EARNED VALUE MANAGEMENT SYSTEM IN MANUFACTURING INDUSTRY

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DISSERTATION SUBMITTED TO THE FACULTY OF ENGINEERING,
UNIVERSITY OF MALAYA IN PARTIAL FULFILLMENT OF THE REQUIREMENT
FOR THE DEGREE OF MASTER IN ENGINEERING (MECHANICAL)

2013

UNIVERSITI MALAYA
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EARNED VALUE MANAGEMENT IN THE MANUFACTURING INDUSTRY

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This project paper is dedicated to my lovely family: my father Mansoor, my mother Rima, and my sister Elnaz and to my beloved friend Hamed.

ACKNOWLEDGEMENTS

I would like to thank everyone who had contributed to the successful completion of this dissertation.

My deepest thank to my supervisor, Ir. Dr. Abu Bakar Mahat for his valuable advices, guidance and his enormous patience throughout the development of the research with attention and care.

I express my thanks and deep sense of gratitude to Mr. Kamaludin Ahmad, Manager-Planning & Kaizen Department and Mr. Mohamed Nor Hassan, Executive-Marketing & Sales Department, from MCIS Safety Glass Company support and guidance. Thanks and appreciation to the helpful people at MCIS Safety Glass Company for their support.

I would also thank my institution and my faculty members without whom this project would have been a distant reality. I also extend my heartfelt thanks to my family and well-wishers.

Fatemeh Rasooli Haghighi

Malaysia, May 2013

ABSTRAK

Pengurusan projek adalah proses perancangan, penyusunan, motivasi dan pengawalan sumber-sumber masa dan kos bagi mencapai matlamat tertentu yang dikenali sebagai skop projek. Pengurusan Nilai diPerolehi (EVM) atau Nilai Projek diPerolehi / Pengurusan Prestasi (EVPM) adalah teknik pengurusan projek yang mengukur kemajuan projek dan prestasi secara objektif dan memberi ramalan yang tepat mengenai masalah prestasi projek (Marshall, 2006). EVM diterima secara meluas dalam projek-projek pembuatan di negara-negara maju seperti Amerika Syarikat, United Kingdom dan Australia (Garrett, 2006). Pengurusan Nilai (EV) yang diperolehi tidak dikenali sebagai cara yang biasa digunakan dalam sektor industri pembuatan di Malaysia (Khamidi, Ali et al., (2011). Kajian ini akan membincangkan teknik Pengurusan Nilai diperolehi, satu kaedah untuk menilai dan mengukur prestasi projek dan kemajuan, yang dikenali sebagai salah satu yang paling tepat dan tajam teknik menguruskan (Vandevoorde & Vanhoucke, (2006), Moslemi Naeni, Shadrokh et al. (2013)). Menurut Anbari (2003), EV diperolehi adalah satu kaedah yang berkesan dalam pengurusan projek dan pengendalian yang menyokong kos, masa dan skop projek. Brandon & Daniel (1998) juga memperkenalkan EVM sebagai satu teknik yang berkemampuan untuk kerja pengukuran prestasi projek sebenar.

Bagi tujuan untuk menunjukkan keberkesanan EVM dalam pengurusan projek pembuatan dan bagaimana diperolehi hasil dari pelaksanaan EVM, ianya akan membantu pengurus projek dalam mengemukakan ramalan projek dan pengurusan dalam sektor pembuatan, EVM dilaksanakan pada projek pembuatan menghasilkan kaca mata keselamatan dalam industri automobil di Malaysia. Tujuan kerja ini adalah untuk menunjukkan bahawa bagaimana teknik EVM boleh digunakan bagi projek-projek perkilangan di Malaysia. Keputusan yang diperolehi daripada pelaksanaan EVM projek

pembuatan ini bertujuan untuk menunjukkan bahawa EVM boleh memberi gambaran yang sangat jelas prestasi projek dan pengurus projek serta menyediakan penilaian yang tepat bagi kemajuan projek. Teknik ini akan membolehkan pengurus projek menilai prestasi projek secara lebih mendalam dan membantu pengurus projek untuk mengawal dengan lebih berkesan, memantau dan menguruskan kos projek dan jadual. Selain itu, EVM akan memudahkan pengurus projek memberikan ramalan yang terbaik trend jangkaan prestasi projek tersebut.

Keywords: Pengurusan diNilai Projek (EVM), Pengukuran Prestasi Projek, Ramalan Prestasi Projek berMasalah, Pengurusan Projek Pembuatan.

ABSTRACT

Project management is the act of planning, organizing, motivating and controlling resources of time and cost to achieve specific goals known as scope of project. Earned Value Management (EVM) or Earned Value Project/Performance Management (EVPM) is a project management technique that measures project progress and performance in an objective manner and provide accurate forecast of project performance problem (Marshall 2006). EVM is widely accepted in many manufacturing projects in developed countries such as the USA, UK and Australia (Garrett,2006). EVM is not classified as a common used tool in manufacturing industry sector in Malaysia (Khamidi, Ali et al. 2011). This study will discuss the technique of EVM, a method of evaluating and measuring project performance and progress, which is known as one of the most accurate and sharp managing techniques (Vandevoorde and Vanhoucke 2006, Moslemi Naeni, Shadrokh et al. 2013). According to Anbari (2003), EVM is a powerful method of project management and handling that supports cost, time and scope of project. Brandon & Daniel,1998 also introduced EVM as a powerful technique of true project performance measurement.

In order to practically demonstrate the effectiveness of EVM on manufacturing project management and how obtained result from EVM implementation would help project managers in project forecast and management in manufacturing sector, EVM is implemented on a manufacturing project producing safety glasses for automobile industry in Malaysia. The aim of this work is to show that how EVM can be applied to Malaysian manufacturing projects. The results obtained from successful implementation of EVM on purposed manufacturing project demonstrated that EVM can bring a very clear view of the project and provide project managers strong insight into the project progress. This technique would enable project managers to assess project performance more in-depth and

help project managers to effectively control, monitor and manage project cost and schedule. Moreover EVM facilitates project managers with a very good prediction of future performance trend of the project.

Keywords: Project Management, Earned Value Management (EVM), Project Performance Measurement, Forecast Project Performance Problem, Manufacturing Project Management

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LIST OF ABBREVIATIONS

PV	Planned Value
EV	Earned Value
AC	Actual Cost
CV	Cost Variance
SV	Schedule Variance
CVP	Cost Variance Percentage
SVP	Schedule Variance Percentage
CPI	Cost Performance Index
SPI	Schedule Performance Index
EVM	Earned Value Management
PM	Project Manager
EAC (c)	Estimate at Completion of Cost
EAC (T)	Estimate at Completion of Time
BAC	Budget at Completion
AUT	Actual Time Utilized
PD	Planned Duration
TCPI	To Complete Performance Index
ETC	Estimate to Completion
OB	Original Budget
BP	Batch Production
WSH	Windshield Car Glass
FD	Front Door Car Glass
RD	Rear Door Car Glass
RRQ	Rear Quarter Car Glass
PC	Percentage to Complete
BCWP	Budgeted Cost of Work Performed or EV
ACWP	Actual Cost of Work Performed or AC
BCWS	Budgeted Cost of Work Schedule
DOD	Department of Defense
SET	A Set of car glasses containing of WSH, FD, RD and RRQ

LIST OF FORMULAS

CV = EV-AC

SV = EV-PV

CPI = EV/AC

SPI = EV/PV

TCPI = (OB-EV) / (OB-AC)

EAC1(C) = AC + (BAC-EV) / CPI

EAC2(C) = BAC / CPI

EAC1(T) = ATU + (PD-ATU×SPI) / SPI

EAC2(T) = PD/SPI

ETC = EAC-AC = (BAC-AC) / CPI

CHAPTER ONE
INTRODUCTION

1. Introduction

1.1 Background of study

This study described the Earned Value Management method for manufacturing project producing safety glassed for automotive industry in Malaysia. In Malaysia the number of high-tech manufacturing projects are growing rapidly and since manufacturing has a great influence on country economy it is important for company owners, project managers and contractor to control and monitor their projects cost, time and scope effectively. The performance of project can be assess by employing different traditional methods and approaches like day to day monitoring, monthly or weekly management reports, performance reviews, project audit report etc. (Rodrigues and Bowers 1996, Wysocki and McGary,(2003)). In traditional approaches two types of information are evaluated the budget (or planned) expenditure and the actual cost. In these methods the actual cost is compared with planned expenditure and indicated that how much has been spent at any given time. And also how much has been produced. Therefore, there is no way to determine physical amount of work performed. In traditional methods neither can be determined physical amount of work produced nor is it being produced according to schedule originally planned (United States of America Department of Energy). Based on limitation of traditional project management technique this study discusses Earned Value Management (EVM) as an effective tool for project performance and progress measurement, controlling and monitoring. This project management technique integrates

project cost, time and scope and enables project managers to forecast future progress trend of project.

EVM uses three data sources including Planned Value (PV) or budgeted work scheduled, Actual Cost (AC) or actual expenditure and Earned Value (EV) of physical work performed; and compare these elements to assess project performance (United States of America Department of Energy). To define what means by project performance: it is the overall quality of a project in terms of its impact, value to beneficiaries, implementation effectiveness, and efficiency and sustainability (A Guide for Project M&E,1977).

1.2 Problem Statement

This research project focuses on application of Earned Value Management (EVM) method on a manufacturing project completed in MCIS Safety Glass Sdn Bhd in Malaysia. The project goal is production of four types of car glasses including windshield, front door (L/R), rear door (L/R), and rear quarter (L/R) windows for Suzuki Swift.

With the rise in number of industrial and service projects, EVM as a new and efficient method plays an important role in integrated project controlling. Earned Value Management is one of the methods have been used and given special attention to in today`s world to manage and control project time and expenses (Chou, Chen et al. 2010, Khamidi, Ali et al. 2011, Garrett,2006). Using this powerful technique, project management team can control project performance considering originally planned cost and time of project and thereby reduce potential losses and risk assessment(Khamidi, Ali et al. 2011). Earned Value management expresses the relation between current real cost and work done and focuses on project performance conformity. EVM also indicates what resources were used and what was achieved related to the actual cost spent. If fact it makes a comparison between

amounts were really spent on project and what budget plan expected to be spent till time-now. So it is clear that Earned Value can be measured after each activity is completed.

In Malaysia, the concept of Earned Value Management have not been well appreciated by project managers, company owners and it is not very common for project managers and contractors to implement EVM as a project management technique (Khamidi, Ali et al. 2011). In this work Earned Value management will be introduced and effects and results of applying Earned Value Management to projects will be discussed. To provide real and acknowledged information and results, this method has been applied on a completed manufacturing project from MCIS Safety Glass Sdn Bhd Company in Malaysia. EVM is a measuring and monitoring tool for project management while project is in ongoing phase and can provide early warnings, even after only 15 percent of project is accomplished (Fleming and Koppelman 2006). EVM also would help project managers to detect cost and schedule incompatibility and predict project performance and total funds needed to finish the project. As mentioned previously during this work EVM has been implemented on a completed job to see whether EVM predictions of cost and schedule would match the real final result. Note that though EVM is a tool providing early warnings and enables managers to monitor and control project progress, while considering health of project and comparing that with the planned progress, this technique does not suggest or recommend any solution to help project performance improvement. Meaning that EVM is only a monitoring tool and it is project manager team responsibility to decide how to improve the progress.

EVM is relatively less common tool utilized for project monitoring and performance control for Malaysian manufacturing industry and currently it is rarely used as project monitoring and controlling tool. Therefore this study shows that how EVM can be effectively implemented in order to be used as project management technique.

1.3 Objectives of the Study

The main purpose of this dissertation is to study the application of Earned Value Management in a manufacturing project. Control of project performance improvement resulted from EVM implementation will also be determined. Findings obtained from EVM application and calculations demonstrate that EVM is a reliable technique for project tracking, monitoring and estimating in manufacturing industry sector in order to improve the project management. This study has four objectives that need to be achieved and reported in this study.

The study focuses of following four main objectives:

i. To assess EVM as a project performance monitoring, controlling and measurement tool.
ii. To study how EVM can add value to project performance management and manufacturing projects.
iii. To find out how accurate and precise are the results obtained from EVM calculations.
iv. To study that how EVM can predict the future progress trend of the project.

1.4 Disposition

Chapter Two of this dissertation will give a general view about Earned Value Management to familiarize the readers with EVM technique. In Chapter Three all necessary basics of EVM concept are discussed and some interesting studies concerning the implementation of EVM are summarized. Chapter Four focuses on methodology of our work and the project in which the EVM was implemented is

introduced. Chapter Five is giving an overall result of this study. And last but not least, in Chapter Six conclusion and suggestions are discussed.

Chapter Two

EARNED VALUE, A PROJECT MANAGEMENT TECHNIQUE

2. Earned Value Management

2.1 Introduction

Progress measurement is an activity that managers perform in order to reach the predefined goals that are derived from the company's strategic objectives. Figure 1, illustrates this idea by taking a systems perspective on the control of an organization (Lohman, Fortuin et al. 2004, Lohman,(1999)). In this figure at the transformation process (operational level) a comparison of input and output values with predefined goals takes place.

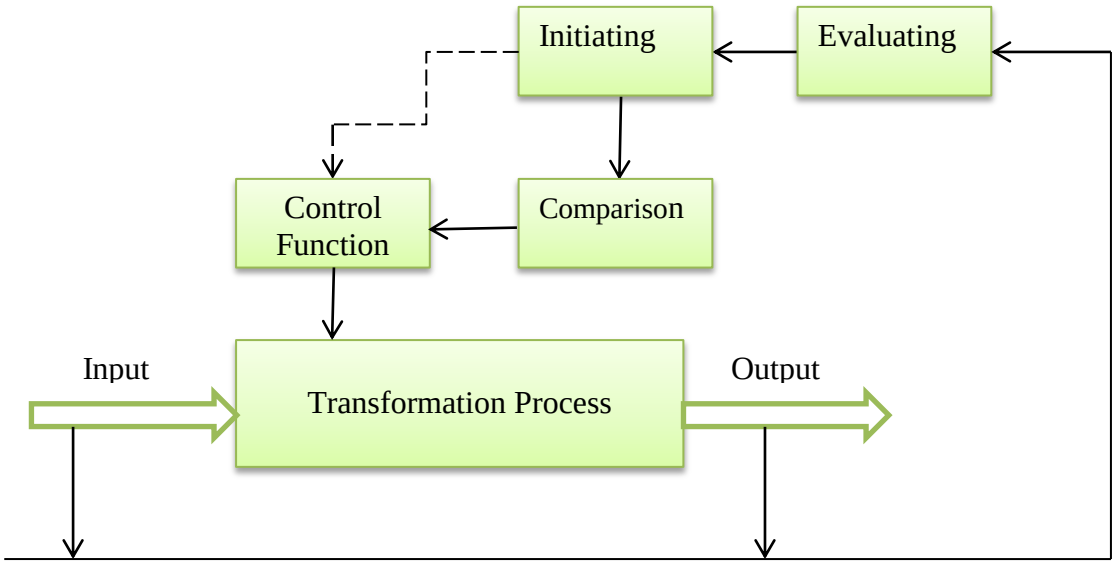

Figure 1: System perspective on the control of an organization (Lohman, 1999)

If there is discrepancy between the actual value and desire goals knowledge about the behavior of organization is used to find an appropriate action that means modifying the progress. The ability to measure the performance of operations can be seen as an important prerequisite for improvement, and companies can increase the capabilities of their performance measurement systems (PMSs) (Lohman, Fortuin et al. 2004, Neely, Gregory et al.,(1995)). A large number of industrial and non-industrial projects have employed project performance measurement effectively (Neely, Gregory et al.,(1995), Pillai, Joshi et al.,(2002), Bassioni, Price et al.,(2004)).

