CHAPTER 1 :INTRODUCTION

1.1 INTRODUCTION

Construction is a complex, creative, and important activity that transforms physical resources into useful structures. The basic resources involved are raw materials, machinery, manpower, finance, and technology. Besides, construction industry could be recognized also as one of oldest industries in the world. This can be seen through the famous ancient building structures like Pyramid of Egypt, Great Wall of China , and other wonders of the world (Nigel J.Smith , 2002) .

The Sudanese construction sector is characterized by many small and large projects and high labor intensity; it is also highly dependent on public regulations and public investments. The Sudanese construction industry also has a number of factories and material suppliers that provide building materials and specialist fittings including but not limited to, concrete, sand, cement, plasterboard, timber, electrical fittings, plumbing and heating fittings.

The construction sector is important to Sudan is economy and it accounted for 3.2% of the country's GDP in 2009 and grew by about 10% in 2010 in nominal terms, according to the Central Bank of Sudan. The sector employs 4 - 7% of the total population. The country has a large demand for construction works (Sal, 2010).

Construction is one of the largest sectors of the UK economy. It contributes almost £90 billion to the UK economy (or 6.7%) in value added, comprises over 280,000 businesses covering some 2.93 million jobs which is equivalent to about 10% of total UK employment.

In Sudan, The construction industry has played a very important role in the development of infrastructures and economy of the country. With increasing number of projects in areas of

industry, construction, service, etc., and the complexity of managing and executing projects, the project management knowledge became more and more important.

Nevertheless, construction field is an industry where construction projects involved several parties like clients / developers, architects, consultants, main-contractor, sub – contractor, suppliers, local authority and so on (Nigel J.Smith , 2002).therefore construction projects could be one of the most challenging industries . This is because construction projects should be completed by the contractor within the completion date established by the contract time without exceed the overall cost of projects and ensure that the quality is achieved which all is written in contract document.

It is obviously that there are 3 main objectives in managing construction projects, which are TIME, COST, and QUALITY. These 3 main objectives are important for those contractors who want to maximize their profit margin through their construction projects. In construction field, the practice of management tools and techniques plays an important role in order to manage the time, cost, and quality of the construction projects wisely.

Therefore, Time, cost and scope are project success factors, and they are commonly mentioned by many researchers. This study has been presented The Earned Value (EVM); it is a forward looking method to assist Project Managers (PM) with the task of making timely and appropriate decisions about cost outcome of their in-progress projects. Earned Value (EVM) is a project management Method that measures project progress in an objective manner, and provides an early warning of performance issues, if any. EVM Method measures project performance and progress by an integrated management of three most important elements in a project, namely cost, schedule and scope. (PMI, 2004).

1.2 PROBLEM STATEMENT

One of the problems of the construction industry in Sudan is the lacking of use of adequate methods of analyzing and controlling the performance of construction projects.

Analyzing and controlling the performance of construction projects plays important role in managing the success of a projects. Because of the uncertain nature of the construction projects, it is not always possible to complete projects to the exact project scope, time a, cost and quality as originally had planned.

1.3 AIMS OF THE STUDY

The aim of the study is to investigate the applicability of Earned Value techniques in analyzing and controlling the performance of construction projects in Sudan .(Besides, this study also focuses on project management tools and techniques used in managing construction projects in Sudan.)

1.4 OBJECTIVES

1. To list especially the element of a successful construction projects.
2. To gauge the level of understanding of using Earned Value technique (EV) in construction project in Sudan.
3. To list especially the frequency of using Earned Value technique (EV) in construction project in Sudan.
4. To highlight the importance of using project management in analyzing and controlling the performance of construction projects in Sudan.

1.5 Research Hypothesis

According to Leedy (2000), after defining the problem of the research, the next step is to formulate the hypotheses that could answer the proposed problem and guide the next steps of the research. To answer the central question the following hypotheses are formulated:

H1 - company in Sudan has a perception about the importance of using the EVM for project performance.

H2 – EVM Applied in construction industry in Sudan.

H3 - there is a good Understanding of EVM among engineers in Construction industry in Sudan.

H4 - Management tools is a best Description of Earned Value Management.

H5 - primavera p6 is Valuable Software used in Implementation Of EVM in construction project in Sudan.

1.6 Methodology

The study has been carried out by two methods and these methods will be used to obtain date namely:-

Primary Date – has been obtained from external sources as books, journals, internet, interviews with lecturers and Magazines

Secondary Date – has been collected through completed projects, personal questionnaire and interviews especially from contractor in both government and private sectors.

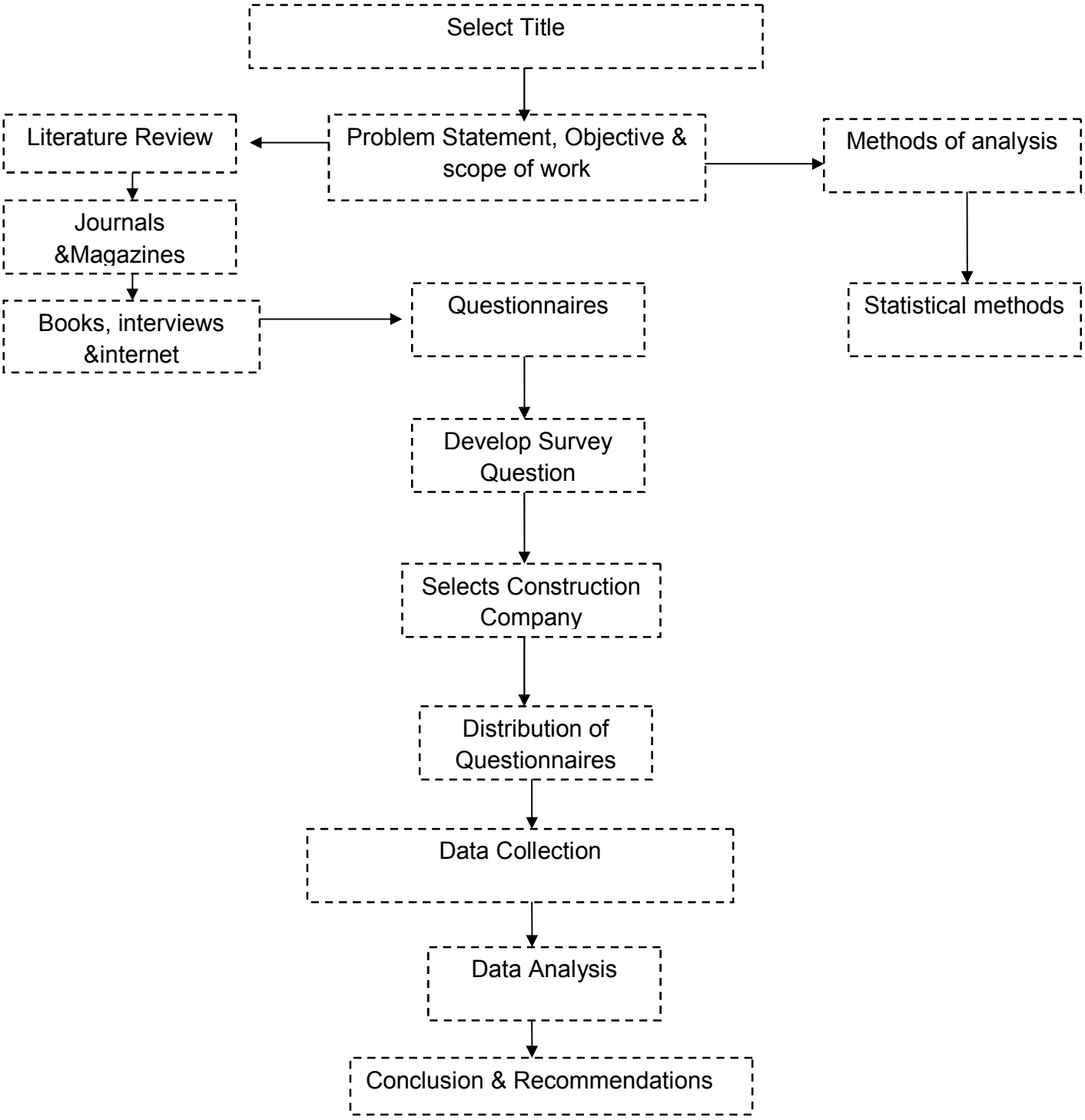


Figure 1.1 shows the flowchart and framework study of the research

CHAPTER 2: LITERATURE REVIEW

2.1 INTRODUCTION

This chapter basically has been discussed the literature review the history and general concept of The Earned Value Management (EVM) and its functions. It has been also review the use of The Earned Value Management (EVM) in construction industry and in the completion of a project. In addition to that, this chapter has been described the factors that were considered developing the Earned Value (EV).

2.2 GENERAL OVERVIEW

The construction industry is a conglomeration of diverse field and participants that have been loosely lumped together as a sector of the economy. The construction industry plays a central role in national welfare, including the development of residential housing, office buildings and industrial plants, and the restoration of the nation's infrastructure and other public facilities. The importance of the construction industry lies in the function of its product which provides the foundation for industrial production, and its impacts on the national economy cannot be measured by the value of its output of the number of persons employed in its activities alone.

In general, when talking about the pitfalls of the construction industry in all words especially Sudan, the main concern is on quality and the ability of the contractor to complete on time, within the budget and with the specified quality. however , that is not all , because according to Zaini (2004) issues such as good design , proper town planning , choice of contract procurement , selection of contractor , availability of labours and good management practice are the contributing factors to the fall and rise of the construction industry in all contraries .

The statement stated above shows that the important of construction project management in achieving a successful project. There are functions of management which are:

- Planning (choosing goal)
- Controlling (monitor &measure)
- Organizing (working together)
- Leading (coordinate)

Besides, there are 3 main objectives in managing construction projects which are time, cost and quality. “Primary objectives are usually measured in terms of time, cost and quality, and their inter-relationship, Nigel J.Smith (2002) However, it is difficult for a contractor to meet the all 3 main objective successfully in construction project at the same time “It may be possible to meet one or two of the primary objectives and Nigel J.Smith (2002) in his research mentioned that it is impossible to meeting all three 3 main objectives in construction industry.

