**Figure 32 Pie chart showing the percentage spent results**

**Figure 33 Pie chart showing the percentage achieved results**
4.3.2 General EVA Analysis

This part of EVAT gives the user a quick view of the whole project using few EVA metrics. These are the BCWS, ACWP, BCWP, EAV and ETC. From the example and from the results it produced depicted in figure 34 at the current period (period four) with the BAC at SEK1600 it was budgeted to cost SEK900 (BCWS) but however it actually cost SEK1100 (ACWP) at the end of the period with a performance of SEK1000 (BCWP). This tells the user right away that a lot of resources were pumped in to recover the project from the previous (period three) bad performance of the project. Hence less time was spent to reach this point. It can also be seen that the EAC dropped from SEK2240 to SEK1760. Also, the ETC dropped from SEK1400 to SEK660.

Figure 34 A chart showing a general overview of the results in combination with other metrics
4.4 CONCLUSIONS

The use of Earned Value in managing projects is gaining popularity in the world wide (Christensen, 1999). As one of the main focus of the 3p model, it is designed to be used worldwide by most project managers, who would like to have a well organised project from initiation through execution to closure. Therefore, it became imperative to add a template to the 3p model that would serve as a helping guide for users in making earned value calculations with ease. It is essential to note that earned value variances and performance indices when used in the right way would help the project manager and the project team in diverse ways such as:

- Giving them the chance to make reallocation of resources to improve upon the current situation.
- Showing a good picture of as to where the project is heading towards, whether to success or discontinuity.
- A good way to manage risks in a project.
- Keeps them on alert on any mishaps.
- It serves as a precedent for other future projects. I.e. Project managers learn from the mistakes in their current projects and try to avoid them in future projects through the figures ascertained through EVA.

Further, users of the template should note that earned value demands a lot of proper integration of planning, effective costing and monitoring systems of project activities to ascertain the input figures needed for calculating earned value. Hence the use of a work break down structure and an appropriate accounting system would be of immense help in making earned value work effectively for a project.

Finally, due to the growing realisation of the importance of earned value, the implementation of earned value in the 3p project management model would enhance the software’s capabilities in fully managing a project, hence help attract a number of potential customers for the software.
4.5 Proposition for further work

After completing the template and with several reviews the following was suggested for future work on the template:

- Integration of a progress bar that would reflect the percent complete in the template.

- For a quick overview of the performance of a project to management it is necessary to separate the traffic light function or have it also in another excel sheet together with the EVA analysis section.

- Providing another excel sheet that would calculate the actual cost and the BCWP. For the actual cost it would include time rates, cost of resources, project management etc. The total results of these expenses would be the input in the main template area for the ACWP, which would be transferred automatically. On the other hand, the results by multiplying the percentage complete to the budget of the various activities in a particular month in another sheet would give the BCWP and the totals BCWP for the month would be placed automatically in the main excel area in the BCWP column for the respective month.

To make all these functions possible it would require programming in excel (Macros).
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APPENDIX 1 Excel Formulas Used In Implementing the EVA formulas in EVAT

- Cost Variance (CV) - \( =B10-B12 \)

- Schedule Variance (SV) - \( =B10-B11 \)

- Variance at Completion (VAC) - \( =IF(B10,IF(B12,B9-B29,"\"\"\"\"\"\"\")\")\)

- Cost Performance Index (CPI) - \( =IF(B12,B10/B12,\"\"\"\"\"\"\"\")\)

- Schedule Performance Index (SPI) - \( =IF(B11,B10/B11,\"\"\"\"\"\"\"\")\)

- To-Complete Cost Performance Index (TCCPI) - 
  \( =IF(B9,IF(B10,IF(B12,(B9-B10)/(B9-B12),\"\"\"\"\"\"\"\")\")\)

- To-Complete Schedule Performance Index (TCSPI) – 
  \( =IF(B9,IF(B10,IF(B11,(B9-B10)/(B9-B11),\"\"\"\"\"\"\"\")\")\)