Manufacturing companies can improve their organization profits and business if they would be able to monitor project performance data and to detect unpredicted problems of cost and schedule immediately in order to take correction actions. Monitoring project data and presenting them visually in form of graphs, charts and tables is easier and more understandable rather than numerical information. Moreover with graphical information presentation there is no need for companies to train stuff for interpreting complex numerical information. This idea would be achieved by choosing an adequate project controlling and managing technique such as Earned Value Management (EVM).

Effective implementation of EVM would influence manufacturing project especially in production phase in which the capability of change in cost and schedule plan reduces noticeably. Project management techniques other than EVM such as WBS (work breakdown structure) are generally applicable in project planning and initiation while using EVM in an on-going project enables PMs to update project information frequently and to predict and measure project outcome and performance.

Therefore EVM is a powerful management technique that enables project managers to control and track project performance by not only monitoring project key performance indicators and expressing them usefully but also highlighting risks and measuring project

performance. EVM can provide a baseline for project performance measurement so that project outcome can be determined and controlled.

2.2 Traditional Project Management

Traditional project management is only concerning today`s date and real amount of money spent up to the date. The actual spent money is then compared with the related budgeted cost of the project as per schedule to measure the project performance. However, the actual performance of the project is never measured (Wysocki and McGary,(2003)). Considering Figure2, in traditional project management the result will not give us any view of how much physical work have accomplished up to time-now. The only matter considering in traditional approach is about funding and not project performance (Khamidi, Ali et al. 2011). Let us think of simple example, consider a project that is funded RM1,000,000 for a period of 10 months allocating budget of RM100, 000 for each month. It is now month three and according to schedule the amount of RM300,000 should be spent, the actual cost spent is RM300,000 as well, since the difference between measured values is zero it can be concluded that the results are perfect against the planed expenditure nevertheless in this method the physical completion of project is not reflected. So the project performance will never be measured.

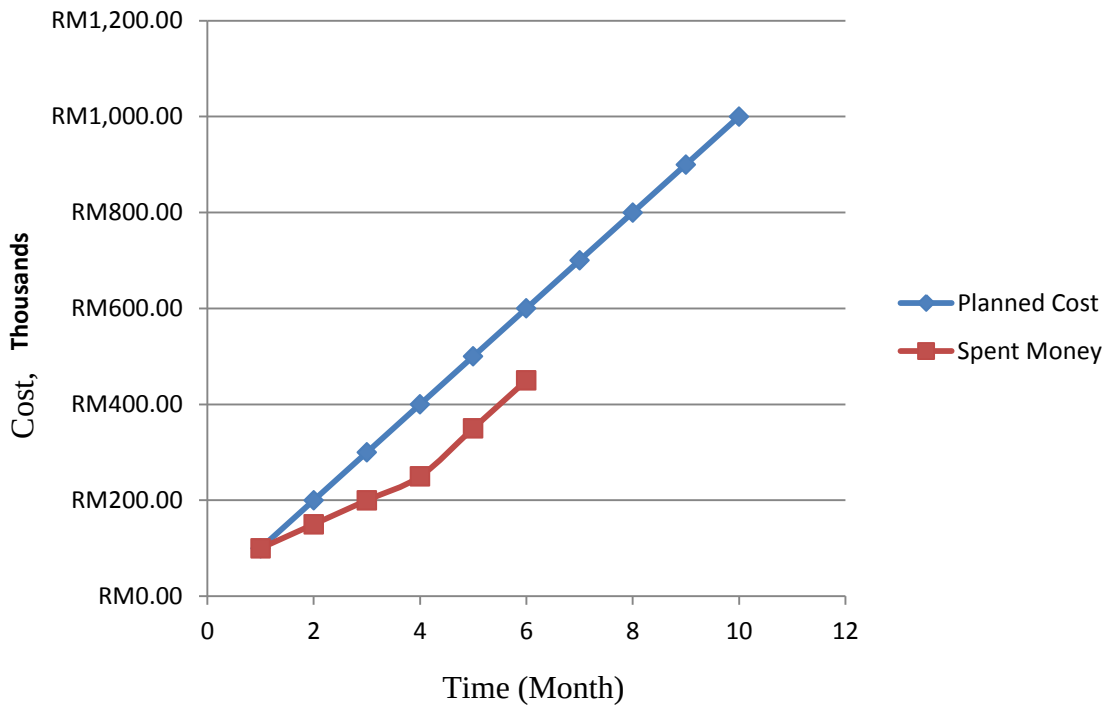

Figure 2: Traditional Project Management

2.3 History of EVM

The Earned Value concept is not in any way new, in fact the basics and the ideas have been used for more than a century. In the late nineteenth century the industrial workers in the American factories started using the concept of earned value. The workers measured their earned work and actual expenses which they compared to the planned standards. These measurements were their way to control the work in the factories. Since they also had defined the cost variance, consisting of the actual money spent relative to the work achieved, they used the core of earned value although they did not address it that way. One could say that this basic definition of cost variance is what characterizes earned value (Cabri and Griffiths,(2006)).

In the end of the 1950's the United States Navy introduced the Program Evaluation Review Technique (PERT) as a network scheduling and risk management device. In 1962

PERT was extended to PERT/costs aiming to add resources to the time scheduler. Since the computers back then was not powerful enough PERT did not live on for many years. However PERT left something to the afterworld. The implementation of PERT/costs had required some new reporting formats from the contractors. One of those formats contained "value of work performed" versus "actual cost"(Koppelman (2005))

By the second half of the 1960's the United States Air Force made a new effort to oversee the industry performance. Instead of imposing a specific management control system they wanted the industry to satisfy some criteria with their existing management control systems. The result was an earned value concept called Cost/Schedule Control Systems Criteria (C/SCSC) which comprise 35 criteria that one had to adapt while being a contractor for the Department of Defense (DoD) (Buyse, Vandenbussche et al.,(2006)).

During the next three decades the C/SCSC evolved to be more and more difficult to use. The basic criteria were added with implementation guidelines, surveillance manuals and implementation checklist which were intended to be used as guidelines used with good judgments. However the guidelines were not always used as guidelines but instead as peremptory rules. Furthermore the private sector never adapted the C/SCSC. One of the main reasons why the industry never adopted the C/SCSC, except the rigid guidelines, was the new vocabulary. Instead of calling things what they are C/SCSC used their own expressions and abbreviations. For example earned value was called "Budgeted Cost of Work Performed", BCWP, or simply "p". Overrun was called OTB which stood for "Over Target Baseline". Some of those expressions are still used today by some people, although there are simpler expressions meaning the same thing (Buyse, Vandenbussche et al.,(2006)).

In 1995, the National Defense Industrial Association, NDIA, accepted the task of rewriting DoD's formal earned value criteria. The objective of the rewriting was to make

the criteria more practicable for the private industry. The 35 criteria became 32 and terms as Budgeted Cost Work Performed (BCWP) and Budgeted Cost Work Scheduled (BCWS) where changed to Earned Value and Planned Value. But the main change was in the attitude of all parties. The private company was now adopting the technique since it had proven to be best-practice instead of something that were forced from the government to their contractors (Koppelman, 2005).

2.4 EVM: ***How it works?***

The concept of Earned Value Management is to measure the physical progress against planned details of a project to determine a good prediction of final cost and schedule of the project (Fleming and Koppelman 2000).

Generally the EVM is used for project where estimation of costs and time at completion is required. EVM would enable project managers to predict and control cost of a given task as well as comparing that cost with what it was planned to be. The concept of EVM is commonly used because it is easy to understand and also integrates time, cost, and scope of the project present them into understandable form. According to Fleming and Koppelman (2000), EVM focuses on actual performance obtained against what was spent to achieve that result.

To explain Earned Value Management, Webb (2003) stated that EVM has three basics value, Figure 3:

i. How much value is expecting to be obtained from progress according to planned schedule? (Planned Value, PV)
ii. How much money has been spent up to time-now? (Actual Cost, AC) &
iii. How much value has been obtained or generated in reality up to time-now? (Earned Value, EV) (Webb 2003)

It is very important to understand these basic elements to find out how EVM works and comes in handy.

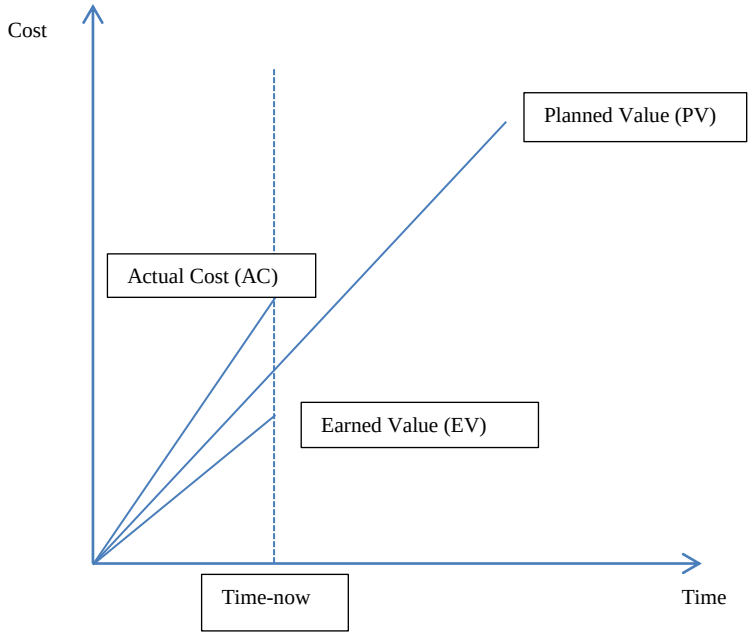

Figure 3: Basic elements of EVM, source: (Webb 2003)

To clarify the EVM concept and its basic elements, let us bring an example: think of a project that is to be completed within 12 months and the total cost of the project is RM100,000. According to schedule after 6months 50% of the work should be completed. So the schedule says that in the sixth month we are supposed to have done 50 percent of the total work, then that is the percent of the total budget that we have earned so far. Therefore the Planned Value is 50% of RM100,000, then PV = RM50,000.

Now we want to track how our project is actually doing versus budget then we have to use Earned Value. Six months have passed and according to project financial data RM60,000 has been spent, however, on closer view we found out that only 40% of total work is done. From this statement it is clear that 40% of project scope is delivered to

costumer or is achieved, since the Earned Value is the value of work completed in reality then EV= 40% of the total budget, EV_{40} = RM40,000. On the other hand the Actual Cost that is the actual money spent up to time-now is equal to RM60,000.

The EVM is applied to a project as the necessity of better vision of both cost and schedule perspective would be recognized. Although the ability of EVM is generally known as providing a clear view of how well the project is progressing and defining points that it is over budget or cost, it is possible to acquire followings using EVM (Buyse, Vandenbussche et al.,(2006)):

I. Early warning of any decline and unexpected problems so that project managers team have chance to make corrective action before it is too late.

II. Accurate prediction of outcome enables PMs to make better decisions about course of the project.

III. Accurate prediction also enables PMs to make better decisions about project surroundings that may be influenced as the project progresses.

IV. A clear and verifiable view of project progress improves sponsor confidence and costumer reliability.

CHAPTER THREE

REVIEW OF RELATED LITERATURE

3. Literature Review

3.1 Introduction

Earned Value Management is a technique that integrates three elements of project management, time, cost, and schedule. It helps the project managers to calculate the cost and schedule variances and to estimate the cost and schedule at completion (Chou, Chen et al. 2010).

EVM works as a powerful tool that allows project performance monitoring at any stage of the project. This will give project manager team the chance to detect cost and schedule overruns at the early stage to modify the project progress and prevent project to forget then its predefined goals . Effective implementation of EVM will affect strongly the project progress where detailed information of project is needed and the ability of changing cost and schedule reduces, that is called execution phase(Anbari 2003, Anbari Dec 2003).

Over the last decades, plenty of industrial and non-industrial projects have applied EVM successfully as an effective tool to control and develop their project progress in order to improve their business operation and profits (Lipke.et.al,(2009)).

3.2 Earned Value Management Technique Key Components

To employ the EVM as a strong and effective means, one should understand and can answer to these questions: What is this technique? How does it work? What are the main components used in this technique? How it can be calculated?

EVM uses the following parameters to control project performance:

- **Planned Value (PV)**: Previously known as the Budgeted Cost of Work Schedule (BCWS) is the time-phase budget baseline, Figure4. PV is the authorized and approved cost of the project, task or activity that is related to the schedule (PMBOK.Guide,(2000).). In other word it is the value, stated in currency, of the work that should be earned as a function of project progress up to given point at time; i.e. it is the money that you should have spent as per the schedule.

- **Budget at Completion (BAC):** Total planned value for the project is known as the budget at completion (PMBOK.Guide,(2000).).
- **Earned Value (EV):** Is the actual work completed to the date, also called Budgeted Cost of Work Performed (BCWP). EV is the amount, specified in currency, of actual work performed up to a given point at time. As per the PMBOK Guide "Earned Value (EV) is the value of work performed expressed in terms of the approved budget assigned to that work for an activity or WBS Component."
- **Actual Cost (AC) or Actual Cost of Work Performed (ACWP):** Is the actual amount of money that you have spent up to a point of time so far. According to PMBOK GUIDE "Actual Cost (AC) is the total cost actually incurred in accomplishing work performed for an activity or WBS component (PMBOK.Guide,(2000).)".
- **Percentage of Completion (PC):** Is a measure of project, task or activity performance and progress until now. Note that both PC and AC are based on the same data.

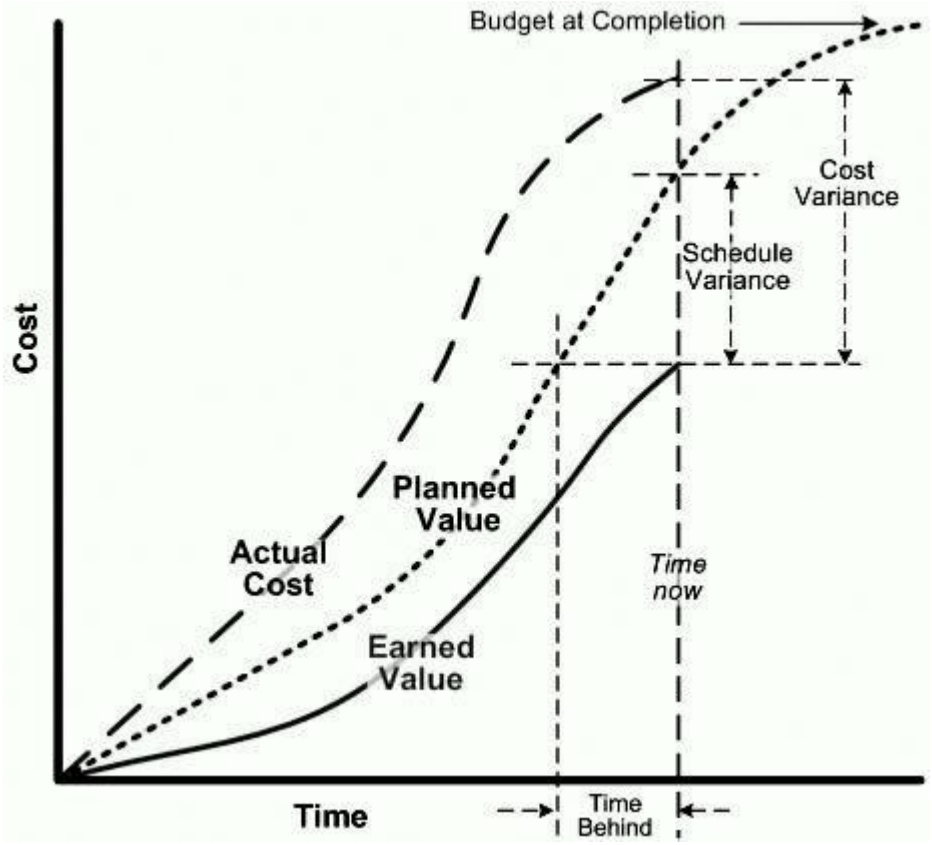

Figure 4: EVM Graphical Representation (Chambers+Software,(2013))

The presented curves on the EVM graph, Figure5, are actual cost (AC), planned value (PV), and earned value (EV) curves. The AC cure demonstrates the total project cost incurred. Meanwhile, the PV curve also called BCWS curve represents the approved cost of the project based on schedule. The PV information is included in initial accepted contractor. The EV curve also known as BCWP curve shows actual work completed related to schedule. The AC and EV curves are dynamic and subjected to change as project progresses. Furthermore, project performance and progress can be measured using cost and schedule variances (CV & SV) and cost and schedule performance indexes (CPI & SPI).