Figure: 2.1. Below shows the main objectives in construction project which are time, cost, and quality:

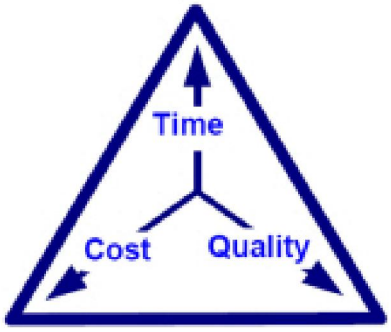


Figure 2.1 main objectives of construction management

Hence, that is a need for a proper planning and scheduling in construction industry in order to get the project to be complete on time, within the budget and with the specified quality. However, the effective use of scheduling techniques requires control. To simply plan a project is not enough: the plan schedule must serve as a guidance document. In order for plan to be an effective guidance document, the plan must incorporate any limitations that may arise during the construction operations.

Earned Value Management (EVM) is one of the several analytical methods and graphical techniques for planning, schedules, linear balance chart and the critical path method (CPM) which normally deals with the software programs.

2.3 EVM- IN THE CONSTRUCTION SECTOR

In the development of any country, the construction industry plays vital roles in transforming the aspirations and the needs of its people into reality by implementing various physical structures (Ahmed, 2002). A construction project is commonly acknowledged as successful when it is completed on time, within budget, and in accordance with specifications and to stakeholder's satisfaction.

The application of EVM principles varies among industries, practitioners, and organizations. Each new project controls method should be optimized for the organization to gain the highest benefit from the cost spent. In the building construction industry, EVM principles are commonly used to determine contractors' monthly payments. In large projects a "cost loaded schedule" is used to forecast the monthly payments. The field progress is typically reported by describing activities and comparing the budget spend plan to the actual costs spent.EVM has become the most commonly used method of project performance measurement (PMI, 2008). Practitioners also refer to EVM concept as Earned value project management, Earned value system or Earned value analysis (EVA), but there is no much difference between these terminologies. EVM offers the project manager a tool

to timely evaluate the general health of a project along the life of the project. Particularly, EVM has been used to:

- Estimate cost and time to complete.
- Identify cost and schedule impacts of known problems.
- Accurately portray the cost status of a project.
- Trace problems to their sources.
- Portray the schedule status of a project.
- Provide timely information on projects.
- Identify problem areas not previously recognized.

2.4 TRADITIONAL PROJECT MANAGEMENT

In traditional project management the most important measurements are today's date and the actual amount of money spent on the project. The amount of money spent is compared to the budgeted cost for the reached date to measure the performance of the project. The actual performance is never measured. ANSI/EIA-748-A-1998, Arlington, Electronic Industries Alliance.

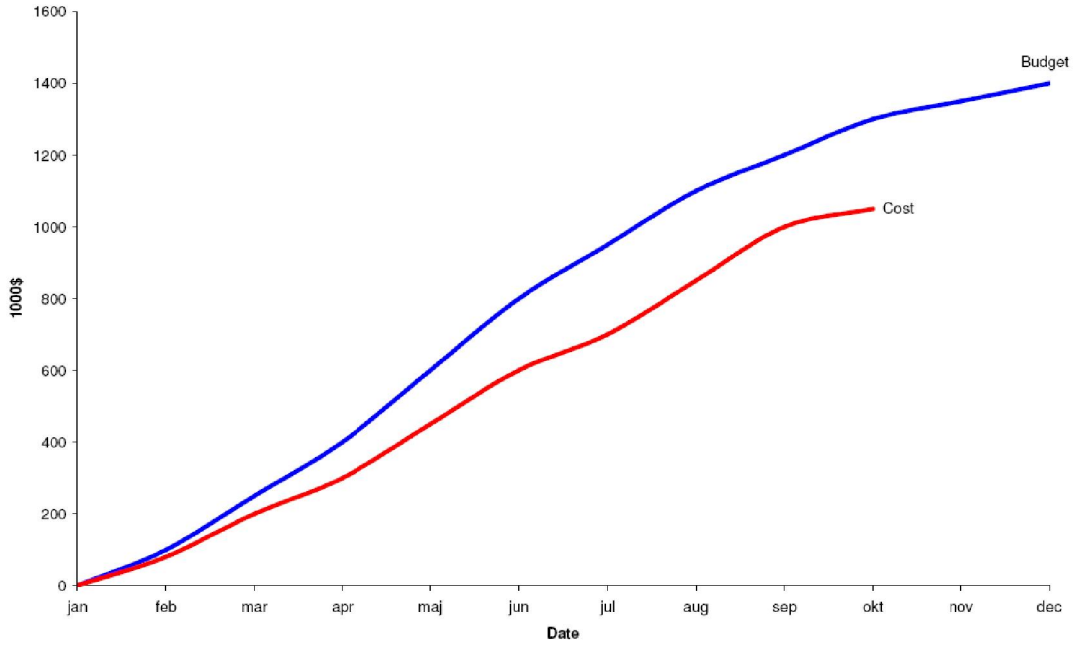


Figure 2.2 Traditional Project Management Performances

Thinking about it, the data displayed in Figure 2.2 above does not say anything about the projects performance. To determine the true performance of the project one would have to look at the schedule result in the same format as the cost. Often the financial people breaks out the cost by function while scheduling people develop their displays from tasks in the Work Breakdown Structure (WBS).

2.5 EARNED VALUE MANAGEMENT (EVM)

Earned Value Management is a method used for handling of medium and large scaled projects. The details about EVM and the differences between EVM and traditional project management systems will be displayed in this section.

2.5.1 HISTORY OF EARNED VALUE MANAGEMENT (EVM)

Fleming and Koppelman (2005) mentioned in their book that 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.

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".

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).

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 judgment. 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.

In 1995 the National Defence 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. The restriction of EVM to DoD was removed and in 1998 the new technique became accepted as an ANSI/EIA document. Fleming and Koppelman (2005).

The EVM concept presented in these requirements is a sound management approach, that once incorporated on any type of program, whether research and development, construction, production, etc. provides all levels of management with early visibility into cost and schedule problems. Earned value management is now used on programs world-wide. Primary users include the United States, Europe, England, Canada, Australia, China, and Japan. It is a requirement of many U.S. Government agencies, including the Department of Defence (DoD), the National Aeronautics and Space Administration (NASA), the Department of Energy (DOE), the Intelligence Community, the Department of Homeland Security (DHS), the Federal Aviation Administration (FAA) and Department of Transportation (DOT), Health and Human Services (HHS), and others.

2.5.2 DEFINING EARNED VALUE MANAGEMENT

The Project Management Institute's definition of EVM is a method for integrating scope, schedule, and resources, and for measuring project performance. It compares the amount of work that was planned with what was actually earned with what was actually spent to determine if cost and schedule performance are as planned" (PMI, 2004) Earned Value Management (EVM) methodology is commonly defined as a management technique that relates resource planning and usage to schedules and to technical performance requirement more specifically, EVM can be said to bring cost and schedule variance analysis together to provide managers with a more accurate status of a project.

The basic concept of EVMS is more than a unique project management process or technique. It is an umbrella term for 32 guidelines that define a set of requirements that a contractor's management system must meet. The objectives of an EVMS are to:

- Relate time phased budgets to specific contract tasks and/or statements of work.
- Provide the basis to capture work progress assessments against the baseline plan.
- Relate technical, schedule, and cost performance.
- Provide valid, timely, and auditable data/information for proactive management action.
- Supply managers with a practical level of summarization for effective decision making.

2.5.3 CONCEPT OF EARNED VALUE MANAGEMENT

The main concept of Earned Value Management is to add the amount of work actually performed when measuring the project. The work actual performed provide the managers with more accurate information on the status of the project which leads to better forecasting and corrective actions. Christensen David S (1998).

2.5.3.1 MAIN EVM PARAMETERS

For implementing EVM/ES, a clear project scope is required together with a project budget and a project schedule. The project budget must reflect all planned costs incurred by the activities of which the project consists. The

budget is then distributed over all the activities in the project schedule. By cumulating these budgeted costs over time a first measure is obtained, the **Planned Value (PV).** The PV is the value that was planned to have been spent according to the original plan at a certain point in time. The Budget at Completion (BAC) is the total cost of the project as it was budgeted at the start of the project and is equal to the planned value at the end of the project (see figure 2.3)

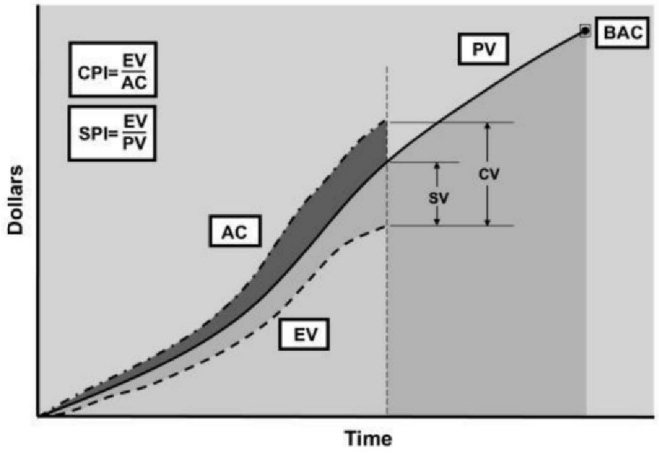


Figure 2.3: Earned Value concept

During project execution two more measures are obtained so that a comparison can be made between reality and plan. Earned Value (EV) is the monetary value of the activities that are finished at a certain point in time. Another way of putting it, is that the EV equals the BAC multiplied by the percentage completed (PC) at a certain point in time (EV = PC * BAC).

The other measure is the Actual Cost (AC). This represents the real costs for all work that is executed at a certain point in time. As can be seen in figure 2.3 these measures are also cumulatively represented over time.

Summarized, EVM makes use of three key parameters:

- Planned Value (PV) = (BCWS) Budgeted Cost of Work Scheduled
- Earned Value (EV) = (BCWP) Budgeted Cost of Work Performed
- Actual Cost (AC) = (ACWP) Actual Cost of Work Performed

2.5.3.2 PERFORMANCE MEASURES

When the three key parameters are properly recorded along the project life, PMs are able to calculate two types of performance measures. The first types of performance measures are Variances which represent the difference between the current status of the project and its baseline, in monetary terms. The Cost Variance (CV) is used to follow up the project budget. A negative (positive) value points out that more (less) has been spent for the execute activities than what was originally planned. The Schedule Variance (SV) is an indicator that provides PMs with a value that represents whether the project is on schedule or not. A negative (positive) value means that the project is behind (ahead of) schedule. The variances are also shown in figure 2.3

The **variances** can be derived as follows:

- Cost Variance: CV = EV – AC
- Schedule Variance: SV = EV – PV

Another type of performance measures are indices, also calculated from the three key parameters of EVM. The indices are again used to display how well the project is performing, now relatively in comparison with the baseline. Again two types of indices can be distinguished.