- Cost Schedule Index (CSI) - \( =IF(B10,IF(B11,IF(B12,B22*B24)))\)

- Estimate at Completion – \( =IF(B11,IF(B12,B9/B22,\"\"\"\"\"\"\"\")\")\)

- Estimate To Completion – \( =IF(B10,IF(B12,B29-B12,\"\"\"\"\"\"\"\")\")\)

- Estimate Time to Completion - \( =B13/B24 \)

- Schedule Variance as a % of the Schedule Achievement (SV%) – 
  \( =IF(B10,IF(B11,(B10-B11)*100/B11,\"\"\"\"\"\"\"\")\")\)

- Cost variance as a % of the Earned Value (CV%) – 
  \( =IF(B10,IF(B12,(B10-B12)*100/B10,\"\"\"\"\"\"\"\")\")\)
• % of Project Schedule to be Achieved at the Report Point -
  =IF(B11,IF(B9,(B11*100)/B9,""),"")

• % Complete at the Report Point - =IF(B10,IF(B9,(B10*100)/B9,""),"")

• % Spent at the Report point - =IF(B12,IF(B9,B12*100/B9,""),"")

**Project Status**

• Project Status Based on SPI -
  =IF(B11,IF(B12,IF(B24<0.65,"DANGER!",""),IF(B24<0.85,"WARNING!",IF(B24<1,"WATCH OUT!","ON TRACK"))),))

• Project status Based on CPI -
  =IF(B10,IF(B12,IF(B22<0.65,"DANGER!",""),IF(B22<0.85,"WARNING!",IF(B22<1,"WATCH OUT!","ON TRACK"))),))

• Project Status Based on TCPI(BAC) -
  =IF(B9,IF(B10,IF(B12,IF(B22<23,"UNFAVOURABLE",""),IF(B23>B2,"FAVOURABLE")),""))

• Project Status based on TCPI(OD) -
  =IF(B9,IF(B11,IF(B12,IF(B24>=25,"FAVOURABLE",""),IF(B25>B2,"FAVOURABLE")),""))

• Cost schedule Index -
  =IF(B10,IF(B11,IF(B12,IF(B26<0.65,"DANGER!",IF(B26<0.85,"WARNING!",IF(B26<1,"WATCH OUT!","OK"))),)),))

**Formatting of the Project Status Area**

**CPI and SPI**

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<tr>
<th>Condition</th>
<th>Format</th>
</tr>
</thead>
<tbody>
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<td>=$B24&lt;0.85</td>
<td>Red colour</td>
</tr>
<tr>
<td>=$B24&lt;1</td>
<td>Yellow colour</td>
</tr>
<tr>
<td>=$B24&gt;=1</td>
<td>Green colour</td>
</tr>
</tbody>
</table>
## TCCPI and TCSPi

<table>
<thead>
<tr>
<th>Condition</th>
<th>Format</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cell value is equal</td>
<td>=“FAVOURABLE”</td>
</tr>
<tr>
<td></td>
<td>Green colour</td>
</tr>
<tr>
<td>Cell value is equal</td>
<td>=“UNFAVOURABLE”</td>
</tr>
<tr>
<td></td>
<td>Red colour</td>
</tr>
</tbody>
</table>

## CSI

<table>
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<th>Format</th>
</tr>
</thead>
<tbody>
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</tr>
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<td></td>
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<td></td>
<td>Red</td>
</tr>
<tr>
<td>Cell Value is equal</td>
<td>=“DANGER”</td>
</tr>
<tr>
<td></td>
<td>Black</td>
</tr>
</tbody>
</table>
APPENDIX 2 – Trend Analysis

Trend Analysis Displayed in the “EVA Analysis” Button of EVAT

![Graph showing trend analysis](image)