Variances:

- Cost Variances: Is a measure of cost performance of project that will demonstrate how much over or under budget the project is. It can be calculated as follow:

  Cost Variance (CV) = Earned Value (EV) – Actual Cost (AC)

  If the value of CV is positive or negative we are under budget or over budget respectively, Figure 5.

- Schedule Variances: Indicates the schedule performance of a project. The information derived from this parameter will show how far ahead or behind the project schedule we actually are. The value of SV becomes zero as the project completed, Figure 5.

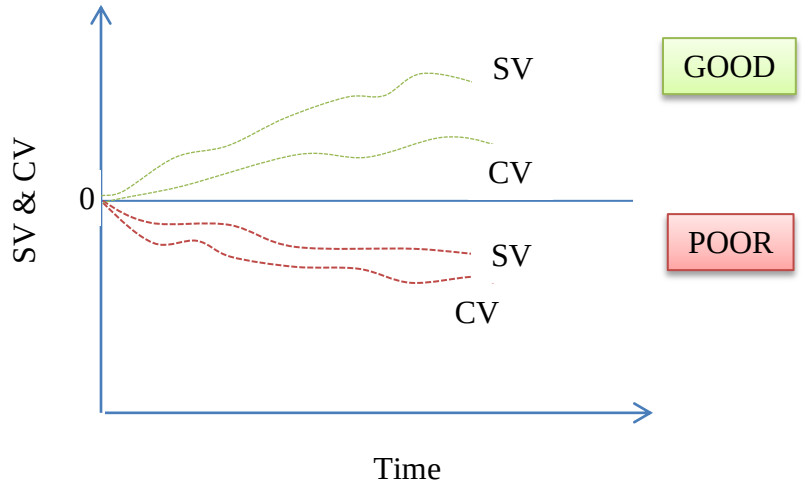

Figure 5: SV and CV Graph

Variance Percentage:

- **Cost Variance Percent (CV% or CVP):** Is the proportion of CV to EV that demonstrates the budgetary accordance of actual cost of work done up to a specified point of time.
- **Schedule Variance Percent (SV% or SVP):** This parameter the agreement of actual work performed to the schedule until now which is normally derived from the following formula:

  SVP = SV/PV.

  However it is more proper to calculate SVP based on EV and replace PV with EV in the denominator of the above formula. The SVP based on Earned value would be described as: SVPEV = SV/ EV.

Performance Indices:

Performance Indices can be considered as parameters to show the efficiency ratio. These parameters enable project managers to compare the health of different project with one another. They are categorized as below:

- **Cost Performance Indices**: It is a measure of effectiveness of cost utilized on project and a comparison between the value of work done and the actual cost spent on the project. If fact this we tell project managers how much they will earn from each dollar the spent on project. CPI can be calculated as follow:

  CPI = EV/ AC

- **Schedule Performance Indices**: It is a measure of progress achieved compare to the progress planed that will tell the project managers the efficiency of the time utilized on the project. It can be calculated from the following formula:

  SPI = EV/ PV

At this stage, this may come to mind that if we can derive all these information from CV and SV, why it is still needed to calculate CPI and SPI?

The answer is the information derived from cost or schedule variance comes in dollar and in fact it shows the difference between the values while the information from indexes comes in ratio. With information derived from indexes we can compare the health of different project to one another, however with one came from variances it is not possible.

3.3 Commercially Available EVM Tools

Over the past few decades, many companies started to use EVM tools, mostly to improve their management program quality and capabilities beside to positioning themselves in a higher tier of Federal Agencies contract. Software available for EVM come in different components that are typically include:

- EVM scheduling engine
- EVM cost engine
- EVM reporting engine

Leading Earned Value Tools in the Market:

- **Microsoft Office Project**: is Microsoft's desktop project management scheduling application. It comes in Standard and Professional editions. The Professional edition includes collaborative enterprise project management capabilities when used with Microsoft Office Project Server.

  Microsoft Project does not support multiple users working on a single project at the same time. The default storage approach is the MPP file format. However, other formats and databases are supported via ODBC.

- **Primavera Earned Value Management:** is a powerful, flexible EVMS cost engine. Primavera Earned Value Management is a comprehensive solution that integrates detailed cost information with the program schedule by aligning and combining project performance data from cost systems, adding complex burdening rates, and tracking committed costs. While the software has the potential to solve your earned value management needs, it can also cause major headaches if not configured properly for your business.

- **Deltek**: provides software solutions specifically designed to meet the needs of project-driven businesses. Today our software applications help more than 12,000 organizations achieve success worldwide. Deltek's solutions help companies to improve business performance management, streamline operations, optimize compliance processes and win new business.

- **EVMS for Project**: is designed to manage projects both large and small, and to scale up to handle hundreds of projects and users in even the largest enterprises. It was designed from the ground up to work closely with Microsoft Project Server (2007 and 2010) and SharePoint. It is unique among earned value management software in its ability to seamlessly synchronize schedule and resource data from Microsoft Project Server.

  EVMS ForProject was designed around the EVM principles and processes as outlined in the American National Standards Institute Guidelines for Earned Value Management Systems.

- **Unanet Project Management**: software can support your organization with centralized project management capabilities and resource scheduling. Unanet offers outstanding reporting with a wide range of detailed and summary reports available including graphical dashboards, earned value, and project costing to see true project costs. Unanet project management software can be the basis of your project management office (PMO) and supports Project Portfolio Management (PPM).

3.4 Benefits of Earned Value Management

Will Earned Value technique benefits exceed its cost?

There is a controversy among experts about the benefits of EVM whether exceed its cost or not. Some believe that EVM is a very powerful management system improves

project outcomes in such way that hides its cost while other ignore its advantages and focus on its cost (Christensen 1998).

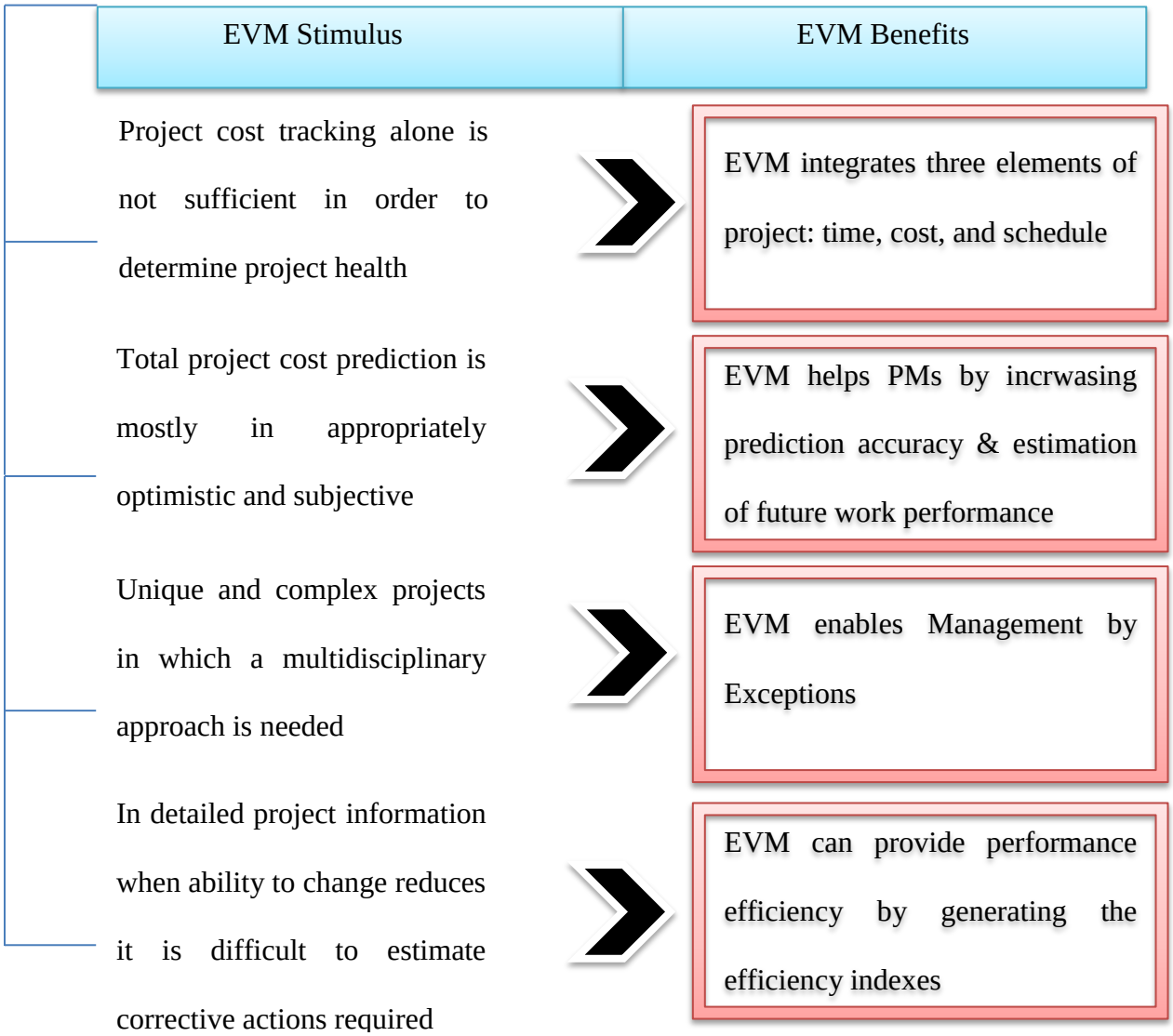

Figure 6: "The fundamentals of EVM are the same regardless of the type ot size of project to which they are being applied."_ PMI Practice Standard for Earned Value Management.

Management System is significant and its requirements are among the largest drivers. However, this study did not focus on the EVMS benefits.

Most of the works centralized the cost of EVMS, mostly considered the incremental cost of EVMS compliance and reporting. Lampkin (1992) have done a review paper on five studies estimating cost of implementation and maintaining EVMS. The result was demonstrated in a table expressing the cost range as a percentage of contract cost.

Ten advantages of EVMS:

The graph on following page, Figure8, reveals a list of ten benefits of EVMS. Fleming and Koppelman (1996. p.22) pointed out to these factors as the legacy of implementing EVM on government contract for about three decades.

Table 1: Related Researches on EVM Cost

Author (Year)	Method of Research (number of samples)	Cost Drivers Related to Over-Implementation
NSIA (1980) (Afs 1980, Sarkar, Little et al. 1984)	Opinion survey (74 contractors)	Excessive documentation
A.D. Little (1984) (Sarkar, Little et al. 1984)	Interview (56 managers)	Excessive levels of detail in the WBS
DoD/NSIA (1991) (Christensen 1998)	Interview (250 mangers)	Written variance analysis reports

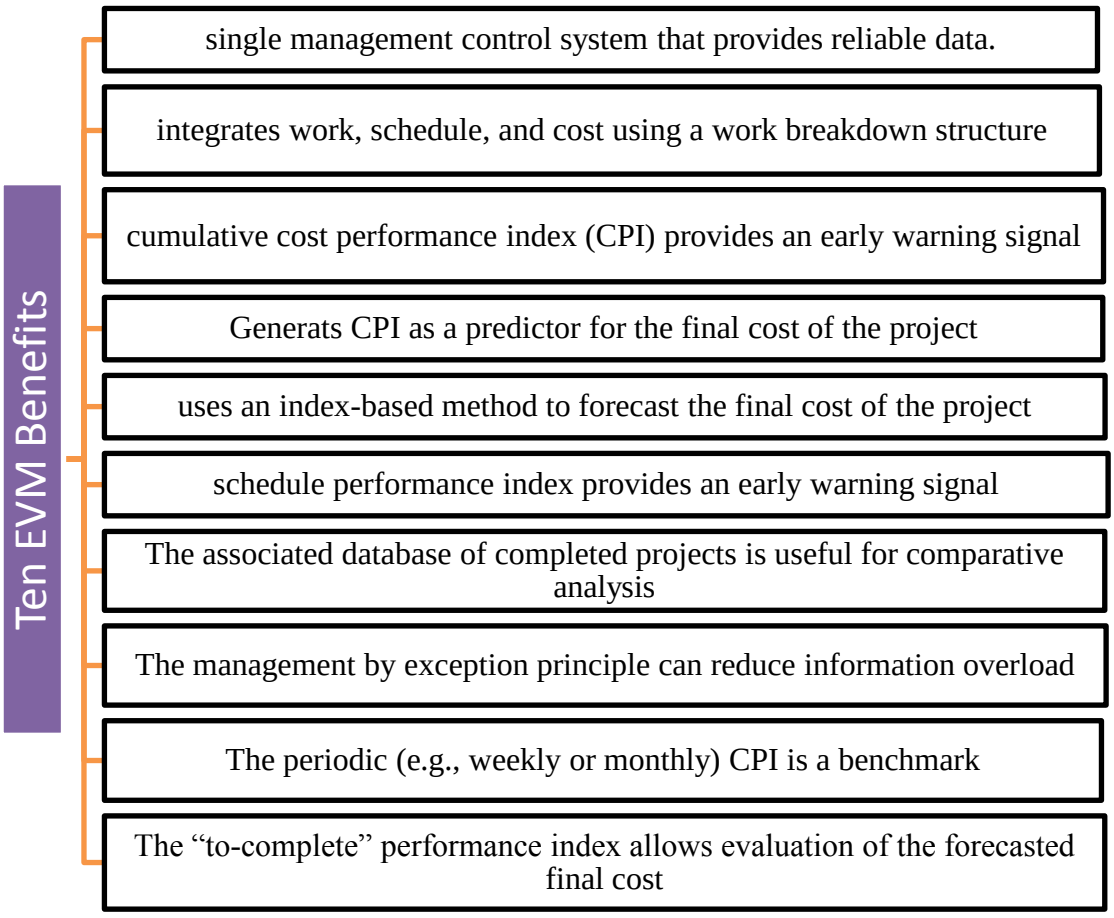

Figure 7: Ten Benefits of EVM

3.5 Application

EVM provides project managers and organizations with triggers and early warning signals that allow them to make timely actions in response to indicators of poor performance and enhance opportunity for project success.