The first type of index is the **Cost Performance Index (CPI),** which expresses the cost efficiency of the executed work. A CPI of less (more) than one means that the project is currently running over (under) budget. The second index is the **Schedule Performance Index (SPI).** The SPI shows whether the project is performing on schedule or not. A SPI of more (less) than one means that the project is ahead of (behind) plan.

The indices can be derived as follows:

- Cost Performance Index: CPI = EV / AC
- Schedule Performance Index: SPI = EV / PV

It is clear that the variances and indices are interrelated. Still it is useful to calculate both performance measures. The variances can give a snapshot of where the project is today (expressed in monetary value) while the indices are rather used to represent the evolution in performance of the project. This is of significant importance to make forecasts about the future of the project.

It is helpful to see an example of Earned Value to make things even clearer. The project in Figure 2.4 bellows extent over ten months (see Figure 2.4) with a total budget of $1,000,000. Each month has a budget of $100,000 and distinct milestones for each budgeted $100,000. Once a milestone is accomplished the project will earn $100,000. The budget is labeled the “Planned Value” which consists of two elements, the work scheduled and the budget for that work.

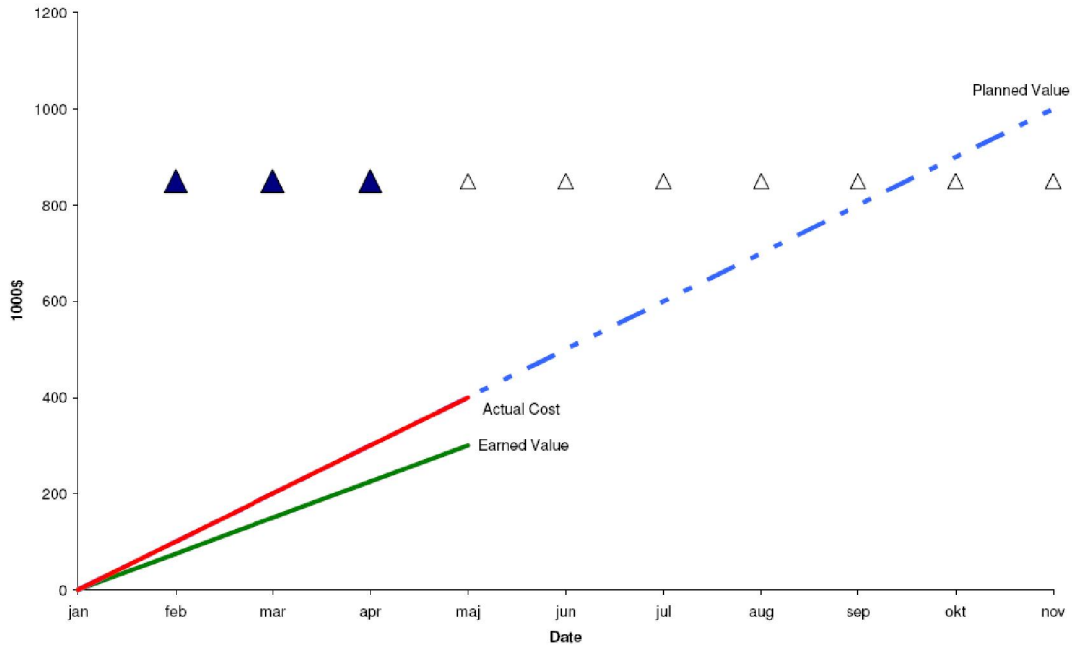


Figure: 2.4 Earned Value Example

After four months the project has spent the planned $400,000 and would by traditional project management be performing well. The Actual Cost is therefore $400,000. When also looking at the work performed, as in EVM, you notice that only three of the four milestones have been achieved and the Earned Value is only $300,000. One could immediately see that the project is running behind and have a negative Schedule Variance at $100,000 (Schedule Variance = Earned Value – Planned Value, see Figure 2.4). Also shown in Figure 2.4 is the Actual Cost, $400,000. The Actual Cost is greater than the Earned Value which tells us that the project is not cost effective. The Cost Variance is defined as the Earned Value – Actual Cost (see Figure 2.4).

Voices have been raised against the Earned Value method, saying it is one of the larger cost drivers in a project. Fleming and Koppelman (2005) the important question is why should one use Earned Value? Christensen David S (1998) mentioned in his researches that are several benefits with employing Earned Value and among others:

- It provides reliable data.
- It provides early warning signals.
- It makes reliable predictions possible etcetera.

The core basics of Earned Value is the measurement of actual work performed compared to a baseline plan. Perhaps the most advantageous thing about Earned Value is the, through measurement of performance, provided possibility of reliable prediction of the project. Some people would say that this measurement requires too much effort compared to the advantageous with the system.

The three-dimensional way of looking at the project gives us further possibilities to evaluate the project. Earlier mentioned above about the Cost Variance and the Schedule Variance see Figure 2.5. Those two measurements could be used in a slightly different way. Firstly is Schedule Performance Index, SPI, secondly is Cost Performance Index, CPI. The Schedule Performance Index is calculated as the Earned Value divided with the Planned Value. The Cost Performance Index is calculated as the Earned Value divided with the Actual Cost. If looking at a similar example as the one above (PV is $400,000 and EV is $300,000 but AC is $500,000 instead of $400,000) that gives us an SPI of 0.75 (EV $300,000 / PV $400,000 = SPI 0.75) and a CPI of 0.6 (EV $300,000 / AC $500,000 = CPI 0.6).

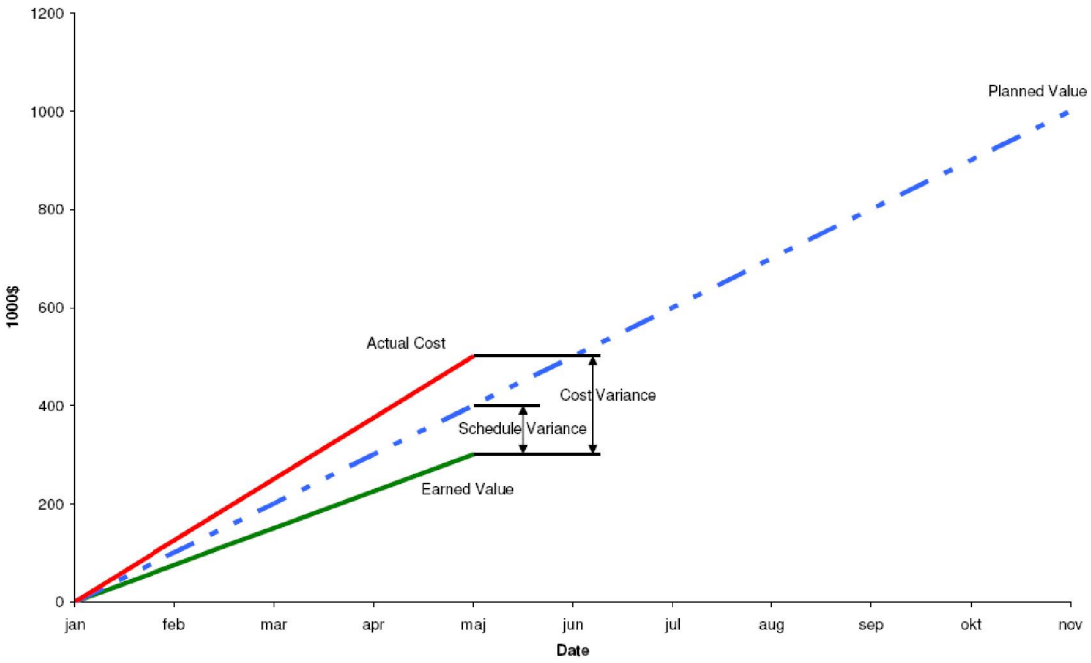


Figure: 2.5 Earned Value Basics

The SPI and CPI can then be used to predict the rest of the project. With an **SPI of only 0.75** you could say that for every dollar of physical work this project had planned to achieve only $0.75 was accomplished. With an original budget of $1,000,000 this project will take $1,333,333 to finish. That is more than three months of extra work. Note that the schedule is measured in money but can be directly transformed to man hours or time in Gant-chart. This is at first sight at bit confusing but will after a while feel perfectly naturally. The **CPI in our example is 0.6** which in the same way as the SPI can tell us something about the future of the project. For every dollar spent we have only got a value of $0.6 which gives us the final cost of $1,666.666 for the project. The table bellow shows the important terminology and figures which are make correct decisions about the project can be easily. It is not likely that the estimated total cost of the project is possible to improve, unless you change the scope. However the duration of the project can perhaps be improved by adding extra funds.

2.5.4 BASELINE - SCOPE THE PROJECT

The baseline or the Planned Value is the guiding value for the project. Therefore it is very important to carefully develop the baseline. Actually you cannot use the Earned Value technique if there is not any Planned Value. Knowing what is included and, perhaps more important, what is not included is essential for managing of the project.(A Guide to the Project Management Body of Knowledge (2005) The generated Performance Measurement Baseline (PMB) is the total time-phased budget for the project. It is important to update this baseline when the scope of the project is changed. Otherwise the measurement will take place against an invalid reference. (ANSI/EIA-748-A-1998).

A useful tool for scooping the project is the Work Breakdown Structure (WBS). A WBS can be developed in different kind of ways and take different shapes; the important thing is that it helps grasping the scope.(Wenell, Torbjörn (2004) The type of WBS discussed further will be the one described in PMBOK.(A Guide to the Project Management Body of Knowledge (2005)).

A WBS looks like an organizational chart but it is important to realize that it is not. However the WBS is for the project leader what the organizational chart is for the company executive. (Fleming and Koppelman (2005) The WBS represents the project work to be done and the deliverables of the project. The WBS is separated into different products or work in several levels. Either one chose to do a product or a work oriented WBS (se Figure 2.6).(Wenell, Torbjörn (2004 A success factor is to let the WBS reflect the way the manager actually plans to manage the project.(Fleming and Koppelman (2005).