- **Budgeted Cost of Work Scheduled (BCWS)**: 300.00, 500.00, 700.00, 900.00
- **Actual Cost of Work Performed (ACWP)**: 300.00, 520.00, 840.00, 1,100.00
- **Budget at Completion (BAC)**: 1,600.00, 1,600.00, 1,600.00, 1,600.00
- **Budgeted Cost of Work Performed (BCWP)**: 300.00, 450.00, 600.00, 1,000.00
- **Estimate Cost At Completion (EAC)**: 1,600.00, 1,848.89, 2,240.00, 1,760.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00
- **Estimate to Completion (ETC)**: 1,300.00, 1,328.89, 1,400.00, 660.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00, 0.00
Trend Analysis Displayed in the “Variances and Performance indices” Bottom of EVAT

Variances

Cost variance (CV) Schedule Variance (SV) Variance at Completion (VAC)

Cost Performance Indices

Cost Performance Index (CPI), Schedule Performance Index (SPI)
Analysis Displayed in the “Other Analysis” Bottom of EVAT
APPENDIX 3- Extra Information on Earned Value

The following ten points necessary for Measuring Earned Value are extracts from Knutson and Joan (2001)

Step 1: Define the Scope of Work
This step involves the making of a Work Breakdown Structure (WBS) stating the scope of a project. The WBS gives the manager a paranoiac view of all the deliverables in the project. It also gives you the opportunity to know which deliverables follows the other. A WBS also enables the manager to know the resources (human, equipment and money) that would be necessary to complete each deliverable.

Step 2: Integrate the WBS Work Packages into Subprojects
Once the details of the project’s work scope have been diagrammed at the bottom level of a WBS, the project manager moves up the hierarchy from these detailed tasks, combining them to form control account plans (CAPs). There may be several work products in one CAP, depending on the size and complexity of the project and the number of managers available. For example, a technical CAP might include most of the tasks from the prototype deliverable except the artistic design, all of the tasks in the engineering deliverable, and some manufacturing tasks. A legal CAP might include competitor research, patent application, independent safety audit, and review of marketing materials. Each CAP is essentially a subproject that is managed, measured, and controlled by a CAP manager, who is responsible for scheduling and estimating resource requirements for each of the detailed tasks in that CAP. Establishing these CAPs will enable you to integrate cost and schedule information. This contrasts with the way many projects are monitored in which the project manager uses a schedule that can’t be examined by cost center, and accountants use a cost-coding system that shows only budget margins without relating them to the amount of work being accomplished. Each CAP’s performance will be measured independently, and the master (total) project’s performance is the summation of the performance of its CAPs. Thus the project manager can—at any stage of the project—evaluate the earned value of the project as a whole, and, more importantly,
identify which CAPs are underachieving—producing less work product than what should have been produced by the resources expended at that point.

**Step 3: Schedule the CAPs**

Earned value incorporates two metrics: money and time. As you probably do when planning a project, we’ll start with time. In order to measure performance in time, you must create a project schedule, a plan that specifies what is to be done when. All projects require a scheduling system, and it’s crucial to the success of the project that you use project scheduling software. Choose software that will support you in listing tasks for the project, assigning resources to those tasks (in hours or monetary values), scheduling them in sequence using dates or dependencies, establishing key milestones in the project, identifying deadlines, recording progress on the tasks, and making adjustments to the plan. The more complex the project, the more demands you’ll make of the scheduling system. For example, a project spread over several sites requires more flexibility for recording progress. A complex project requires the ability to observe and report progress at several levels, from the master project to the CAPs to department group tasks. If you haven’t used scheduling software before, you’ll want to consult your system’s manual for advice on where to start. In general, though, you’ll want to list the tasks required for each product and how much time you expect each one to take. Then you’ll connect them in sequential order (some are likely to overlap), and end each sequence in a milestone that represents the completion of that product. You’ll probably assign deadlines to many of the milestones. When all the tasks at the bottom level of the WBS have been linked up to their end products, you have a project schedule baseline. This is the planned work, the baseline against which you will later measure work accomplished to calculate schedule performance. Later you will assign resources (hours and monetary values) to the tasks to create another Baseline for planned costs.