3.6 Related Earned Value Study

Over the past years many companies and industries over the world have accepted the EVM technique and understood the usage and benefits on this technique since the EVM it monitors the physical completion of the project procedure. It has become an important part of project handling since it integrated project three important elements of the project cost, schedule, and time with project scopes, so that many studies and researches done on this areas (Atkinson 1999). Accordingly the IT has been recognized to have a significant role in effective implementation of EVM technique as it facilitate the data handling (Vargas 2004, Chou, Chen et al. 2010, Schwalbe 2010).

Earned Value acts as powerful managing and project controlling tool that consolidates and compares project information, expresses them graphically, and points out project risks and deficiencies to measure project performance(Gokhale and Bhatia 1997, Anbari Dec 2003) .

Besides knowing as a powerful project performance technique, EVM aids project managers to comprehensively control the project progress by increasing the progress estimation degree of accuracy. This technique also helps PMs to control project risks accurately and unified as they can provide a stage combining and comparing information and predicting risk (Chapman 2007., Raz (2001):).

As mentioned previously Information Technology has become a useful tool in project management and controlling that assists project managers to detect unpredicted problems and unexpected situations to reduce the adverse impact of them. Accordingly, Hemachandra and Ruwanpura (2008) integrated EVM and Monte Carlo Simulation and developed a controlling tool (P.S. Hemachandra (2008)), Benjoran also, implemented a cost control tool for five selected small-and medium-sized projects based on EVM providing a novel and efficient system using Information and Communication Technology (ICT) and

developed (Benjaoran 2009). Furthermore, Lipke et al., (2009) devised a control tool for forecasting final cost and project time. The author adopted an statistical method to EVM and SPI to improve project managers capability to make accurate decisions and prediction of project outcome (Lipke, Zwikael et al. 2009).

Despite all benefits mentioned previously of using EV technique some studies have discussed factors on why EVM is not accepted widely although it is a very helpful managerial tool? Brock R.(1983) have published an article on The Measurable News with the title of "EVM: benefit or burden?" and pointed out to project manager`s lack of understanding of EVM (R. 1983;Sept:) and Kemps RR. (1993) On the same magazine commented lack of Government concentrate on EVM implementation and therefore user involvement (RR. 1993;Dec:) as factors affected the acceptance of EVM. Moreover, political battle between groups that initiate the EVM employment and project managers (Butler GC 1993) on one hand and pressures to report only good news on the other hand can be considered as another factors that influences the EVM acceptance (Association 1980). To overcome these deficiencies an effective EVM application, with high-level management support on the basis of trust between government and contractors, knowledge sharing and compromise relation between contractors and stakeholders is required.

Acceptance and adoption of EVM increases significantly by successful implementation of EVM requiring various factors including: top-level management support, Government centralization, organizational support, effective training, user-centered application. The EVM application should also adopt easy-understanding methodology, project environment easy-learned implementation (Kim, Wells Jr et al. 2003).

Previous studies have demonstrated the potential of effective web-based EVMS once executed by engineering professionals and engineering applications for auto data

retrieval (Alheraish 2004, Ghanem[1] and AbdelRazig 2006). Among them Ghanem and Abdelrazig for example employed a Radio Frequency Identification and introduced a new and efficient model for tracking construction project on the basis of wireless communication technologies. Their model enables project managers to growth productivity reduce tracking time and labor once can generate more accurate estimates (Ghanem[1] and AbdelRazig 2006).

Although a convenient remote data recovery is pleasant, progress measurement and documentation for PC&M is essential especially during execution in which project is surrounded by uncertainties. Therefore project management wishes a project tracking system platform which is secure, accurate, easy and flexible, economical and easy-scaled-up database in order to monitor project progress (Turban, Wetherbe et al. 1996, Bradley, Mascaro et al. 2005, Li, Moselhi et al. 2006, Chou and O'Connor 2007).

Besides, effective implementation of EVM requires on-site managers to provide timely data as well as web-based EVMs associated with project cost, schedule, and scope (Alsakini, Wikström et al. 2004, Kerzner 2013). Traditionally project data were recorded and input manually so the possibility of error occur while recording data was not out of mind and also time spent for data recovery was not reasonable, thanks to modern IT technology that facilitated project managers to automatic data retrieval, acquisition, and input, simplified project monitoring and controlling (Cheung, Cheung et al. 2004, Li, Moselhi et al. 2006, Chou and O'Connor 2007, El-Omari and Moselhi 2009).

CHAPTER FOUR

METHODOLOGY AND SURVEY DATA

4. Method and Principle

4.1 Introduction

The EV is a powerful tool assisting project teams to assess and evaluate the project performance and progress by variety of indices and estimates. By definition, the EV of a work, project, task, or activity is a measure of completed work demonstrating the budgeted cost of work performed. In simple terms, EV shows how well and efficient project resources are utilized by project team as well as what has been obtained until now and what is going to be obtained in the future from the project.

In this chapter we are going to reveal methods used to conduct Earned Value in this dissertation. First, all necessary abbreviations and formulas used in calculating Earned Value are shown then available methods and theories behind them using in EV calculations are discussed. In the following this study would cover an introduction to MCIS Safety Glass Company and present a brief description of proposed project on which EV technique was implemented. Last but not least, in the final part we surveyed and studied data collected from the MCIS Safety Glass Sdn, Bhd. and how they were used in our EVM calculations.

4.2 Methods

To calculate Earned Value for a project, task, or activity generally three methods are used:

1. Difference Measurement (Variances)
2. Efficiency Measurement (Indices)
3. Forecast (Estimate at completion)

4.2.1 Difference Measurement (Variances)

In Earned Value Management variances are used in order to measure difference in planned, actual, and earned cost as well as schedule. There two significant variances mostly used: Cost Variance, and Schedule Variance.

- Cost Variance (CV)

  Cost Variance which is the difference between Earned Value and Actual Cost and calculated after each activity is completed describes that how much the project expenditure is different from initial expected cost progress. In other words this variance demonstrates whether the project is under budget, over budget, or compatible to budget.

  Cost Variance can be calculated from the following formula:

  $$\mathrm{CV} = \mathrm{EV} - \mathrm{AC}$$

  The unit is in proposed currency so that it can be compared with the original planned budget.

  If CV is in positive value project is in favorable condition meaning that project is under budget in compare to Planned Value unlike while CV value is negative project progress is in bad condition and it is over budget in compare to Planned Value.

- Schedule Variance (SV)

  Schedule Variance assists project managers to find out how far project progress is ahead of schedule or behind of schedule in compare to original duration. SV is the difference between Earned Value and Planned Value and its value would be derived from the following formula:

  $$\mathrm{SV} = \mathrm{EV} - \mathrm{PV}$$

  If Schedule Variance has a positive value it shows that project progress is ahead of schedule and is favorable, however, if SV is negative project progress id behind schedule. While all project planned value is earned the SV value would become zero since Earned Value is equal to Planned Value.

  Note that in all variances positive value means that the project is in a favorable status and negative value is a sign that project is in bad status.

4.2.2 Efficiency Measurement (Indices)

There are two indices widely used for efficiency measurement in earned value calculation: Cost Performance Index (CPI) and Schedule Performance Index (SPI).

- Cost Performance Index (CPI)

  CPI, or cost performance indices is a measure of effectiveness of cost utilized on project and a comparison between the value of work done and the actual cost spent on the project. CPI is as the ratio of earned value (EV) to actual cost (AC):

  $$CPI = \frac{EV}{AC}$$

In simple term, CPI demonstrates that from each Ringgit spent on an activity how much worth was created meaning that how much efficient is each Ringgit expended. For example if CPI is equal to 90% it means that from each ringgit spent only 90 percent worth of value has been obtained on planned budget basis.

Results obtained from calculating CPI can be interpreted as follow:

If the CPI is more than one it is like when efficiency is more than one meaning that earned progress is more than what was spent. Moreover, while CPI is less than one it indicates that what is earned from project is less than what was spent so project progress is not efficient. However, if CPI equals to one it means that earned progress is equal to actual progress or expenditures.

- Schedule Performance Index (SPI)

  Schedule Performance Indices is a measure of progress achieved compare to the progress planned that will tell the project managers the efficiency of the time utilized on the project. SPI is the ratio of earned value (EV) to planned value(PV):

$$\text{SPI} = \frac{\text{EV}}{\text{PV}}$$

  Where, PV is the authorized and approved cost of the project, task or activity that is related to the schedule (PMBOK.Guide,(2000).) also known as Budgeted Cost of Work Schedule.

  In simple word, SPI shows the efficiency of the time utilized for each activity to complete. This index would enable project managers to find out that what portion of planned schedule has been achieved up to time-now and

what portion of project activities have been completed on the basis of project planned schedule.

Values obtained after calculating SPI can be interpreted as follow:

If project SPI is more than one it means that more project activities have been completed in compare to planned schedule and if project SPI is less than one then portion of project completed is less than what was expected to be completed according to planned schedule therefore time utilized on project is more efficient or less efficient respectively. However, if SPI is equal to one so part of work completed is compatible with planned schedule.

Figure 8 shows a traditionally report of SPI and CPI recently developed during a construction project by R.Aliverdi et al.(Aliverdi, Moslemi Naeni et al. 2013) .

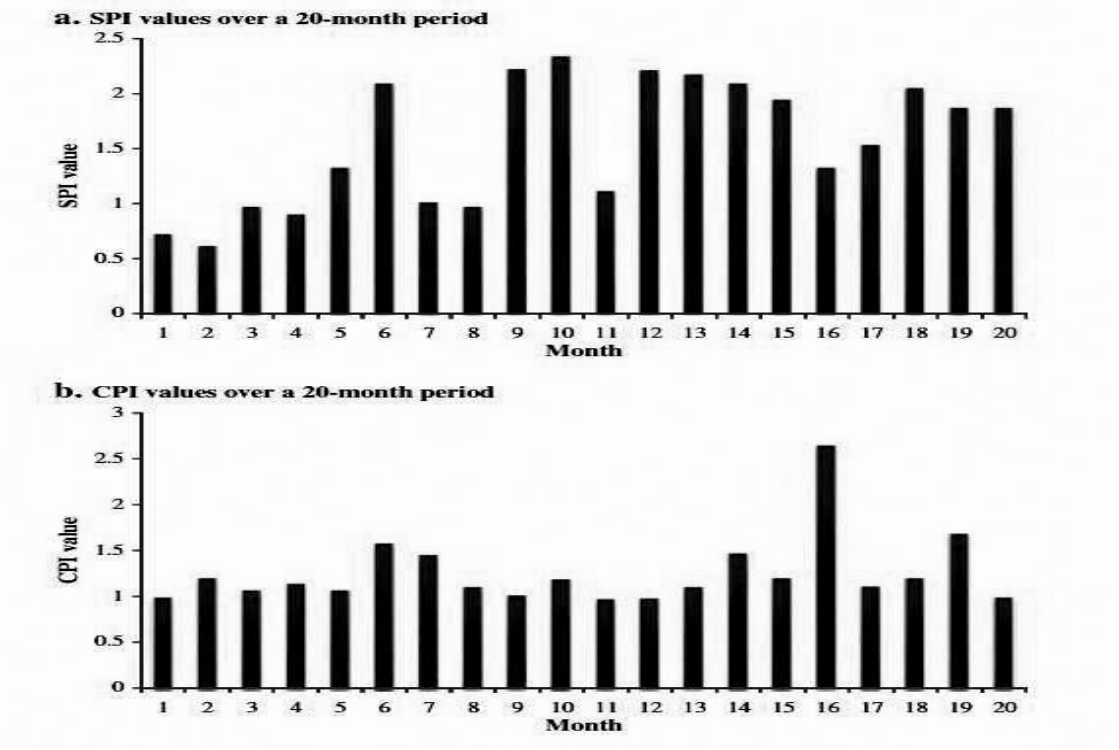

Figure 8: Traditional graphical report SPI and CPI monitored over a 20 month period. It was generated by Microsoft excel 2007. a) SPI data, b) CPI data. (Aliverdi, Moslemi Naeni et al. 2013).

4.2.3 Forecast (Estimate at Completion)

As mentioned before Earned Value Management enables project managers to predict project future performance by monitoring and tracking project progress. Estimate at Completion (EAC) is method of forecasting in EVM calculations and estimates value of project when all planned tasks are completed. EAC is divided into two:

- Estimate at Completion of cost, EAC(C)

  EAC(C) indicates that how much project will costs when the total project is completed. In fact EAC(C) is total cost value of completed project on the basis of Budget at Completion (BAC) which is planned budget for project to be completed. So by knowing EAC project managers would be able to estimate total cost while project is still in earlier stage and take correct action if needed.

  EAC(C) is consists of two parts: cost already spent and estimated future cost. Considering that project would follow current trend and nothing in project existing condition would be changed, EAC(C) can be calculated from the following formula:

$$\text{EAC C} = \text{AC} + \frac{\text{BAC} - \text{EV}}{\text{CPI}}$$

  Where, AC = Actual Cost,
  BAC = Budget at Completion,
  EV = Earned Value, &
  CPI = Cost Performance Index

  By knowing that $\text{CPI} = \frac{\text{EV}}{\text{AC}}$ then substituting in above equation:

$$EAC(C) = AC + \frac{(BAC - EV) \times AC}{EV}$$

$$EAC(C) = \frac{AC \times EV + (BAC\_EV) \times AC}{EV}$$

$$EAC(C) = \frac{AC \times BAC}{EV}$$

Then finally,

$$EAC(C) = \frac{BAC}{CPI}$$

- Estimate at Completion of time, EAC(T)

  EAC(T) is an indicator that would estimate total duration of project when all planned tasks are completed on the basis of original planned duration of project to be completed. EAT(T) provides project managers with reasonable information about duration of future activities so that they would be able to do re-baseline and take correct actions to reduce probable risks.

  EAC(T) is consists of two parts: actual time utilized and future activities estimated duration. By considering that project progresses in the same manner as existing condition and nothing would change EAC of time can be derived from following equation:

$$EAC\ T\ = ATU + \frac{PD - ATU \times SPI}{SPI}$$

Where, ATU = Actual Time Utilized

PD = Planned Duration

SPI = Schedule Performance Index

By subtracting above fraction from ATU then we have:

$$\text{EAC T} = \frac{\text{ATU} \times \text{SPI} + \text{PD} - \text{ATU} \times \text{SPI}}{\text{SPI}}$$

$$\text{EAC T} = \frac{\text{PD}}{\text{SPI}}$$

Three discussed method are the most common used methods in EVM calculation, however, there are some other methods rather than these ones. In the following we will presents a brief description of other EVM methods of calculation.

4.3 Other EVM Methods of Measurement

4.3.1 To Complete Performance Index, (TCPI)

(Fleming and Koppelman 2000).pp137 introduced a new method called To Complete Performance Index (TCPI) for project performance measurement using Earned Value. TCPI is an indicator demonstrating that in order to stick to project financial goal what performance factor much be attained on remaining progress.

TCPI can be derived using following formula:

$$TCPI = \frac{Work\ Remaining}{Funds\ Remaining} = \frac{OB - EV}{OB\_AC}$$

Where, OB = Original Budget

EV = Earned Value

AC = Actual Cost

4.3.2 Estimate to Completion, ETC

ETC is another forecasting method using Earned Value that estimates cost of remaining planned work. ETC is a tool for cost management that indicates how much is expected to be spent to complete remaining work, in other word it predicts planned cost remaining activities. For instance, let`s say that we are owning a project of which 40 percent has been completed up to now and 60 percent must be completed. The Estimate to Complete is amount of expenditure need to complete that remaining 60 percent.