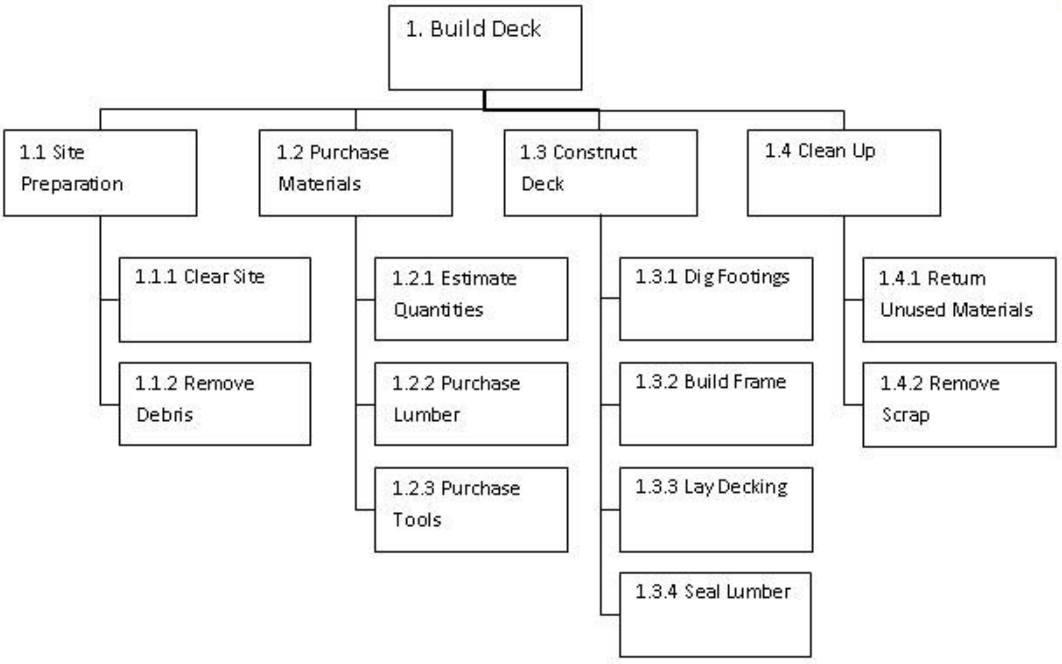


Figure: 2.6 Work oriented WBS

At the top levels the product or work is described very briefly, called planning packages. It is not uncommon that the owner of the project specifies the three top levels of the WBS. The lower levels are extended by the project leader to contain work, costs and schedule, the work packages. It is first at work package level that one can accurately estimate cost and schedule and it is also at this level the Earned Value is computed. (ANSI/EIA-748-A-1998).

In very large projects it can be hard to plan everything on work package level from the beginning. The manager then has to do a rolling planning bye and bye. (A Guide to the Project Management Body of Knowledge (2005) It is also

common that the WBS is reassessed from time to time when the knowledge gets wider or when requirements changes.(ANSI/EIA-748-A-1998) Each company must determine its own standard for the conversion of planning package into work packages.(ANSI/EIA-748-A-1998).

Different deliverables need different levels of breakdown to clearly define the work. More detailed breakdown gives better opportunities to control and manage the work. In the same time too detailed breakdown will inhibit the productivity and lead to ineffective work. It is of most importance for the project manager to keep the breakdown at a balanced level. (A Guide to the Project Management Body of Knowledge (2005).

For the breakdown of the WBS-element it takes that different subprojects and deliverables is split into its basic elements. Each element must be clearly defined and assigned to a specific unit taking the responsibility for the task. When work has been defined it is possible to assign the tasks to personnel through an Organization Breakdown Structure, OBS. The lowest level of the WBS is expanded with more details into a WBS-dictionary. This dictionary is the Statement of Work (SOW) for the project. Of course there are other techniques used than the WBS to scope the work. The important thing is naturally not which technique one chooses to use, but the result when grasping the project.

2.5.5 SCHEDULING

Independent of which management techniques are being used all projects has to schedule the work, so also the ones applying Earned Value. Perhaps the ones using Earned Value especially needs it. (Kondur Mohan (2007) - Larger projects may have multiple schedules correlated to each other with a formal scheduling system. But also the smallest project needs at least a project master schedule, PMS, containing the most important tasks to be performed. (Fleming and Koppelman (2005).

To implement Earned Value Management there are two basic needs. First, as earlier discussed, one must define the project and all the work which has to be done. Second, the work has to be put into a time frame so that performance can be measured against it.(Fleming and Koppelman (2005) The time based schedule together with the WBS is evidently the spinal column of the projects baseline.

The Earned Value Project Management implies that there is no other way to establish a time schedule except the Critical Path Method (CPM). (Fleming and Koppelman (2005) The Critical Path Method is a technique used for analyzing web plans. There are some different kinds of web planning methods although they are all very similar. The concept of them all is to display the tasks in the project in a web, showing the connections between the different tasks.(Project Management Body of Knowledge (2005)) The CPM and the dependencies between the tasks are then used to show the shortest possible duration of the project.

The difference between cost variance and schedule variance takes some extra attention except what has been told earlier. A negative cost variance is always a serious matter telling us that the project is not performing as planned. A negative schedule variance on the other hand does not have to be a big issue. The schedule variance only tells us how much of the planned work it has been accomplished. That could of course be a big problem if we for example have a tight schedule and an important deadline to keep. But it could also be the result of a late start, either on

some of the work packages or on the entire project. If the negative schedule variance is a consequence of some single work packages starting late, and those not being on the critical path, the variance in fact could be insignificant. (Fleming and Koppelman (2005) .

Most of the time schedule variance can also be compensated. In the best case it is enough to reorganize the schedule to get back on track. Otherwise one can add extra money to speed up the work. A negative cost variance is seldom to compensate for. The basic reason for this difference in cost and schedule variance is that the scope is almost never dependent on what date the work is being done.

2.5.6 RE- BASE LINING

As it described above the project baseline is a schedule consisting of all the activities of the project. As certain activities are difficult to forecast at the project start and depend heavily on other activities, the baseline is often established with a lot of uncertainty. During project execution, it might turn out that the original baseline becomes unrealistic as a basis for management control. This can be due to changes in scope, schedule, cost or a combination of these factors. To make the project manageable again, the project baseline can be changed. This is called re-base lining. An example is given in figure 2.7 and 2.8

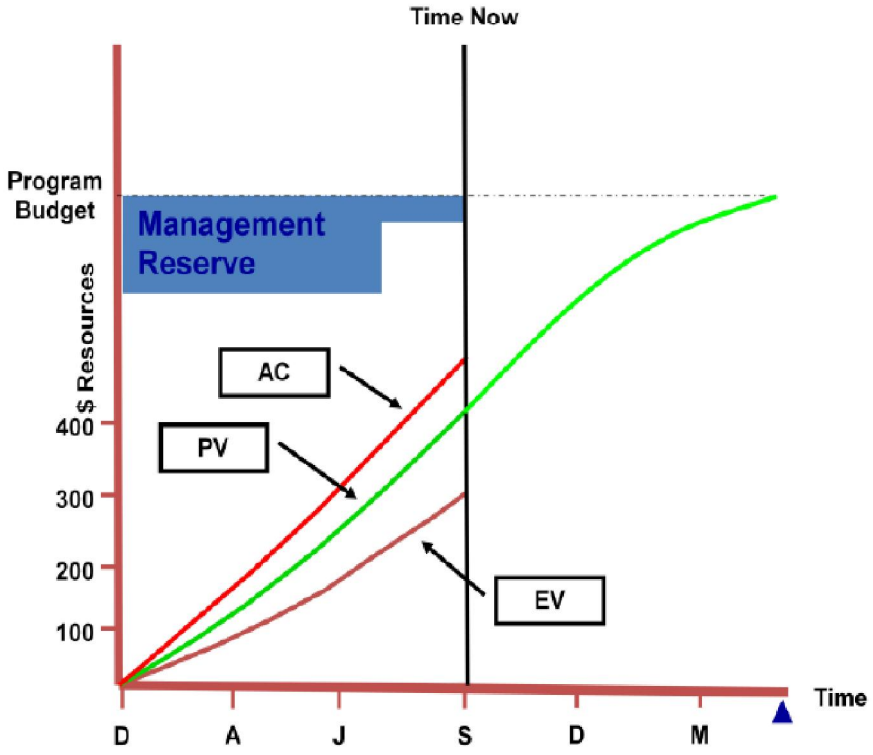


Figure 2.7: Project with current baseline

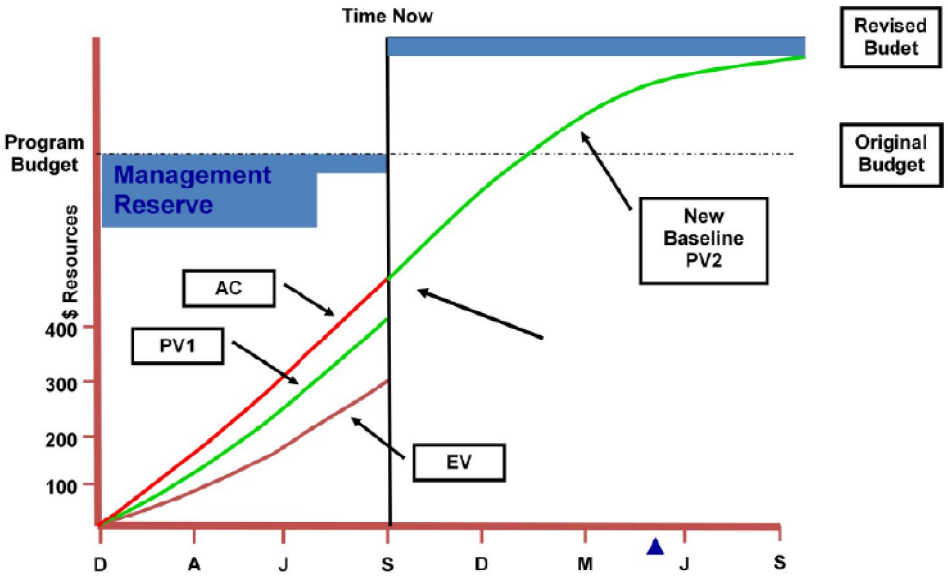


Figure 2.8: Project re-baselined

Starting from figure 2.7, it can first be seen that there is a persistent trend of the actual cost being higher than the planned value. This explains a cost overrun for the performed work and a budget revision is required. Second the earned value in September (time S) is a lot lower than the planned value at that time. By performing less work than planned the project will be behind schedule and the end date of the project should be revised. Figure 2.8 shows the re baselined schedule that continues on the Actual Cost curve (AC) of the project. Start dates, duration and budgeted cost of the different activities are adjusted to the new state of the project which results in a higher budget and longer duration of the project.

2.5.7 FORECASTING

The Earned Value Management is a very helpful tool when predicting the outcome of the project. To make accurate predictions, it is very important that the plan is of good quality. If the plan is not credible the same thing will be evident for the predictions. If the measurement of a project in progress shows a cost overrun or a schedule variance the manager has to take aggressive actions. Unfortunately managers often do not like or accept the final forecast results and choose not to take necessary action. If the managers did believe in the plan they created, they should also believe in the predictions given to them concerning their plan and statistic figures.