**Step 4: Assign Each CAP to an Executive Responsible for Its Performance**
You must assign each CAP to a permanent functional executive and hold that executive accountable for that CAP’s performance. This sounds obvious, but it’s often overlooked in situations a company regards as temporary—like projects. By their very nature, projects are transient within a firm’s permanent organizational structure. They are planned, authorized, worked on, accomplished, and then cease to exist. To secure a firm commitment from the functional executives, who have the authority and resources to turn the project plan into reality; it is wise to have each of the CAPs adopted by a senior functional executive, such as a vice president, director, or formally titled manager.

Step 5: Establish a Project Measurement Baseline

The next essential step is to create a project baseline of estimated work to which actual costs and earned value will eventually be compared. To accomplish this, each CAP manager loads every task in the CAP with an estimate of the resources required to accomplish it. It’s simplest to measure these resources in monetary values, but if you’re using reasonably sophisticated software, you can estimate hours required and the software will convert these estimates to costs for each task. Once the schedule is adjusted to make realistic use of the available resources, you have a baseline for expenditures that represents expected costs for the entire project. It is made up of the planned expenses of the separate CAPs plus any other projected expenses or funding. For an in-house project, the project baseline may be the sum of the CAPs’ planned expenses plus any contingency reserves. (If management holds contingency reserves, not within the discretionary power of the project manager, they should be excluded from the baseline.) On a commercial-type contract, the project baseline may also include indirect costs, profits, fees, and other line items leading up to the total amount of money authorized for the project. With the schedule baseline from Step 3 and this cost baseline, you can measure planned value, the first set of earned value calculations. Planned value requires two data points: work scheduled for completion and budgeted value of work scheduled. Work scheduled for completion comes directly from the project master schedule.

Step 6: Measure Schedule Performance
One of the simpler measurements of the successful management of a project is its adherence to the original schedule. But the work you’ve put into the plan so far provides you with a more sophisticated measurement of progress—earned value. To measure earned value, we need to measure the amount of work accomplished and the budgeted value of work performed.

**Step 7: Measure Cost Performance**

Now the established earned and planned values, we will be compared to actual costs—the amount of money actually spent on the project so far.

**Step 8: Forecast Final Costs Based on Performance to Date**

Management at all levels must continually reforecast the project’s final cost. Almost as soon as work begins on a project, the originally budgeted total cost ceases to be the most accurate assessment. A far more accurate predictor related to earned value—the cost efficiency—replaces it. Simply put, you can use the cost efficiency rate of the completed work to realistically predict the cost of the remaining work, under the valid assumption that the project continues to perform at about the same efficiency. This calculation deploys a sanity check against the more comfortable but less quantifiable idea that “we can make up the difference as we go along.”

**Step 9: Manage Remaining Work**

The work accomplished to date, costs accrued, cost efficiency rate, and earned value achieved to date are in effect sunk costs—gone forever. Any improvements in performance must come from future work, so managing a project means continually monitoring and managing the project’s remaining work. After using earned value to quantify the value of the work achieved, you can quantify what will be required for the rest of the project to stay within the project’s, and management’s, objectives. If progress and efficiency to date is falling short, the project manager can exert more pressure on future work, and can focus on the most at-risk CAPs within the project.

**Step 10: Continually Adjust the Baseline—Manage Changes**
In most real-world projects, the performance baseline—the original plan for the project—is subject to change. Calculations involving earned value remain accurate only to the extent they reflect those changes over the duration of the project, no matter when they occur. For example, if the project manager fails to incorporate into the baseline such changes as increased or reduced work, the original baseline will no longer be a valid point of comparison to the work accomplished to date, throwing off subsequent earned-value–based calculations. Keeping the baseline updated is as important, and sometimes as challenging, as the initial definition of the project scope. However, the payoff is the ability to predict the effects of changes to the plan and understand their implications in a quantifiable manner.