ETC can be calculated as below:

$$ETC = EAC - AC$$

Where $EAC = \frac{BAC}{CPI}$ & $= \frac{EV}{AC}$, then by substituting in above equation:

$$ETC = \frac{BAC}{CPI} - AC$$

$$ETC = \frac{BAC - AC \times (\frac{EV}{AC})}{CPI}$$

$$ETC = \frac{BAC - EV}{CPI}$$

In this part we discussed about available and fashionable methods of using EV for analyzing, monitoring, controlling, and predicting project progress. However in addition to theories it is important to find out how practical is EVM in real manufacturing projects to boost projects efficiency and enhance companies cost and time utilization. In continue we are going to present a case study so that can be used as an easy example of Earned Value Management in practice and how well this technique can help project managers.

4.4 MCIS SAFETY GLASS Sdn Bhd

The MCIS Safety Glass Company produces safety glass for automotive industry. The products are including windshield and side-windows glasses Malaysian automobile companies and replacement market. MCIS Safety Glass Sdn Bhd was first found in 1973, with the cooperation of Malaysia Cooperative Insurance Society (MCIS) and Hindustan Safety Glass Works Pte. Ltd. and started commercial production in January, 1975. In April 2008, MCIS finally become a part of Trade-winds Corporation Berhad and its name changed to MSIC Safety Glass Sdn. Bhd (MCIS 1973-2008).

MCIS Safety Glass Company major customers are Proton, Perodua, and Honda respectively. MCIS Safety Glass produces high-quality car glasses of all types including Windshield glass, Back Door Window glass, Front Door glass (left and right), Rear Door glass (left and right), and Rear Quarter glass (left and right) with modern production line equipment and skilled workers (MCIS 1973-2008).

4.5 Background

In Malaysia it is not common in manufacturing companies and factories having Mass Production to use a controlling and monitoring technique like EVM to follow their production progress and manufacturing projects especially in companies in which their manufacturing projects is based on the Batch Production (BP).

The overall scope of this dissertation is to study EVM system in practice on a manufacturing project using Batch Production (BP) technique for mass production in Malaysia. In order to pursue our goal, in this study, we presented an introduction to EVM previously and will discuss on result of implementing EVM on projects in continue. Then as a practical and real example of EVM performance we implemented this system on project of production of glasses for Suzuki Swift car from Proton Company which was completed in MCIS Safety Glass Company.

4.5.1 MCIS Production of Glasses for Proton Suzuki Swift Car

In MCIS Safety Glass Company, as mentioned before Proton is the biggest client and a great portion of MCIS productions are according to Proton orders. Commercial production of “Set of Glasses for Suzuki Swift model” namely known as “Suzuki Swift” project commenced in January, 2008 for duration of five years and completed by the end of December 2012. Manufacturing technique is based on Batch Production so that production volume for each month is according to costumer`s need. Therefore each month MCIS assign production plan for that month.

4.5.1.1 A brief of manufacturing process

MCIS Safety Glass Company is an automotive manufacturing company and production lines of glass manufacturing are shown in Figure 9. Manufacturing flowchart is attached in appendix A.

4.5.2 Batch Production

Batch Production is kind of manufacturing process when production is completed stage by stage and the object in question is produced in groups or batches. In batch production when one part of production is completed that produced batch is passed down to next stage of production. Using this technique immense number of components or goods can be manufactured on one production line. Number of manufactured components is generally based on costumer`s need and although there is an initial plan for production in big companies, this plan is subjected to change very often since the costumer`s need of that component may vary during manufacturing process.

4.5.2.1 Batch production characteristic

I. Set up production line
II. Once one production line is completed then batches are passed down for next production line.
III. Flexible workspace, meaning that workers would be switched from one production line to another.
IV. Multi-task production line, which is quick and easy to change so that different component can be manufactured right after previous batch is completed.

V. Individual parts of product are purchased from another companies then assembled in production line

VI. Production line is used for a fixed amount of time for each product and afterward it is changed to produce different components.

VII. Several number of products can be manufactured in a single production line

VIII. Less initial outlay

IX. BP Is a common technique in companies in which forecast of demand is difficult, trial runs for productions are needed, or manufactures products with very high profit margins.

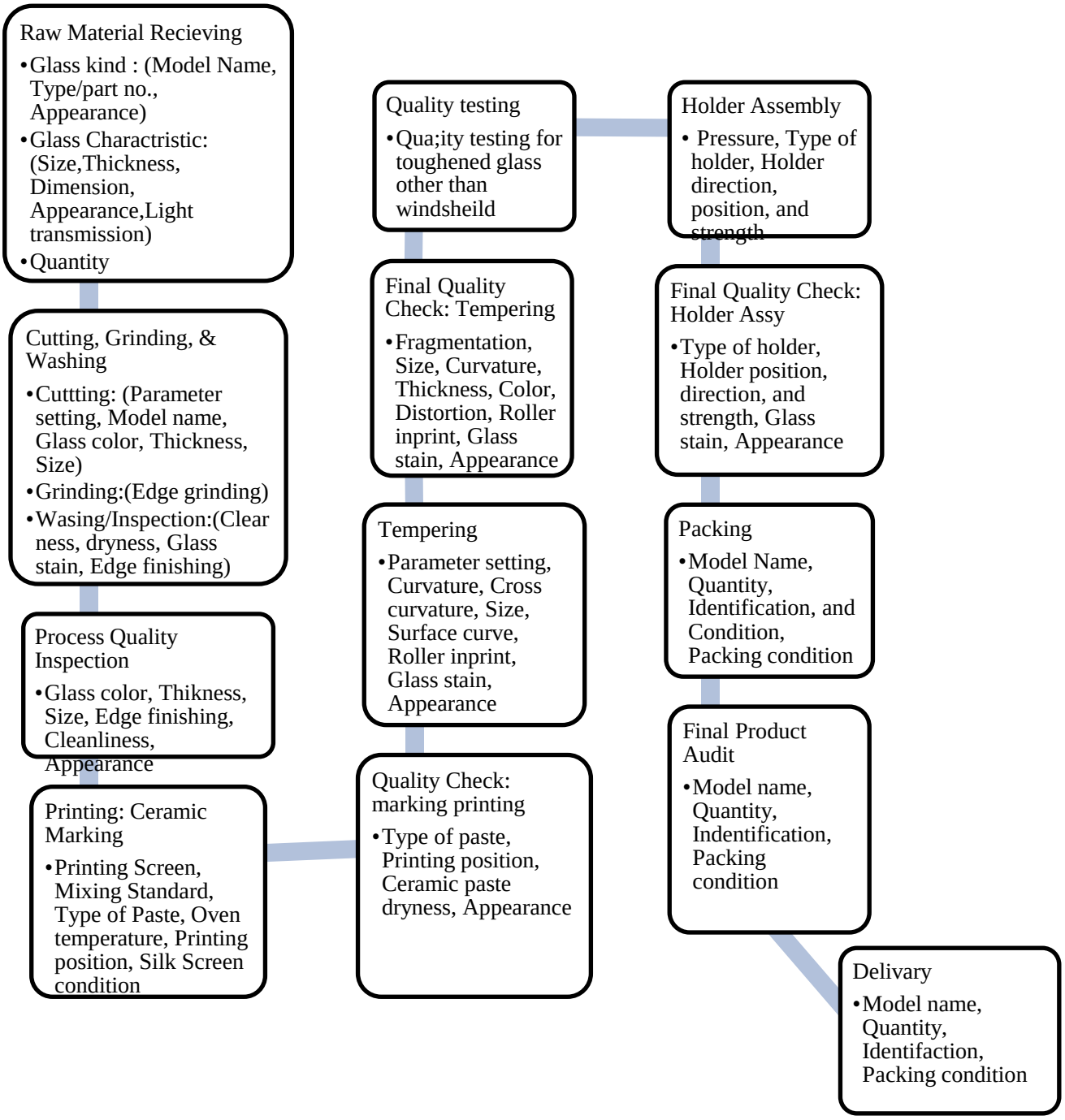

Figure 9: MCIS SAFETY GLASS Company Manufacturing

4.6 Survey Data and Application of EVM

According to contract between two parties, MCIS Safety Glass and Proton, four types of glasses were produced for Proton i.e. Windshield, Front door, Rear door, and Rear quarter that are called one SET of glass/car. Initial agreement production of 3600 volume of SET for each year, Table2, however, since manufacturing is based on batch production and costumer`s need production volume may change during the project progress. As mentioned before duration of the Suzuki Swift project is five years, Table2, therefore initial planned volume (PV_{volume}) for five years would become $PVvolume = 3600 \times 5 = 18000\ sets$. Note that although production volume may vary during project contract, it would not be less than initial agreement of total of 18000 sets for five years.

Table 2, shows OEM costing for the "Suzuki Swift" and total cost of each type of glass so total cost of one SET of glass can be calculated:

$$\text{Total Cost} = cost\ WSH\ + cost\ FD\ \times 2 + cost\ RD\ \times 2 + cost(RRQ) \times 2$$

$$\text{Total Cost} = 106.19 + 27.44 \times 2 + 17.32 \times 2 + 6.23 \times 2 = 208.17\ MYR$$

This is the total costing for MCIS Company to produce one SET of glass for one car which is obviously less than proposed selling price- price that Proton should pay for one SET of glass. Based on OEM costing, Table 2, proposed selling price for each type of glass has been calculated and demonstrated so total selling price of one SET can be calculated as following:

$$\text{Total Selling Price} = S.cost\ WSH\ + S.cost\ FD\ \times 2 + S.cost\ RD\ \times 2 + S > cost(RRQ) \times 2$$

Total Selling Price $= 122.55 + 31.85 \times 2 + 20.45 \times 2 + 8.85 \times 2 = 244.85\ MYR$

4.6.1 Planned Value

Based on the initial production planned and volume of production of each year, Table2, we know for one year production volume would be 3600 SETs, and since a year has twelve months, therefore production volume for one month become:

$$\text{Volume per Month} = \frac{3600}{12} = 300\ SETs/month$$

And as we are aware a month has average working day of 21 days then,

$$\frac{300}{21} \cong 15\,\frac{SETs}{day}$$

15 SETs per day can be produced.

In order to calculate Planned Value we need to know real working days of each month. Here we calculated production volume of each month for five years and tabulated in Table3, however, as clarifying examples here we presented calculation for first quarter of year 2008 and since the calculations are same for rest of months it would be waste of time revealing calculations for five years. Now let`s look at year 2008, Picture1:

Picture1 Malaysia Calendar, 2008(Date)

January for example, except weekends, Saturdays and Sundays, there is holidays on 1st, 10th, and 23rd of January. Furthermore, as we are aware due to new year`s holidays normally companies do not work for at least a week so considering these all, total January working days would be:

$$\text{January working days} = total\ days - weekends - publich\ holidays$$

$$= 31 - 8 - 7 = 16\ days$$

And since volume of production in one day is 15 SETs then,

$$\text{Total Volume}_{\text{Jan-2008}} = 16\ \ days\ \times 15\ \ SETs\ \ = 240\ SETs$$

Now let`s look at February, which is shortest month of each year:

Total days = 29

Weekends = 8

Public holidays = 3

Therefore, total volume should be produced on February, 2008 would be:

February working days $= 29 - 8 - 3 = 18\ days$

Total Volume$_{\text{Feb-2008}} = 18\ \ days\ \times 15\ SETs\ = 270\ SETs$

Same for March, according to Malaysia calendar, Picture1:

Total days = 31

Weekends = 10

Public holidays = 1

So February working Days $= 31 - 10 - 1 = 20$

and, Total Volume$_{\text{Mar-2008}} = 20\ \ days\ \times 15\ SETs\ = 300\ SETs$

Table 2: OEM Costing

	WINDSHIELD		FRONT DOOR L/R		REAR DOOR L/R		RR QTR L/R		
	COST/M2	AREA COST	COST /M2	AREA COST	COST /M2	AREA COST	COST /M2	AREA COST	
RAW MATERIAL	1.216		0.397		0.228		0.062		
GLASS COST	23.94	29.12	14.79	5.87	14.79	3.37	14.79	0.92	
FILM	21	25.54							
PRINTING	3.75	4.56							
SUB TOTAL	48.69	59.21	14.79	5.87	14.79	3.37	14.79	0.92	
PURCHASED PARTS		NOT INCLD.		NOT INCLD		NOT INCLD		NOT INCLD	
MFG. COST									
UTILITY	6.58		7.55		7.55		7.55		
MAINTENANCE	4.13		6.78		6.78		6.78		
DEPRECIATION	5.95		3.97		3.97		3.97		
LABOUR	8.21		14.45		14.45		14.45		
ROYALITY	0.64		0.13		0.13		0.13		
PROCESSING	3.19		7.55		7.55		7.55		
MATERIAL	28.7	34.9	40.43	16.05	40.43	9.2	40.43	2.51	
SUB TOTAL									
TOOLINGS									
VOLUME/YEAR	3600	5							TOTAL
DIES/MOLD	9500		3500		3500		3500		34000
INSPECTION	30000		30000		30000		15000		210000
GAUGE/JIG	15000		12000		12000		8000		94000
PALLETS	2000		500		500		500		5500
SILKSCREEN	750		250		250		250		750
S.SCREEN FRAME	1500								1500
POS FILM									
MARKED UP GLASS	6500		2000		2000		2000		23500
TESTINGS	1000		500		500		500		5000
OTHERS									
SUB TOTAL	66250	3.68	48750	2.71	48750	2.71	29750	1.65	374250
SUMMARY									
1. MAT.COST		59.21		5.87		3.37		0.92	
2. PURCHASED PART		0		0		0		0	
3. MFG.COST		34.9		16.05		9.2		2.51	
4. SUB TOTAL		94.11		21.92		12.56		3.42	
5. TRANSPORTATION	2.75	2.75	1.5	1.5	1.3	1.3	0.95	0.95	12.55
6. ADMIN CHARGES									
_% OF (4)	6%	5.65	6%	1.32	6%	0.75	6%	0.21	
7. TOOLING COST		3.68		2.71		2.71		1.65	
TOTAL COST		106.19		27.44		17.32		6.23	208.17
PROPOSED SELLING PRICE		122.55		31.85		20.45		8.85	244.85

Contract Duration

Production Volume of one year

Total Cost & Proposed Selling Price

Now that we calculated the monthly total production volume we can generate planned value for each month considering that we are looking at proposed selling price as proposed cost. Table 3 demonstrates monthly Planned Value and Cumulative Planned Value for the "Suzuki Swift" production.

Note that in common manufacturing projects that production occurs in a continuous line, for each activity there is an allocated budget so that the budget is the planned value but in batch production manufacturing is not based on budget allocation and planning so planned value should be calculated in different way.

In EVM implementation the Cumulative Planned Value is considered as Planned Value (PV) so from now-on we also consider the same and whenever talk about PV in calculation we are looking at Cumulative Planned Value. In manufacturing industry it is very common to illustrate cumulative cash flow in form of graph knowing as S-Curve because usually it is a non-linear S shape curve. Figure10 shows cumulative cash flow or cumulative planned value for "Suzuki Swift".