In traditional project management an Estimate at Completion (EAC) is calculated as the sum of Cumulated Actual Cost and a new Estimate to Complete (ETC). The new ETC is prepared by the project manager based on the experience from the project in progress. This gives a quite accurate image of the projects future and is probably the most reliable forecasting method. However, there is one disadvantage with this approach. The work to develop a new ETC takes time and is

most likely not in the scope of the project. That is why the use of Earned Value Managements easy forecasting is so favourable. (Fleming and Koppelman (2005) - {8}. When using any of the three formulas below, one uses the EV, AC and BAC at the same level as the forecast is made at. For example, if one would like to forecast the entire project, the EV, AC and BAC for the entire project are used.

2.5.7.1 Mathematical EAC – Best Case Scenario

This forecasting formula is very simple and easy to understand. The EAC is calculated as the Actual Cost, plus the Budget at Completion, less the Earned Value. That simply means the Actual Cost today, plus the rest of the budgeted work.

Estimate atCompletion = ActualCost + (Budget atCompletion − EarnedValue)

Formula 1

This formula can be looked upon as a best case scenario. The project has incurred an overrun which not likely will go away. Assuming that the rest of the project will follow the plan, this gives the accurate estimate. Almost never the project will under run in the future and compensate the early overrun. (Fleming and Koppelman (2005)

2.5.7.2 Cumulative Cost Performance Index – Most Likely

This Formula is based on the experience of the project given by the CPI (se 2.5.3.2). When calculating the EAC one assumes that the remaining work will be done with the same efficiency as the performed work.

Estimate atCompletion = ActualCost + ((Budget atCompletion - EarnedValue)/ Cost Performance Index)

Formula 2

To smoothen out the varieties of the project performance the used CPI is the cumulative to date. This will not give the project team a perfect picture of their recent work, but it will provide an accurate long-term forecasting. The Formula 5 can be simplified as follows.

Estimate atCompletion = Budget atCompletion / Cost Performance Index

Formula 3

This method is often referred to as the "most likely" outcome of the project. Studies of several projects show that the CPI at 20% completion will be stable for the rest of the project.(Christensen and Heise (1993)).

2.5.7.3 Cumulative CPI times SPI – Worst Case Scenario

As the heading implies this method uses both the CPI and the SPI.

*Estimate atCompletion = ActualCost +((Budget atCompletion - EarnedValue)/(Cost Performance Index * Schedule Performance Index)*

Formula 4

Since it is very common that project team strive to be on track with the schedule, this formula is appropriate. If a project is behind schedule, it will take extra effort and probably also money to get it on track again. By multiplying the CPI and SPI one gets a good performance factor. If both the SPI and CPI are less than one (1), the outcome will be worse than in ordinary cumulative CPI forecasting. This is perfectly natural,

since it will take extra funds to compensate the schedule slippage. On the other hand, if one of CPI or SPI is above one (1), the performance factor indicates that the better of the two compensates the worse.

2.5.7.4 PREDICTING COMPLETION DATE

Formula 1 and **Formula 3** can also be used to predict the final completion dates of the project. Instead of using CPI one uses SPI to get the forecast in aspect of schedule. There is no statistic data provided showing this to be a valid forecasting method. Actually some would say this is a to simplified way of predicting the completion date and that it takes careful Critical Path work to do this properly. The SPI only indicates the status of the project based on time and is not sufficient to forecast the completion date itself. Analyzing the Critical Path combined with SPI calculation is the recommended method. (Fleming and Koppelman (2005) .

CHAPTER 3: RESEARCH METHODOLOGY

3.1 INTRODUCTION

This chapter includes the methodology which needed to be adopted to conduct this study. Methodology is a way on how to achieve or fulfill an objective which is proposed. the methodology of this study has been started once the title for the project has been selected then the planning stage which consists of the problem related to study, objectives and scope of work has been determined .when all these agenda has been stated and settled, the next stage of the study has been the date collection where the information on the study has been gathered. Finally the last part of the study has been analyzed the date collected and finally conclude on the findings of the study.

3.2 DATA COLLECTION

The main purpose of this study is to identify the level of Applicability of Earned Value Technique in construction industry in Sudan and also to identify the level of understanding of contractors and consultants about Earned Value Management.

In order to achieve the objectives of the study, primary information and secondary information has been collected. The primary information is the interviews with representative of contractors and consultants in the construction industry. Moreover, questionnaire survey has been conducted to receive feedback from the contractors and consultants in the construction industry. This information has been gathered to form primary information.

On the other hand, for secondary information, the information has been gathered using literature review on the research topic an problems faced by the contractors. It is obtained from

certain websites, books, journals, and papers as well as some other published research works, through literature, a clearer framework of this research has been formed.

3.2.1 PRIMARY DATA

Primary data is the data has been obtained from the reading materials and literature references like journals, text books, internet articles, printing materials published by government or privet sector, magazines and research report. The purpose of the secondary data is to enhance the understanding of the theory regarding the construction management knowledge especially in Earned Value Techniques. It is also give an overall view of the research statement and helps the researcher to meet the objectives highlighted above.

3.2.2 SECONDARY DATA

3.2.2.1 INTERVIEW

The outcomes have been further strengthened by interviews conducted with experienced personnel from the contractors and consultants (organization to collect the information and perspectives regarding the aspects in the objectives of the research). The procedure from the interviews is presented in the subtopic later.

3.2.2.2 QUESTIONNAIRE

A questionnaire survey has been carried out to gather information from contractors and consultants who are involve in the construction industry in Sudan. The purpose of this survey is to obtain contractors and consultant's opinion and understanding from the experienced respondents regarding to the research topic.

3.3 RESARCH SAMPLE

Construction companies (governmental and private) in Khartoum state were selected for investigation due to the state's position as the center of construction firms in Sudan, as well as for reasons of practicality and convenience perceived by the researcher.

This research attempts to answer the following question:

IS There a lacking of using adequate methods (Earned value management (EVM)))of analyzing and controlling the performance of construction projects in Sudan ?

According to Leedy (2000) , after defining the problem of the resarch , the next step is to formulate the hypotheses that could answer the proposed problem and guide the next steps of the research. To answer the central question the following hypotheses are formulated:

- **H1 - company in Sudan has a perception about the importance of using the EVM for project performance.**
- **H2 - It is understood that EVM plays important roles in improving the performance of construction industry in Sudan**
- **H3 - there is a good Understanding of EVM among engineers in Construction industry in Sudan.**
- **H4 - Management tools is a best Description of Earned Value Management.**
- **H5 - primavera p6 is Valuable Software used in Implementation of EVM in construction project in Sudan.**

3.4 QUESTIONNAIRE DEVELOPMENT

The purpose of this survey is to obtain contractors and consultant's opinion and understanding from the experienced respondents regarding to the research topic. The questionnaire will categorized as below:

1. Information of respondents.
2. General information about Earned Value Techniques in construction industry.
3. Purposes and methods of Earned Value Techniques in construction industry.
4. Weaknesses / mistakes/ problems.

Some of the questions in the questionnaire need to provide the level of agreement from the respondents and its understanding according to the ordinal scale numbering from 1 to 5 the respondents need to make a choice from one of the ordinance scale according to the understanding and acceptance of the respondents.

The questionnaire is based on Likert's scale of ordinal measures of agreement towards each statement as shown below:

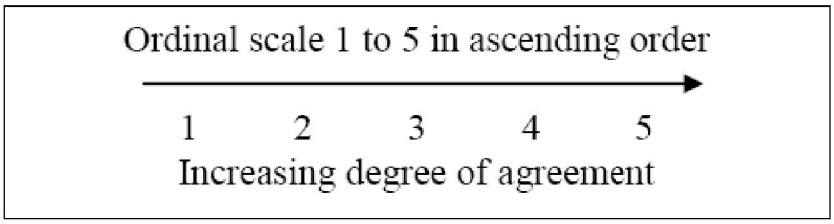


Figure 3.1 : Likert's scale of ordinal measure

Each scale represents the following rating:

Table 3.1 Level of agreement /understanding

Ordinal scale	Level of agreement / understanding
1	Very low degree of agreement / understanding
2	Low degree of agreement / understanding
3	Neutral in agreement / understanding
4	High degree of agreement / understanding
5	Very high degree of agreement / understanding

Table 3.2 Data Interpretation

Totally do not agree /understand	$1.00 \leq$ Mean Index < 1.50
Do not agree /understand	$1.50 \leq$ Mean Index < 2.50
Average agree /understand	$2.50 \leq$ Mean Index < 3.50
Agree /understand	$3.50 \leq$ Mean Index < 4.50
Totally Agree /understand	$4.50 \leq$ Mean Index ≤ 5.00