**Projects Suitable for Earned Value Management**

The following characteristics should be present on a project for EV to be suitably used:

- A clearly defined objective
- A clearly perceived route to the goal
- Work taking place over an extended period
- A high labour content
- Tasks of creative nature
- A formalised management structure
- Cost and time limitations (Webb, 2003)

It must also be noted that projects with the above characteristics must have the following in place:

- A well structured plan
- A cost structure
- A suitable data gathering system (Webb, 2003)

**APPENDIX 4 Glossary of Definition of terms**
Activity – An element of work performed during the course of a project. An activity normally has an expected duration, an expected cost, and expected recourse requirements. Activities can be subdivided into tasks. (PMBOK, 2001)

Baseline – The original approved plan (for a project, a work package, or an activity), plus or minus approved scope changes. Usually used with a modifier (e.g., cost baseline, schedule baseline, performance measurement baseline). (PMBOK, 2001)

Budget at Completion – The sum of the total budgets for a project.

Contract – A contract is a mutually binding agreement that obliges the seller to provide the specified product and obligates the buyer to pay for it. (PMBOK, 2001)

Control Account Plan (CAP) – The CAP is a management control point where the measurement of performance will happen. CAPs are placed at selected management points of the work breakdown structure. (PMBOK, 2001)

Cost Performance Index – The cost efficiency ratio of earned value to actual costs. CPI is often used to predict the magnitude of a possible cost overrun. (PMBOK, 2001)

Deliverable – Any measurable, tangible, verifiable outcome, result, or item that must be produced to complete a project or part of a project. Often used narrowly in reference to an external deliverable, which is a deliverable that is a subset to approval by the project sponsor or customer. (PMBOK, 2001)

Duration – the number of work periods (not including holidays or other nonworking periods) required to complete an activity or other project element. (PMBOK, 2001)

Earned Value – The physical work accomplished plus the authorised budget for this work. The sum of the approved cost estimates (may include overhead allocation) for activities (or portions of activities) completed during a given period (usually project-to-date). (PMBOK, 2001). This is known in this thesis work as Budgeted Cost of Work Performed.

Earned Value Management (EVM) – a method for integrating scope, schedule, and resources, and for measuring project performance. It compares the amount of work that was planned with what was actually earned with what was actually spent to determine if cost and schedule performance are as planned. (PMBOK, 2001)

Estimate – An assessment of the likely quantitative result. Usually applied to project costs and durations and should always include some indication of accuracy. (PMBOK, 2001)

Estimate at Completion (EAC) – The expected total cost of an activity, group of activities, or the project. (PMBOK, 2001)

Estimate to Completion (ETC) – The expected additional cost needed to complete an activity, group of activities, or the project. (PMBOK, 2001)

Finish Date – A point in time associated with an activity’s completion. It is usually qualified by one of the following: actual, planned, estimated, schedule, early, late, baseline, target, or current. (PMBOK, 2001)

Milestone – A significant event in the project, usually completion of major deliverables. (PMBOK, 2001)

Percent Complete – An estimate, expressed as a percent, of the amount of that work that has been completed on an activity or group of activities. (PMBOK, 2001)

Project – A temporary endeavour undertaken to create a unique product, service, or result. (PMBOK, 2001)
Project Scope – The work that must be done to deliver a product with the specified features and functions. (PMBOK, 2001)

Schedule Performance Index (SPI) – The schedule efficiency ratio of earned value accomplished against the planned value. The SPI describes what portion of the planned value schedule was actually accomplished. (PMBOK, 2001)

Schedule Variance – Any difference between the schedule completion of an activity and actual completion of that activity. (PMBOK, 2001)

Scope – The sum of products and services to be provided as a project. (PMBOK, 2001)

Stakeholder – individuals or organisations that are actively involved in the project, or whose interests may be positively or negatively affected as a result of project execution or project completion. They may also exert influence over the project and its results. (PMBOK, 2001)

Work Breakdown Structure (WBS) – A deliverable-oriented grouping of project elements that organises and defines the total work scope of the project. Each descending level represents an increasingly detailed definition of the project work. (PMBOK, 2001)

Work Package – A deliverable at the lowest level of the work breakdown structure, when that deliverable may be assigned to another project manager to plan and execute. This may be accomplished through the use of a subproject where the work package may be further decomposed into activities. (PMBOK, 2001)