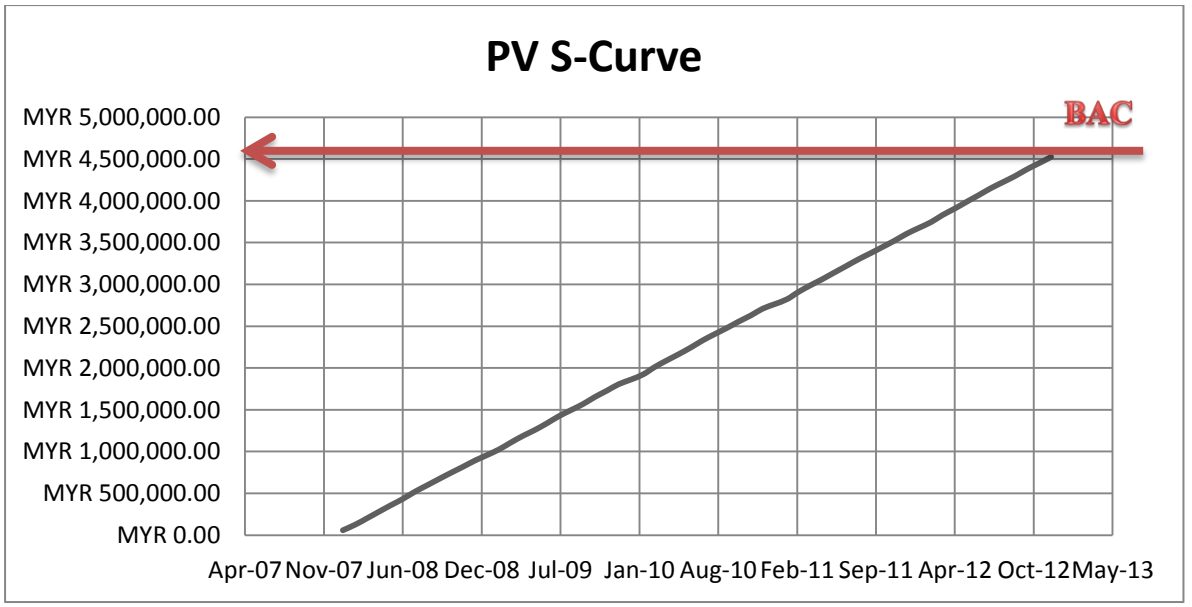

Figure 10: Cumulative Cash flow, Planned Value (PV)

Table 3: Monthly Planned Value & Cumulative Planned Value (Unit: Malaysian Ringgit (MYR))

Mont	working days	Planned Volume	Monthly PV	AccumulativePV
Jan-08	16	240	58764	58764
Feb-08	18	270	66109.5	124873.5
Mar-08	20	300	73455	198328.5
Apr-08	22	330	80800.5	279129
May-08	21	315	77127.75	356256.75
Jun-08	21	315	77127.75	433384.5
Jul-08	23	345	84473.25	517857.75
Aug-08	21	315	77127.75	594985.5
Sep-08	21	315	77127.75	672113.25
Oct-08	20	300	73455	745568.25
Nov-08	20	300	73455	819023.25
Dec-08	20	300	73455	892478.25
Jan-09	18	270	66109.5	958587.75
Feb-09	19	285	69782.25	1028370
Mar-09	21	315	77127.75	1105497.75
Apr-09	22	330	80800.5	1186298.25
May-09	19	285	69782.25	1256080.5
Jun-09	22	330	80800.5	1336881
Jul-09	23	345	84473.25	1421354.25
Aug-09	20	300	73455	1494809.25
Sep-09	20	300	73455	1568264.25
Oct-09	23	345	84473.25	1652737.5
Nov-09	21	315	77127.75	1729865.25
Dec-09	21	315	77127.75	1806993
Jan-10	15	225	55091.25	1862084.25
Feb-10	17	255	62436.75	1924521
Mar-10	23	345	84473.25	2008994.25
Apr-10	22	330	80800.5	2089794.75
May-10	20	300	73455	2163249.75
Jun-10	22	330	80800.5	2244050.25
Jul-10	23	345	84473.25	2328523.5
Aug-10	21	315	77127.75	2405651.25
Sep-10	20	300	73455	2479106.25
Oct-10	21	315	77127.75	2556234
Nov-10	20	300	73455	2629689
Dec-10	22	330	80800.5	2710489.5
Jan-11	15	225	55091.25	2765580.75
Feb-11	16	240	58764	2824344.75
Mar-11	23	345	84473.25	2908818
Apr-11	22	330	80800.5	2989618.5
May-11	20	300	73455	3063073.5
Jun-11	22	330	80800.5	3143874
Jul-11	21	315	77127.75	3221001.75
Aug-11	22	330	80800.5	3301802.25
Sep-11	20	300	73455	3375257.25
Oct-11	20	300	73455	3448712.25
Nov-11	21	315	77127.75	3525840
Dec-11	22	330	80800.5	3606640.5
Jan-12	19	285	69782.25	3676422.75
Feb-12	19	285	69782.25	3746205
Mar-12	23	345	84473.25	3830678.25
Apr-12	21	315	77127.75	3907806
May-12	22	330	80800.5	3988606.5
Jun-12	22	330	80800.5	4069407
Jul-12	22	330	80800.5	4150207.5
Aug-12	20	300	73455	4223662.5
Sep-12	20	300	73455	4297117.5
Oct-12	22	330	80800.5	4377918
Nov-12	20	300	73455	4451373
Dec-12	20	300	73455	4524828

planned value is according to initial plan and contract

4.6.2 Earned Value

Earned Value is physical completion of work and in manufacturing project using batch production technique it would be obtained at the end of each month according to produced volume. Based on financial documents received from MCIS Safety Glass Company- documents are attached in appendix A- showing daily cost of production according to physical completion and volume of production monthly EV could be calculated as well as monthly volume of SETs produced.

Here like in Planned Value, cumulative EV is considered as EV and used in calculations. Table4 shows Earned Value obtained from financial documents and results from the Earned Value table are illustrated as graph in figure 11.

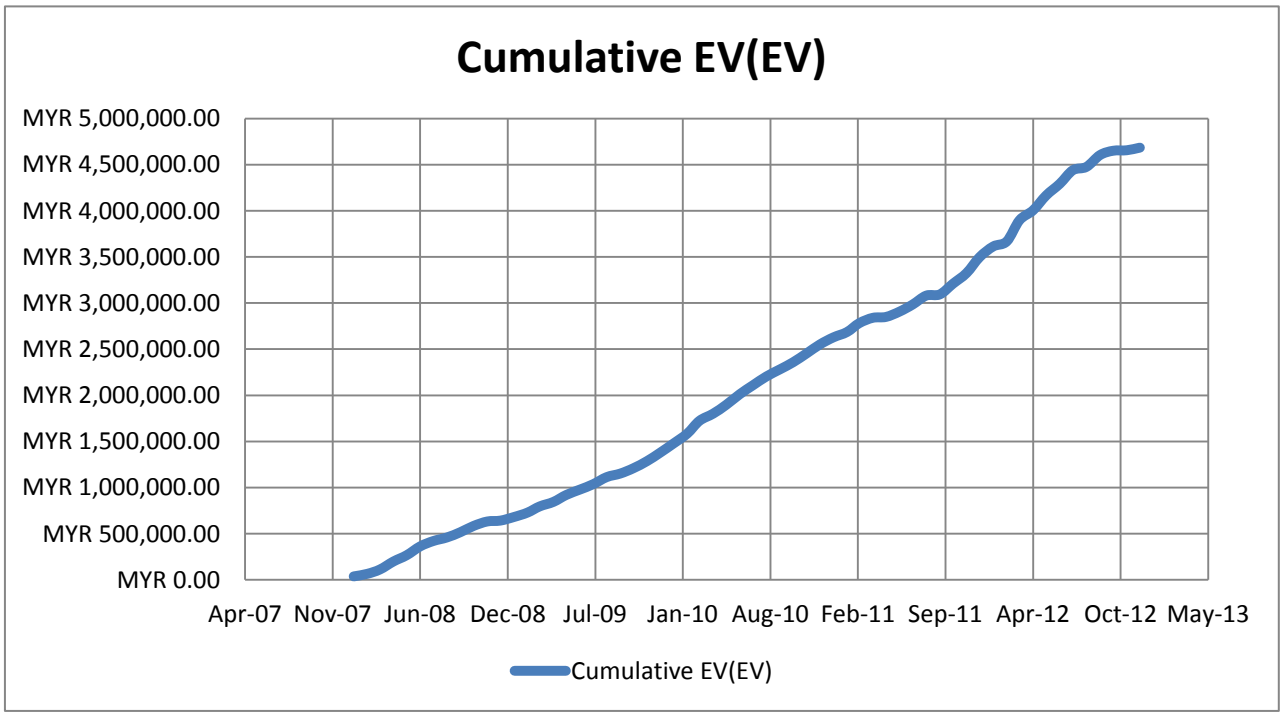

Figure 11: Earned Value (Unit: Malaysian ringgit (MYR))

Table 4: Earned Value

Month	Monthly EV	Cumulative EV	Monthley Earned Volume	Cumulative Earned Volume
Jan-08	37056	37056	151.3416377	151.3416377
Feb-08	27792	64848	113.5062283	264.847866
Mar-08	47400	112248	193.587911	458.435777
Apr-08	86976	199224	355.2215642	813.6573412
May-08	67368	266592	275.1398816	1088.797223
Jun-08	96240	362832	393.0569737	1481.854197
Jul-08	57744	420576	235.8341842	1717.688381
Aug-08	38498	459074	157.2309577	1874.919338
Sep-08	57744	516818	235.8341842	2110.753523
Oct-08	67368	584186	275.1398816	2385.893404
Nov-08	48120	632306	196.5284868	2582.421891
Dec-08	9624	641930	39.30569737	2621.727588
Jan-09	38496	680426	157.2227895	2778.950378
Feb-09	48120	728546	196.5284868	2975.478865
Mar-09	67460.4	796006.4	275.5172555	3250.99612
Apr-09	48120	844126.4	196.5284868	3447.524607
May-09	76632	920758.4	312.975291	3760.499898
Jun-09	57744	978502.4	235.8341842	3996.334082
Jul-09	57744	1036246.4	235.8341842	4232.168266
Aug-09	76992	1113238.4	314.4455789	4546.613845
Sep-09	38496	1151734.4	157.2227895	4703.836635
Oct-09	57744	1209478.4	235.8341842	4939.670819
Nov-09	76992	1286470.4	314.4455789	5254.116398
Dec-09	91248	1377718.4	372.668981	5626.785379
Jan-10	101232	1478950.4	413.4449663	6040.230345
Feb-10	105864	1584814.4	432.362671	6472.593016
Mar-10	138736	1723550.4	566.6162957	7039.209312
Apr-10	76992	1800542.4	314.4455789	7353.654891
May-10	96240	1896782.4	393.0569737	7746.711864
Jun-10	115488	2012270.4	471.6683684	8218.380233
Jul-10	96240	2108510.4	393.0569737	8611.437207
Aug-10	96240	2204750.4	393.0569737	9004.49418
Sep-10	76992	2281742.4	314.4455789	9318.939759
Oct-10	76992	2358734.4	314.4455789	9633.385338
Nov-10	96240	2454974.4	393.0569737	10026.44231
Dec-10	96240	2551214.4	393.0569737	10419.49929
Jan-11	76992	2628206.4	314.4455789	10733.94486
Feb-11	57744	2685950.4	235.8341842	10969.77905
Mar-11	96240	2782190.4	393.0569737	11362.83602
Apr-11	57744	2839934.4	235.8341842	11598.67021
May-11	9624	2849558.4	39.30569737	11637.9759
Jun-11	57744	2907302.4	235.8341842	11873.81009
Jul-11	76992	2984294.4	314.4455789	12188.25567
Aug-11	96313.65	3080608.05	393.3577701	12581.61344
Sep-11	13240	3093848.05	54.07392281	12635.68736
Oct-11	115488	3209336.05	471.6683684	13107.35573
Nov-11	115488	3324824.05	471.6683684	13579.0241
Dec-11	173232	3498056.05	707.5025526	14286.52665
Jan-12	115488	3613544.05	471.6683684	14758.19502
Feb-12	55165.44	3668709.49	225.3030018	14983.49802
Mar-12	228686.16	3897395.65	933.9847253	15917.48274
Apr-12	107752.32	4005147.97	440.0748213	16357.55757
May-12	161628.48	4166776.45	660.112232	17017.6698
Jun-12	125711.04	4292487.49	513.4206249	17531.09042
Jul-12	147468.6	4439956.09	602.2813968	18133.37182
Aug-12	35917.44	4475873.53	146.6916071	18280.06343
Sep-12	127997.76	4603871.29	522.7598938	18802.82332
Oct-12	46802.4	4650673.69	191.147233	18993.97055
Nov-12	5274.77	4655948.46	21.54286298	19015.51342
Dec-12	28462.51	4684410.97	116.2446804	19131.7581

4.6.3 Actual Cost

Actual Cost (AC) is real and actual investment during execution phase and should be recorded on daily basis since it is actual expenditure as project progresses. In MCIS Safety Glass Company there is no available data of actual cost of "Suzuki Swift" project since there have never been a consolidate program for recording actual cost daily. This is a very common issue in many of manufacturing companies like MCIS in which importance of recording Actual Cost on a daily basis still is uncover for both Project Managers and Company owners.

In EVM analysis AC is one of the main elements so that in this case due to lack of information on Actual Cost we have to try to make a good assumption in order to continue our calculations.

4.6.3.1 Estimating Actual Cost

Form Earned Value information on one hand we could derive monthly earned volume of SETs. On the other hand we know from Table5 That total price for MCIS Safety Glass to produce one SET is MYR 208.17 then, by consolidating this information actual cost of earned produced volume would be achieved and we consider this amount as Actual Cost for our calculation. Although Actual Cost have to be based on real data not assumption, here due to lack of information we estimated values of actual cost however these assumptions are quite close to reality and are reliable.

For example from Table4 (EV) it can be revealed that in January 2008 EV is equal to MYR 37,065 and dividing this amount by proposed cost-proposed selling price- Earned volume can be derived:

$$\text{Earned Volume}_{\text{Jan-2008}} = \frac{37{,}056}{244.85} = 151.34\ SETs$$

$$\text{AC}_{\text{Jan-2008}} = 151.34\ \times 208.17 = 31{,}504.79\ MYR$$

Results from calculating AC are tabulated in Table 5 and also demonstrated visually as graph in Figure 12.