3.5 DATA ANALYSIS

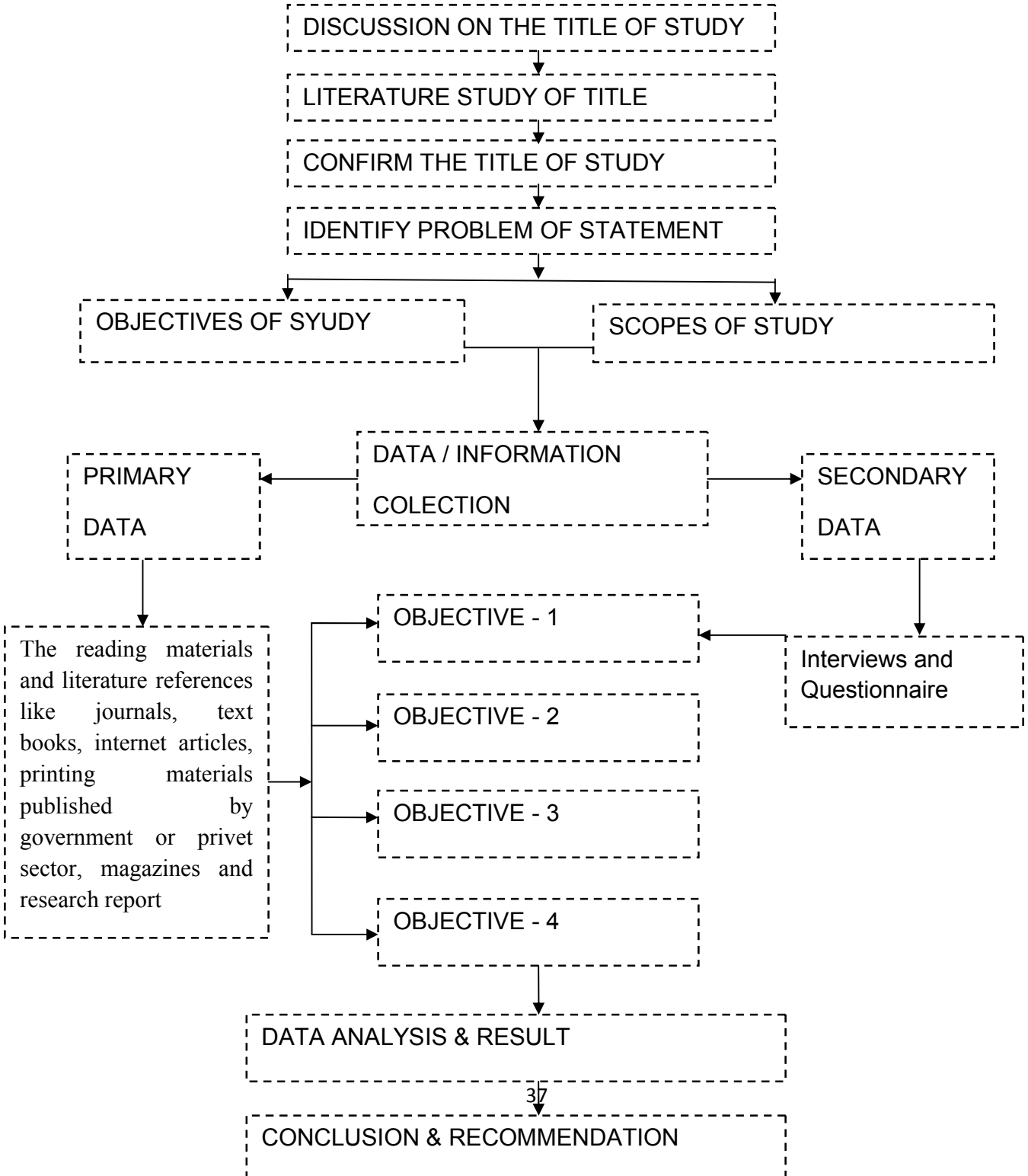
In this study, all the data collected through the conducted questionnaire and interview has been studied; rearranged and the statistical analysis was undertaken. Data was analyzed using the Statistical Package for Social Sciences (SPSS). The analysis has ranked the factors based on the frequency analysis and average index.

Frequency analysis normally made through the analysis of an arrangement of data that displays the number of times or frequency of occurrence of different values of a data set. It is used to show frequency of each variable or item outlined in the questionnaire form

The average index analysis, on the other hand, is used to group or classify the factors into ranking system. In other word, this analysis will be able to indicate which factors are the most important ones. The formula used is as follows:

Average Index = Sum (a X), where X= n/N
a= constant expressing the weight given to each response (1 to 5)
N= total of response
n = Frequency of the response

3.6 RESARCH METHODOLOGY FLOW CHART



CHAPTER 4: DATA ANALYSIS AND RESULT

4.1 INTRODUCTION

This chapter presents the research analysis and discussions. Based on the questionnaire survey done earlier, the Primary data and secondary data are collected through the literature review and questionnaires. The data obtained from questionnaires are analyzed with Statistical Package for the Social Science (SPSS). This analysis has ranked the factors based on the frequency analysis and average index. The data are converted into more useful and informative format and the results have been presented in tables, graphs and charts form. The first section (A) explains the respondent's demographic profile. The next two (B and C) sections displayed the research findings on the applicability of Earned Value.

4.2 Data Analysis and Results

On 9th December 2014 a total of 50 copies of questionnaires were sent out to targeted respondents who are working in construction industry. The targeted group includes contractors, consultants and developers .Altogether, a total number of 44 copies were collected from the respondents, and this means the return rate is 88 %. All the respondents are working in construction industry.

Table 4.1 Description of Questionnaires Received

Number Of Questionnaire Sent	50 - Copies
Number Of Questionnaire Replied	44 - Copies
Number Of Invalid Questionnaire (respondent from different profession)	0 - Copies
Response Rate	88 %

. This chapter starts with the profile of the respondents such as their organization, their job position and so on. Then it has been moved on to the main core of the questionnaire.

4.3 Respondents profile

The profile of respondents who participated in the questionnaires shows that majority are the top management of the company. the positions held were managing director , manager and engineer .this shows and proves that the data gained from the purpose of this analysis is deemed to be strong and appropriate , as they comes from the top management of most of the organizations .

4.3.1 Respondent's Organization sector

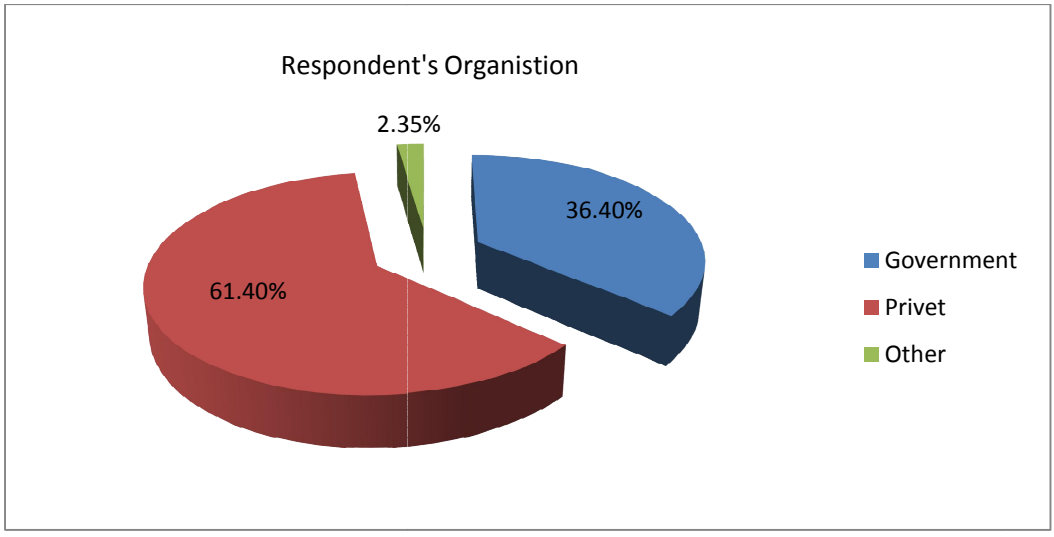


Figure 4.1: Respondent's Organization sector

Table 4.2: Respondent's Organization sector

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Government	16	36.4	36.4	36.4
	Private	27	61.4	61.4	97.7
	Other	1	2.3	2.3	100.0
	Total	**44**	**100.0**	**100.0**	

Table 4.2 and Figure 4.1 show the frequency analysis of the respondent according to the sector of the organization. The three main organization sector involved in this study are government sector, privet sector and other sector. Form the analysis, privet sector takes the biggest share of the study with a total 27 respondents coming from privet sector.

4.3.2 Respondent's Working Organization

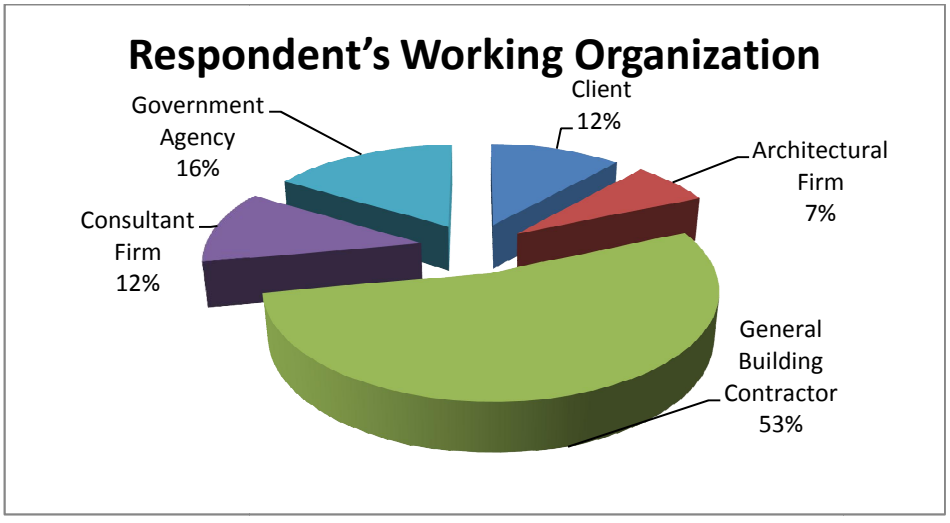


Figure 4.2: Respondent's Working Organization

Table 4.3: Respondent's Working Organization

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Developer/Client	5	11.4	11.6	11.6
	Architectural Firm	3	6.8	7.0	18.6
	General Building Contractor	23	52.3	53.5	72.1
	Consultant Firm	5	11.4	11.6	83.7
	Government Agency	7	15.9	16.3	100.0
	Total	**43**	**97.7**	**100.0**	
Missing	System	1	2.3		
	Total	**44**	**100.0**		

From Figure 4.2 and Table 4.3 above, shows the frequency analysis of respondent according to their organization. The five main organization involved in this study is developer, contractor, Architectural Firm, Government Agency and consultant. Based on the survey done, Figure 4.2 and Table 4.3 above shows 52.3 % of the respondents are represents contractors .15.9% shows that the respondents are represent Government Agency. The survey also shows that 11.6% both shared by the reparative of developers and consultants. Hence, with the higher parentage shown by respondents represent contractor, it may be concluded here that that the data gained are strong enough for the purpose of this study.

4.3.3 Respondent's job position

The objective is to figure out types of respondent's working position in their companies. Based on the questionnaire, the result obtained is shown as Figure 4.3 and table 4.4 from the figure and the tables below, 22 respondents, which cover a percentage 50 % are from civil engineer. Beside, the percentage of respondent working as Quantity surveyor and architectures are nearly same which are 5% and 2% respectively. Project manager poison comes in second place after civil engineers. The least response was from Architecture which covers a 2% of total respondents.