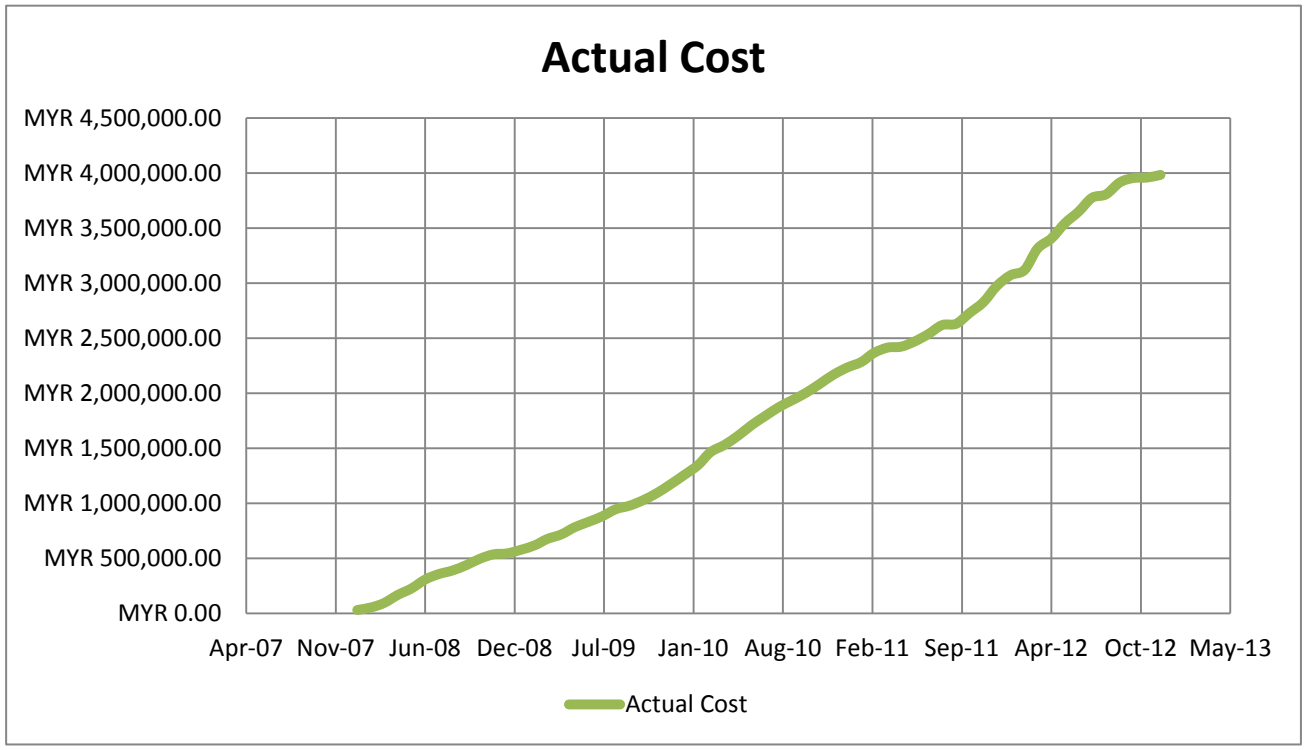

Figure 12: Actual Cost spent in duration of five years

Table 5: Actual Cost (Unit : Malaysian Ringgit (MYR))

Month	Earned Volume	Actual Value	Actual Cost
Jan-08	151.3416377	31504.78872	31504.78872
Feb-08	113.5062283	23628.59155	55133.38027
Mar-08	193.587911	40299.19543	95432.5757
Apr-08	355.2215642	73946.47302	169379.0487
May-08	275.1398816	57275.86915	226654.9179
Jun-08	393.0569737	81822.67022	308477.5881
Jul-08	235.8341842	49093.60212	357571.1902
Aug-08	157.2309577	32730.76846	390301.9587
Sep-08	235.8341842	49093.60212	439395.5608
Oct-08	275.1398816	57275.86915	496671.43
Nov-08	196.5284868	40911.3351	537582.765
Dec-08	39.30569737	8182.267022	545765.0321
Jan-09	157.2227895	32729.06809	578494.1002
Feb-09	196.5284868	40911.3351	619405.4353
Mar-09	275.5172555	57354.42708	676759.8623
Apr-09	196.5284868	40911.3351	717671.1974
May-09	312.975291	65152.06633	782823.2638
Jun-09	235.8341842	49093.60212	831916.8659
Jul-09	235.8341842	49093.60212	881010.468
Aug-09	314.4455789	65458.13616	946468.6042
Sep-09	157.2227895	32729.06809	979197.6723
Oct-09	235.8341842	49093.60212	1028291.274
Nov-09	314.4455789	65458.13616	1093749.411
Dec-09	372.668981	77578.50177	1171327.912
Jan-10	413.4449663	86066.83863	1257394.751
Feb-10	432.362671	90004.93722	1347399.688
Mar-10	566.6162957	117952.5143	1465352.202
Apr-10	314.4455789	65458.13616	1530810.339
May-10	393.0569737	81822.67022	1612633.009
Jun-10	471.6683684	98187.20425	1710820.213
Jul-10	393.0569737	81822.67022	1792642.883
Aug-10	393.0569737	81822.67022	1874465.554
Sep-10	314.4455789	65458.13616	1939923.69
Oct-10	314.4455789	65458.13616	2005381.826
Nov-10	393.0569737	81822.67022	2087204.496
Dec-10	393.0569737	81822.67022	2169027.166
Jan-11	314.4455789	65458.13616	2234485.302
Feb-11	235.8341842	49093.60212	2283578.905
Mar-11	393.0569737	81822.67022	2365401.575
Apr-11	235.8341842	49093.60212	2414495.177
May-11	39.30569737	8182.267022	2422677.444
Jun-11	235.8341842	49093.60212	2471771.046
Jul-11	314.4455789	65458.13616	2537229.182
Aug-11	393.3577701	81885.287	2619114.469
Sep-11	54.07392281	11256.56851	2630371.038
Oct-11	471.6683684	98187.20425	2728558.242
Nov-11	471.6683684	98187.20425	2826745.446
Dec-11	707.5025526	147280.8064	2974026.253
Jan-12	471.6683684	98187.20425	3072213.457
Feb-12	225.3030018	46901.32588	3119114.783
Mar-12	933.9847253	194427.6003	3313542.383
Apr-12	440.0748213	91610.37555	3405152.759
May-12	660.112232	137415.5633	3542568.322
Jun-12	513.4206249	106878.7715	3649447.093
Jul-12	602.2813968	125376.9184	3774824.012
Aug-12	146.6916071	30536.79185	3805360.804
Sep-12	522.7598938	108822.9271	3914183.731
Oct-12	191.147233	39791.11949	3953974.85
Nov-12	21.54286298	4484.577787	3958459.428
Dec-12	116.2446804	24198.65512	3982658.083

CHAPTER FIVE

RESULTS AND DISCUSSION

5.1 Introduction

Earned Value Management of based on three basic and important elements:

i. Planned Value

ii. Earned Value

iii. Actual Cost

By knowing these basics elements from previous chapter Earned Value Measurement and Forecast of Cost and Schedule can be done. As mentioned previously, three common methods using EVM are:

- Difference Measurement (Variances)
- Efficiency Measurement (Indices)
- Forecast (Estimate at completion)

And results from EVM analysis can be summarized as follows:

5.2 Variances and Indices

5.2.1 Cost Variance (CV) and Cost Performance Index

EVM enables us to forecast and control project performance and progress cost-wise. Results from cost variance and cost performance index analysis are tabulated in Table6, showing values of CV, CV% and CPI.

Table 6: Earned Value Cost Analysis (Amounts in Malaysian Ringgit)

Month	CV	CPI	CVP
Jan-08	5551.21128	1.176202143	14.98060039
Feb-08	9714.619735	1.176202143	14.98060038
Mar-08	16815.4243	1.176202142	14.98060037
Apr-08	29844.95128	1.176202143	14.98060037
May-08	39937.08213	1.176202142	14.98060037
Jun-08	54354.41191	1.176202142	14.98060036
Jul-08	63004.80979	1.176202142	14.98060036
Aug-08	68772.04133	1.176202142	14.98060037
Sep-08	77422.4392	1.176202142	14.98060037
Oct-08	87514.57005	1.176202142	14.98060036
Nov-08	94723.23495	1.176202142	14.98060037
Dec-08	96164.96793	1.176202142	14.98060037
Jan-09	101931.8998	1.176202142	14.98060036
Feb-09	109140.5647	1.176202142	14.98060037
Mar-09	119246.5377	1.176202142	14.98060037
Apr-09	126455.2026	1.176202142	14.98060037
May-09	137935.1362	1.176202142	14.98060037
Jun-09	146585.5341	1.176202142	14.98060037
Jul-09	155235.932	1.176202142	14.98060037
Aug-09	166769.7958	1.176202142	14.98060037
Sep-09	172536.7277	1.176202142	14.98060037
Oct-09	181187.1256	1.176202142	14.98060037
Nov-09	192720.9895	1.176202142	14.98060037
Dec-09	206390.4877	1.176202142	14.98060037
Jan-10	221555.649	1.176202142	14.98060037
Feb-10	237414.7118	1.176202142	14.98060037
Mar-10	258198.1975	1.176202142	14.98060037
Apr-10	269732.0614	1.176202142	14.98060037
May-10	284149.3912	1.176202142	14.98060037
Jun-10	301450.1869	1.176202142	14.98060037
Jul-10	315867.5167	1.176202142	14.98060037
Aug-10	330284.8465	1.176202142	14.98060037
Sep-10	341818.7103	1.176202142	14.98060037
Oct-10	353352.5742	1.176202142	14.98060037
Nov-10	367769.904	1.176202142	14.98060037
Dec-10	382187.2337	1.176202142	14.98060037
Jan-11	393721.0976	1.176202142	14.98060037
Feb-11	402371.4955	1.176202142	14.98060037
Mar-11	416788.8252	1.176202142	14.98060037
Apr-11	425439.2231	1.176202142	14.98060037
May-11	426880.9561	1.176202142	14.98060037
Jun-11	435531.354	1.176202142	14.98060037
Jul-11	447065.2178	1.176202142	14.98060037
Aug-11	461493.5808	1.176202142	14.98060037
Sep-11	463477.0123	1.176202142	14.98060037
Oct-11	480777.8081	1.176202142	14.98060037
Nov-11	498078.6038	1.176202142	14.98060037
Dec-11	524029.7974	1.176202142	14.98060037
Jan-12	541330.5932	1.176202142	14.98060037
Feb-12	549594.7073	1.176202142	14.98060037
Mar-12	583853.267	1.176202142	14.98060037
Apr-12	599995.2115	1.176202142	14.98060037
May-12	624208.1281	1.176202142	14.98060037
Jun-12	643040.3967	1.176202142	14.98060037
Jul-12	665132.0783	1.176202142	14.98060037
Aug-12	670512.7264	1.176202142	14.98060037
Sep-12	689687.5593	1.176202142	14.98060037
Oct-12	696698.8398	1.176202142	14.98060037
Nov-12	697489.0321	1.176202142	14.98060037
Dec-12	701752.8869	1.176202142	14.98060037

I. Cost Variance is derived by subtracting AC from EV. For the proposed project, it can be seen that CV consistently comes with positive value that depicts a favorable scenario meaning that Earned Value is more than actual cost spent and project earned progress is more than expenditure. Cost Variance can also be expressed as Cost Variance Percentage (CVP) if CV is divided by EV. Table 6 shows value of CVP that is positive and constantly equal to 15% approximately. While CVP as positive value it indicates that project progresses at a good condition and it is constantly 15% under-budget.

II. By referring to Table6 values of Cost Performance Index values over project duration can be seen that is positive and constantly equal to 1.176, since CPI demonstrates the efficiency of project progress and source utilization having value greater than 1 depicts a very favorable scenario. Therefore project has very high cost efficiency.

5.2.2 Schedule Variance & Schedule Performance Index

EVM enables Project Managers to measure and control time utilization and activity duration in order to enhance project performance and efficiency. Results from Earned Value Schedule analysis i.e. SV, SVP, and SPI are demonstrated in Table7.

Table 7: Earned Value Schedule Analysis (Amount in Malaysian Ringgit)

Month	SV	SPI	SVP
Jan-08	-21708	0.630590157	-0.585816062
Feb-08	-60025.5	0.519309541	-0.92563379
Mar-08	-86080.5	0.565970095	-0.766877806
Apr-08	-79905	0.71373451	-0.401081195
May-08	-89664.75	0.748314242	-0.336336987
Jun-08	-70552.5	0.837205761	-0.194449497
Jul-08	-97281.75	0.812145806	-0.231305995
Aug-08	-135911.5	0.771571744	-0.296055756
Sep-08	-155295.25	0.768944817	-0.300483439
Oct-08	-161382.25	0.783544632	-0.276251485
Nov-08	-186717.25	0.772024482	-0.295295711
Dec-08	-250548.25	0.719266828	-0.390304628
Jan-09	-278161.75	0.709821297	-0.408805293
Feb-09	-299824	0.708447349	-0.411537501
Mar-09	-309491.35	0.720043437	-0.388805103
Apr-09	-342171.85	0.711563386	-0.405356177
May-09	-335322.1	0.733040916	-0.364180332
Jun-09	-358378.6	0.731929319	-0.366252142
Jul-09	-385107.85	0.729055688	-0.371637335
Aug-09	-381570.85	0.744736093	-0.342757535
Sep-09	-416529.85	0.734400724	-0.361654432
Oct-09	-443259.1	0.731803084	-0.366487818
Nov-09	-443394.85	0.743682434	-0.34465997
Dec-09	-429274.6	0.762437043	-0.311583702
Jan-10	-383133.85	0.794244621	-0.259057944
Feb-10	-339706.6	0.823485117	-0.214351031
Mar-10	-285443.85	0.85791704	-0.165613869
Apr-10	-289252.35	0.861588154	-0.160647342
May-10	-266467.35	0.876820811	-0.140483879
Jun-10	-231779.85	0.89671361	-0.115183253
Jul-10	-220013.1	0.905513902	-0.104345276
Aug-10	-200900.85	0.916487957	-0.091121811
Sep-10	-197363.85	0.920389112	-0.08649699
Oct-10	-197499.6	0.922738059	-0.083731174
Nov-10	-174714.6	0.933560737	-0.071167585
Dec-10	-159275.1	0.941237514	-0.062431092
Jan-11	-137374.35	0.950327124	-0.05226924
Feb-11	-138394.35	0.950999484	-0.051525281
Mar-11	-126627.6	0.956467679	-0.045513636
Apr-11	-149684.1	0.94993204	-0.052706886
May-11	-213515.1	0.930293837	-0.074929189
Jun-11	-236571.6	0.924751564	-0.081371515
Jul-11	-236707.35	0.926511263	-0.079317694
Aug-11	-221194.2	0.933008041	-0.071802124
Sep-11	-281409.2	0.916625851	-0.090957667
Oct-11	-239376.2	0.930589686	-0.074587452
Nov-11	-201015.95	0.942987784	-0.060459124
Dec-11	-108584.45	0.969893187	-0.031041369
Jan-12	-62878.7	0.982896771	-0.017400839
Feb-12	-77495.51	0.979313596	-0.021123371
Mar-12	66717.4	1.017416602	0.017118457
Apr-12	97341.97	1.024909622	0.024304213
May-12	178169.95	1.044669724	0.042759661
Jun-12	223080.49	1.054818918	0.05196998
Jul-12	289748.59	1.069815447	0.065259337
Aug-12	252211.03	1.059713822	0.056349007
Sep-12	306753.79	1.071385944	0.066629532
Oct-12	272755.69	1.062302604	0.058648641
Nov-12	204575.46	1.045957834	0.043938515
Dec-12	159582.97	1.035268295	0.034066817

I. SV is calculated by subtracting PV from EV and according to Table7 it can be seen that SV values are consistently negative within four year from beginning of project and this depicts an unfavorable scenario that the project is behind the schedule. However, form March 2012 onward SV is constantly positive indicating that project is ahead of schedule in the last financial year.

II. SV also can be expressed in terms of percentage is SV is divided by EV. As it can be seen in Table7 SV lies between -0.92563379 and 0.066629532 indicating percentage of project which has not be accomplished against planned schedule.

III. SPI is an indicator showing efficiency of time utilized during project progress. Results from SPI analysis are tabulated and Table7 and demonstrate that project team has performed quiet inefficient during 4years started from 2008 since the SPI is less than 1 and varies between 52% to 98%. However in the last year of project time efficiency becomes more than 1 meaning that project time utilization is in favorable condition.

5.2.3 Forecasting (Estimate at Completion)

Apart from being a controlling and monitoring tool, EVM can be powerful forecasting tool to estimate project total cost when all planned activities are completed.

In order to find out how Earned Value analysis would assist project managers, in "Suzuki Swift" project we assumed that if only two third of project has been completed and now we as project managers want to see how much our project will cost at the end of year 2012, Figure13. Two third of project would be completed until April 201. Therefore S-curve would be as follow:

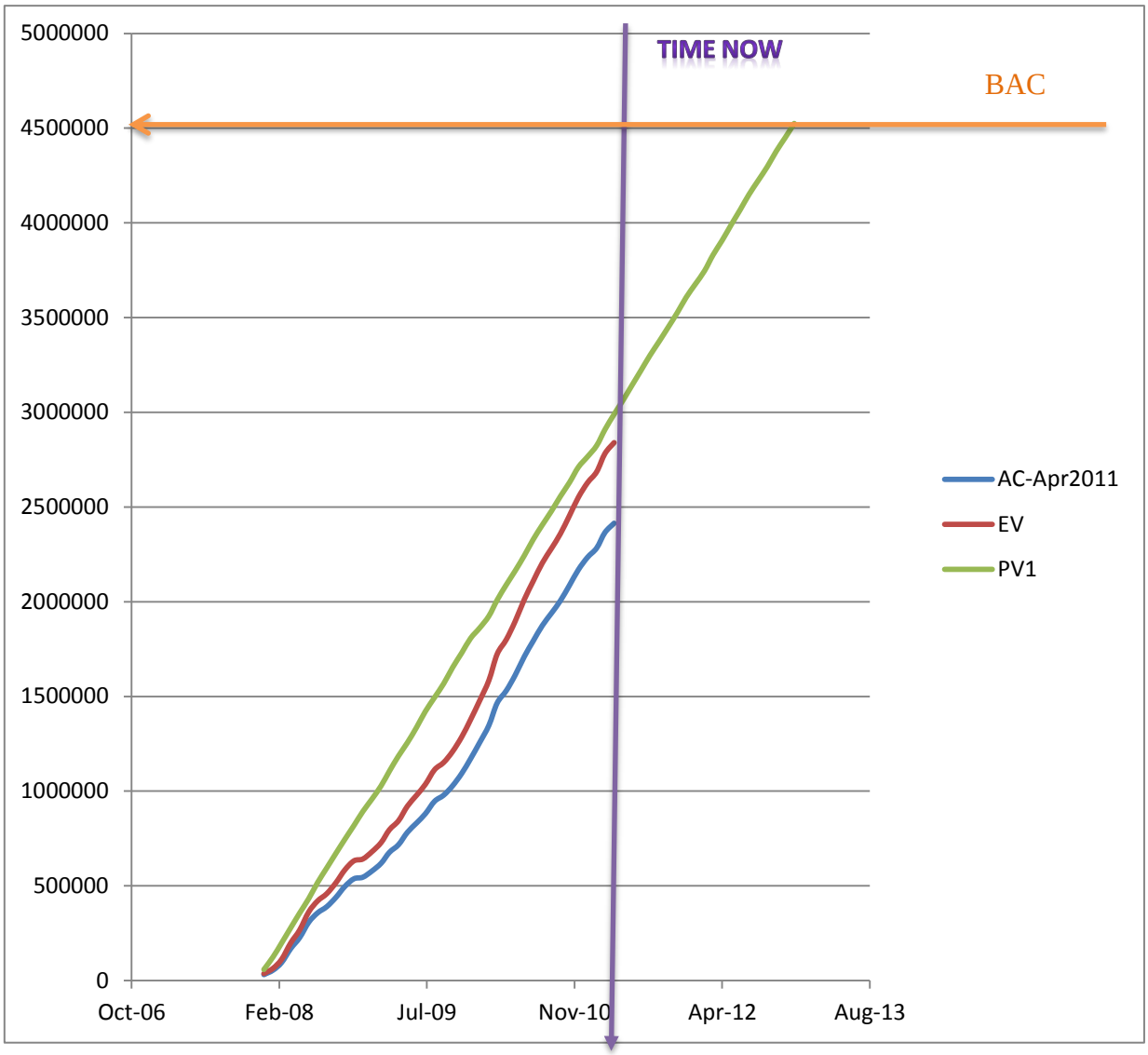

Figure 13: PV, AC, & EV at Time-Now

EAC(C) is calculated as follow:

$$\text{EAC(C)} = \frac{BAC}{CPI} = \frac{4524828}{1.1762} = 3846988.607$$

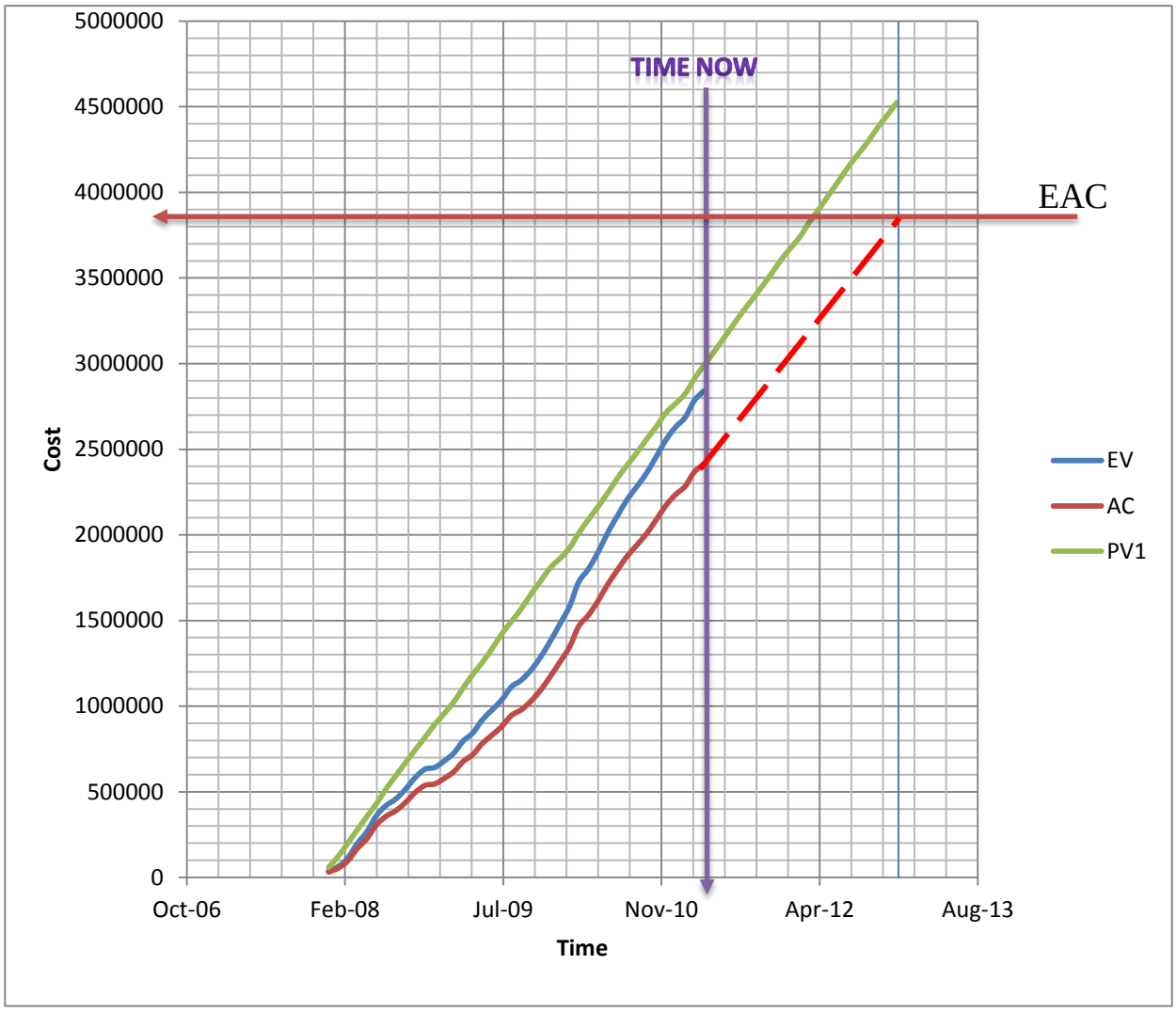

Figure 14: Estimate at Completion

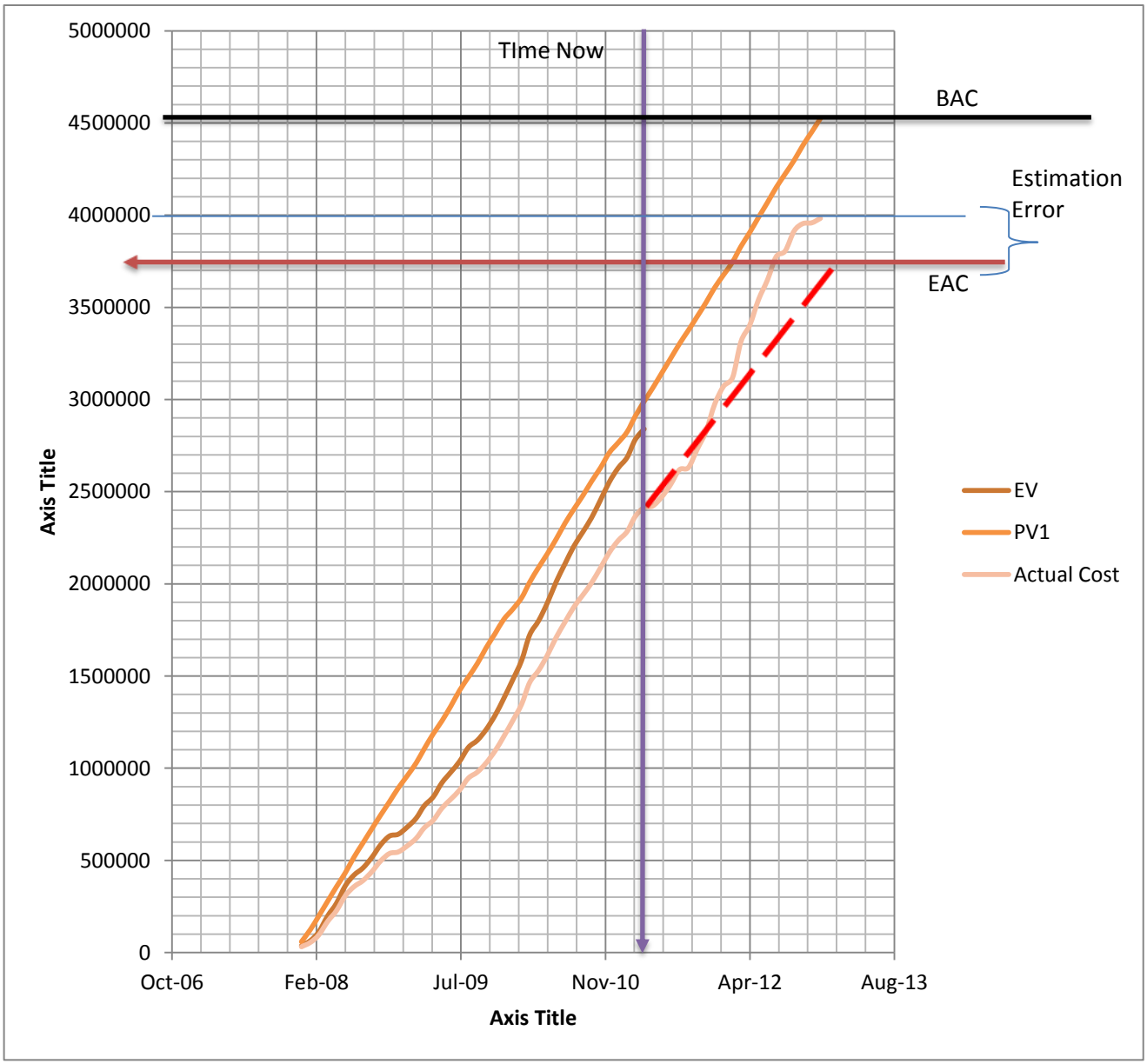

Figure 15: Estimate at Completion in comparison with final Actual Cost

According to Figure15, there is a small error in EAC forecast that is called Estimation Error (EER). EER percentage can be calculated as follow:

$$EER\% = \frac{ACf - EAC}{EAC} \times 100 = \frac{3982658.083 - 3846988.607}{3982658.083} \times 100 = 3.4\%$$

CHAPTER SIX

CONCLUSIONS AND SUGGESTIONS FOR FUTURE WORK

6. Conclusions

In this dissertation EVM system as a powerful performance measurement and forecasting tool was successfully implemented and tested for manufacturing industry and very interesting results have been released for far. In compare with traditional and common project management techniques, EVM technique is more comprehensive so that it covers more aspects of project performance and can assist project managers to boost project performance efficiencies. EVM facilitate project managers a very clear insight to look at project status more in depth and enables them to have a clear view about project future performance.

What makes exception in EVM system from other project management technique is that EVM consolidate project scope with project time and cost. As it came from results and have been seen in this study EVM would be able to measure and analyze project cost and time utilization provides project team with worthy information about how efficient project sources were utilized at any point in project. By calculating variances and indices EVM can help project team to examine and analyze current trend and performance of cost and schedule in many different ways and from the case study it was revealed that EVM provided very useful assessment of actual percentage of work completion. Moreover, as it was demonstrated in this report EVM can make it possible for project managers to predict and estimate future cost and schedule performance with a reasonable error. These types of information cannot be generated from other managing techniques rather than EVM.

The implementation of the EVM methodology on manufacturing projects demands some effort and short-term yield is not obvious. However, this effort only needs to be done at the beginning of the project and will eventually prove valuable throughout the course of the project. This added value consists of providing early warning signals for project managers and in the long run, employing EVM will help to a gain better view on the progress of the project's performance. EVM provides project managers with quantifiable and tangible data on whether the project is performing according to plan or not. This quantifiable data can subsequently be extrapolated throughout the portfolio of projects and will allow better estimates for new projects.

However, though EVM is a helpful and powerful managing technique, it is very important that project frequent monitoring to be done to generate basic elements for Earned Value calculation since lack of information will not give desired results specially in terms of Actual Cost monitoring should be on a daily process.

Conclusively, we strongly believe that the EVM methodology could have helped the studied projects in achieving a better understanding of the project performance. Moreover, when EVM would be incorporated as a general project management tool by manufacturing companies and its methodology would be understood well by project managers, it could definitely serve as a powerful tool to follow up all types of manufacturing projects. EVM will also enable PMs to apply the most appropriate forecasting methods which will eventually lead to even better results. Nevertheless, appropriate training, and organizational support is required to reach these objectives.

Furthermore, it can be concluded that the EVM methodology definitely helps project managers control manufacturing projects by providing accurate forecasts and early warning signals. All necessary information to implement this methodology is available in most manufacturing projects. This information just has to be employed to integrate both schedule

and costs in one Work Breakdown Structure (WBS). Other requirements for using EVM are to have a clearly defined scope and to have the support of the organization which enables allocation of responsibilities.

6.1 Suggestions

While processing the data needed to evaluate the projects, some key insights were obtained which are useful for further implementation of the EVM methodology on manufacturing projects.

I. To join a tender, an estimate of the budget and schedule has to be set up. Therefore, calculations have to be made concerning the cost of the different activities which are scheduled.

II. To make the implementation of EVM a complete success, responsibilities should be clearly assigned to the members of the project team / organization.

III. 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.

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Appendix A

Received Data from MCIS SAFETY GALSS Company Regarding “Suzuki Swift”

Appendix B

Malaysia Calendar from Year 2008 to Year 2012