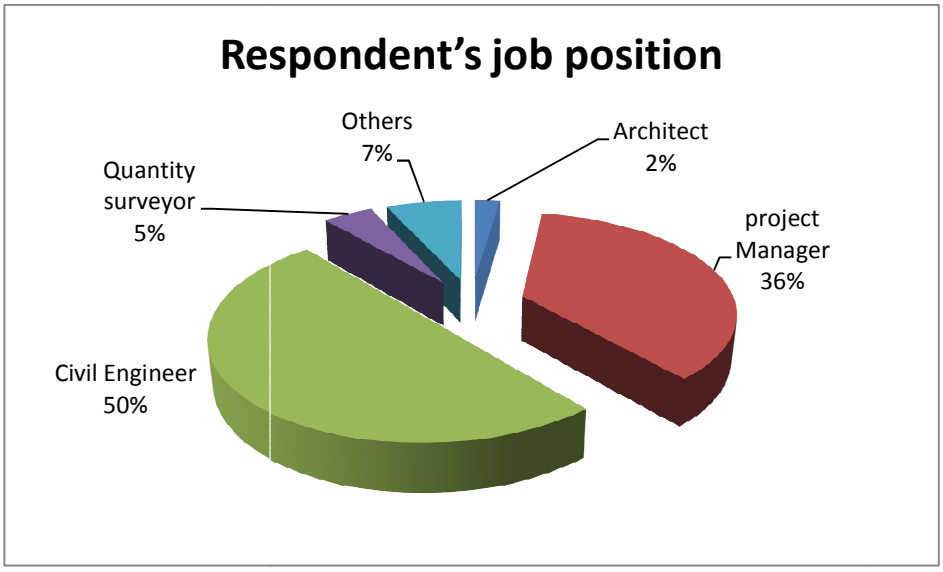


Figure 4.3: Respondent's job position

Table 4.4: Respondent's job position

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Architect	1	2.3	2.3	2.3
	Project Manager	16	36.4	36.4	38.6
	Civil Engineer	22	50.0	50.0	88.6
	Quantity Surveyor	2	4.5	4.5	93.2
	Others	3	6.8	6.8	100.0
	Total	**44**	**100.0**	**100.0**	

4.4 Respondent's work Experience

The objective is to determine the respondent's working experience in their companies. based on the questionnaires, the results obtained are shown below as figure 4.4 and table 4.5 based on both bar chart and table respondent's working experience in between 1 to 5 years has achieved the highest percentage of 43.18% which cover 19 out of total 44 respondents, besides the percentage of respondent's working experience between 5 to 10 years is 40.91 %, which are 18 out of total 44 respondents. This groups that with 11 to 15 years and above 15 years of experience which contributed 6.82% and 9.09% respectively. The least are from the groups with 11 to 15 years of experience which is 6.82%. This shows that the respondents are majorities from the senior and junior management level that have work experience below 10 years experience.

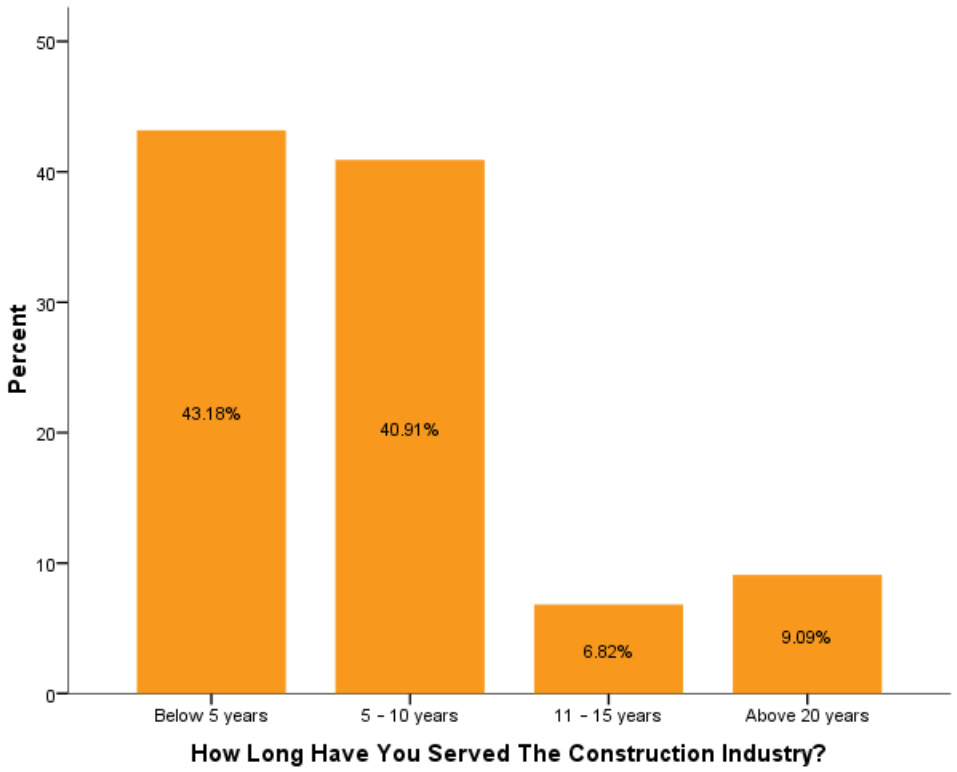


Figure 4.4: Respondent's Work Experience

Table 4.5: Respondent's Work Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Below 5 years	19	43.2	43.2	43.2
	5 – 10 years	18	40.9	40.9	84.1
	11 – 15 years	3	6.8	6.8	90.9
	Above 20 years	4	9.1	9.1	100.0
	Total	**44**	**100.0**	**100.0**	

Research findings on the applicability of Earned Value technique

The objective is to investigate the applicability of Earned Value technique in analyzing and controlling the performance of construction projects in Sudan.

4.4.1 Planning and Monitoring of projects

Based on the table 4.6 and figure 4.5 below shown, the majority of respondents believe that the project manager responsible of planning and monitoring projects which covers about 43.18 % of the total percentage of the respondents (this is shown in table 4.6). The lowest frequency with only 2.27% believes that the site engineer responsible of planning and monitoring the projects. Hence with the higher percentage by respondents believe that the responsibility of planning and monitoring the projects handled by the project manager engineer, it may be conclude here that the project manger plays main role in Analyzing and controlling the performance of construction projects and also plays important role in managing the success completion of a project and complete projects to the exact project scope, time a, cost and quality as originally had planned.

Table 4.6: Respondent's idea about who is planning in projects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Planner Engineer	12	27.3	27.3	27.3
	General Manager	12	27.3	27.3	54.5
	Project Manager	19	43.2	43.2	97.7
	Site Engineer	1	2.3	2.3	100.0
	Total	**44**	**100.0**	**100.0**	

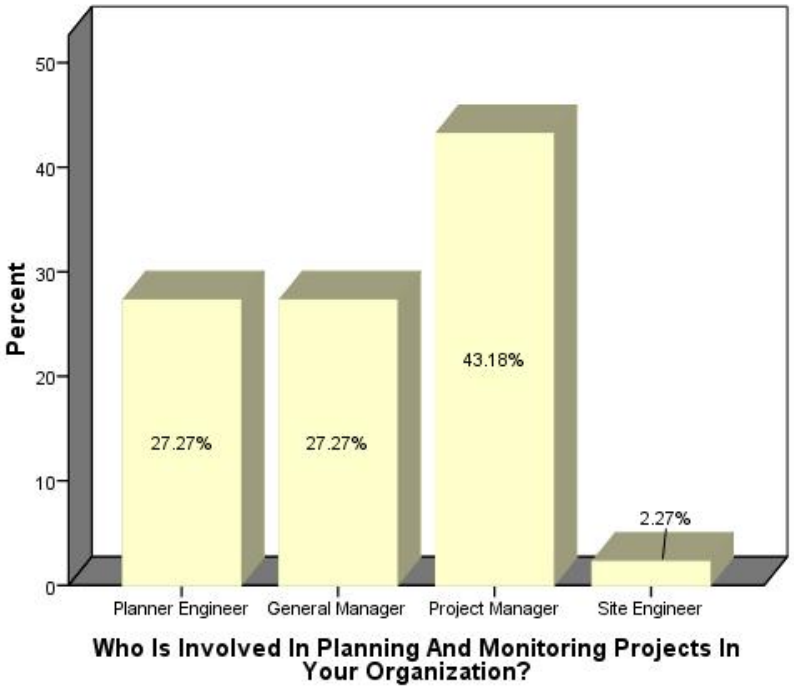


Figure 4.5: Who is involving in Monitoring Project

4.4.2 The Following Elements That Were Considered In Developing the Success of a Construction Projects in Sudan.

The objective is to determine the elements of success of a construction projects in Sudan. Base on the questionnaires, the result is shown as TABLE 4.7 below:

Descriptive Statistics:

Weighted Mean Level:

1. From 1.00 to 1.79 Strongly agree
2. From 1.80 to 2.59 Agree
3. From 2.60 to 3.39 Uncertain/ Not Applicable
4. From 3.40 to 4.19 Disagree
5. From 4.20 to 5.00 Strongly Disagree

Table 4.7: the Elements of a Successful of a construction projects in Sudan

The Elements	N				
	Valid	Missing	Mean	Std. Deviation	Attitude
Within The Allocated Time Period	43	1	2.16	.843	Agree
Within The Budgeted Cost	43	1	2.14	.861	Agree
At The Proper Performance Or Specification Level	43	1	2.16	.871	Agree
With Acceptance By The Customer Or User	42	2	2.38	.764	Agree
With Minimum Or Mutually Agreed Upon Scope Changes	40	4	2.50	.716	Agree
Within Organization's policies	43	1	2.47	.735	Agree
Within Company Culture	43	1	2.42	.763	Agree
In Your Opinion, Rank the Following Elements that Were Considered in Developing the Success of A Construction Projects					

Form the analysis carried out, the average main level for the element (Within Company Culture) is 2.42, which in agree category of the elements of successful project. It shows that the element (Company Culture) plays main role in the successful of the most of the projects and company culture affects the way people and groups interact with each other, with clients, with stakeholders subcontractors and engineers . In addition, company culture may affect how much employees and identify with a company.

The analysis showed that one of the main elements that should Considered in Developing the Success of a Construction Projects is handling the project within organization policies has average main level is 2.47 which means that the organization policies can effect organization members and the total project and the project should be within the general organization policies

Figure 4.6 shows the elements (Within The Allocated Time Period ,Within The Budgeted Cost and At The Proper Performance Or Specification Level) have obtained average main level as 2.16 , 2.14 and 2.16 respectively which that means these three element got less important that the others elements .

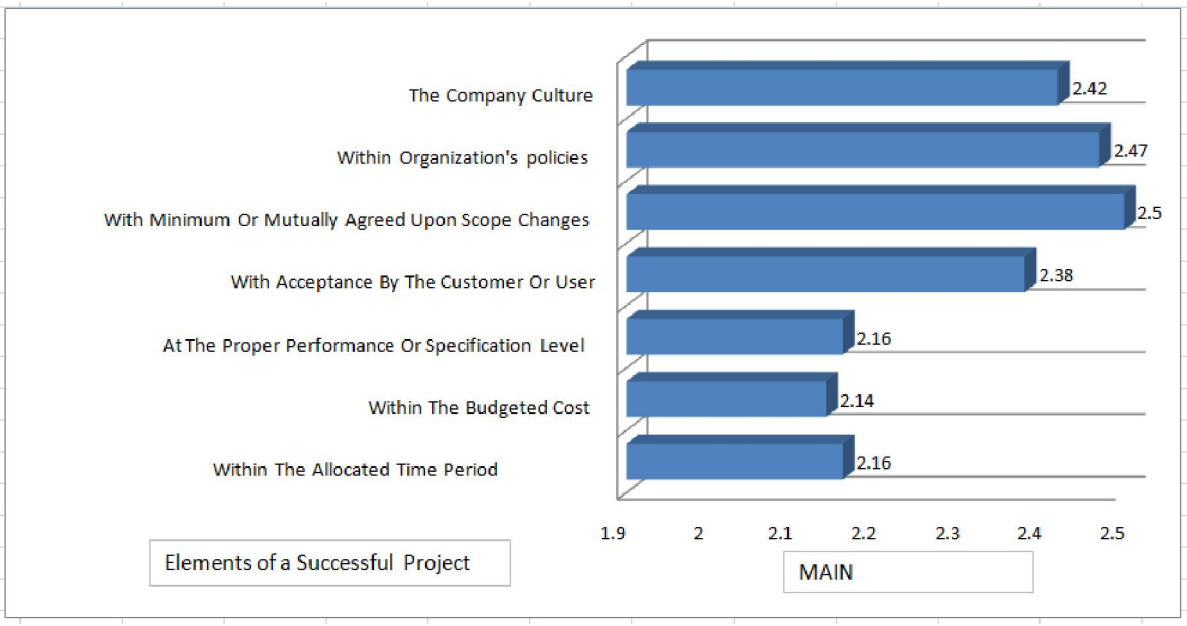


Figure 4.6: Elements of Successful Projects

4.4.3 The Level of Understanding of EVM

The objective is to identify the level of Understanding of EVM Among engineers in Construction industry. From the collected Questionnaires, analysis has been done as result shows as below in bar chart 4.7:

Based on the study done bar chart 4.7shown below, the understanding of EVM among Engineers in Construction industry are (GOOD ,VERY GOOD and EXCELLENT) that means more than 75 % of the engineers are understood the and Used EVM techniques in the Construction Industry

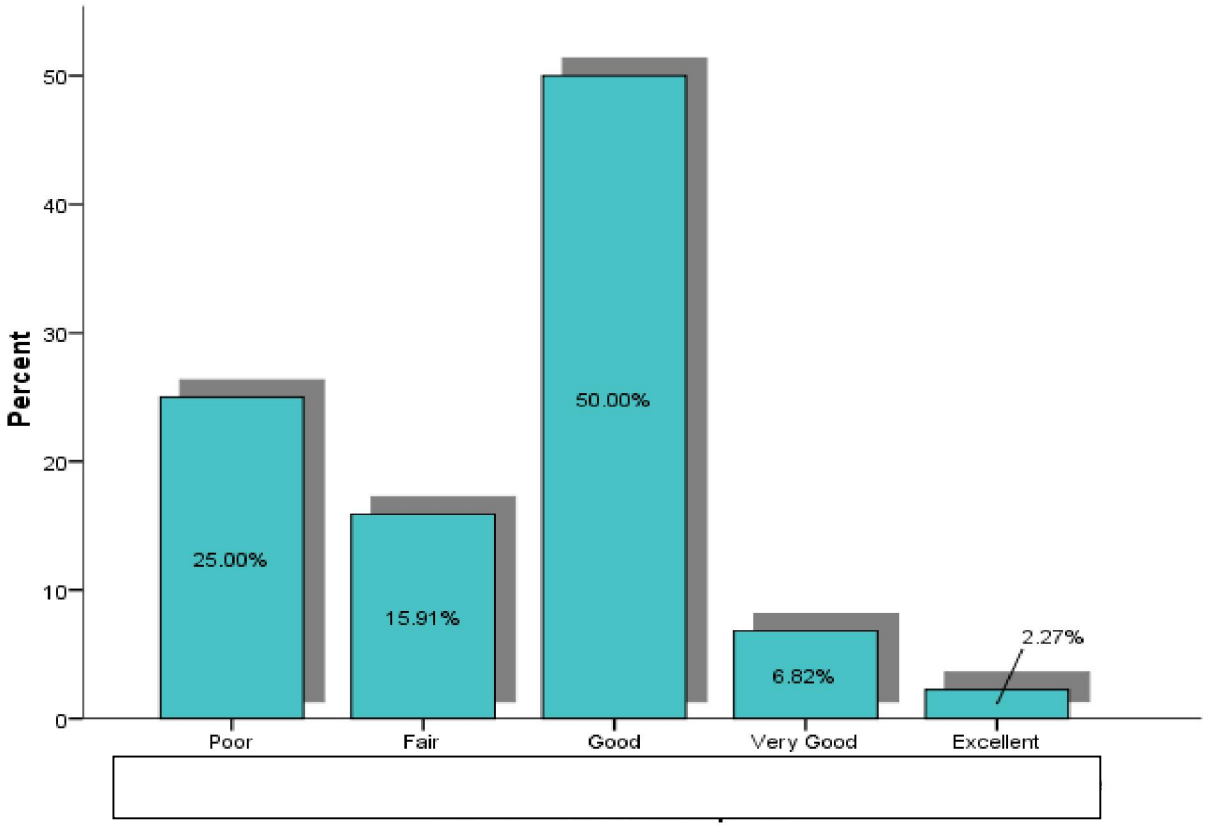


Figure 4.7: Level of Understanding of EVM

4.4.4 Definition and Description of Earned Value Management

The Objective is identifying best Description of Earned Value Management. From the collected questionnaires, analysis has been done as result shown as below:

Table 4.8 best Description of **Earned Value Management**

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Reporting Tool Only	4	9.1	10.3	10.3
	Reporting Tool with (some) Management Uses	7	15.9	17.9	28.2
	Equal Parts Reporting and Management Tool	14	31.8	35.9	64.1
	Management Tool with (some) Reporting Uses	14	31.8	35.9	100.0
	Total	**39**	**88.6**	**100.0**	
Missing	System	5	11.4		
	Total	**44**	**100.0**		

Base on the result shown in the Par Chart below, it is clearly indicated that 35.9 % of the respondents agreed that the best Descriptions of Earned Value Management are Equal Parts Reporting and Management Tool and Management Tool with (some) Reporting Uses. However, the remaining two Descriptions of Earned Value Management got less that 30 % of the respondents the first is describe Earned Value Management as a Reporting Tool Only and the second one describe Earned Value Management as Reporting Tool with (some) Management Uses with 10.3 % and 17.9 % respectively . Based on the result of the Questionnaires it is clearly indicated that the most two definitions of Earned Value Management are Equal Parts Reporting and Management Tool and Management Tool with (some) Reporting Uses

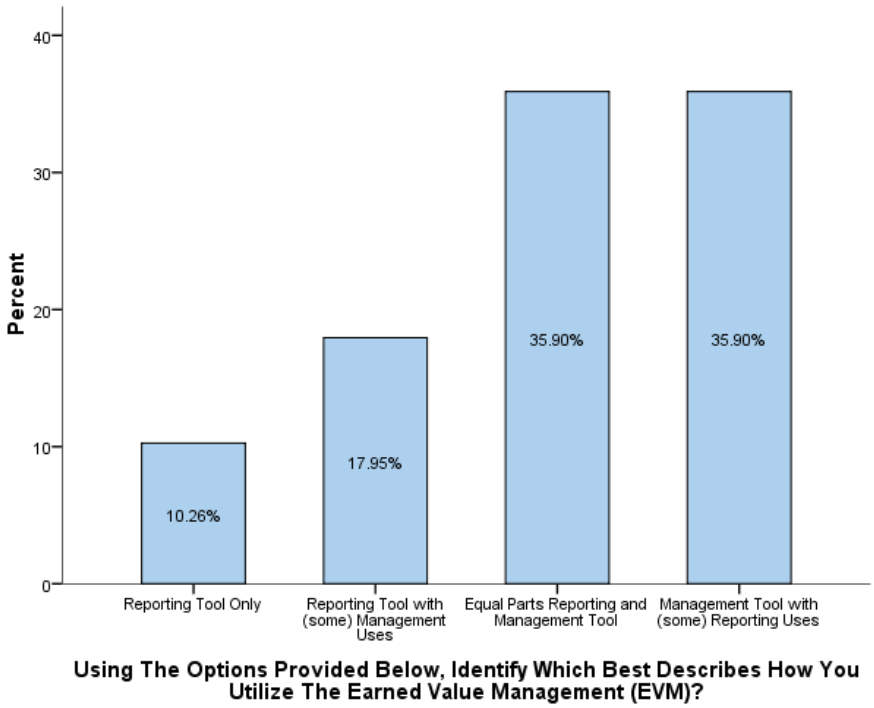


Figure 4.8: Par Chart of best Description of **Earned Value Management**

4.4.5 Implementation of EVM In construction projects

The Objective is identifying How Often Engineers in construction industries and projects Implement EVM in construction projects. From the collected questionnaires, analysis has been done as result shown as below:

Table 4.9 Implementation of EVM In construction projects

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Least Frequent	7	15.9	17.5	17.5
	Less Frequent	5	11.4	12.5	30.0
	Moderate	25	56.8	62.5	92.5
	Frequent	1	2.3	2.5	95.0
	Most Frequent	2	4.5	5.0	100.0
	Total	**40**	**90.9**	**100.0**	
Missing	System	4	9.1		
	Total	**44**	**100.0**		

Table 4.9 above reveals How Often Engineers in construction industries Implement EVM in construction projects. From the analysis carried out, 62.5% of the respondents agree that the implementation of EVM is Moderate. The lowest percentages was implementation of EVM frequently

Based on the result shown above the implementation of EVM its good result and it need more studies and researches to enhanced the implementation of EVM in construction industry in Sudan

4.4.6 EVM Concepts

The main objective is to determine and rank the main concepts of EVM techniques in managing construction projects. Based on the questionnaires collected, analysis has been done and the result is shown as table 4.10 and 4.8 Par Chart

Descriptive Statistics:

Weighted Mean Level:

1. From 1.00 to 1.79 Strongly agree
2. From 1.80 to 2.59 Agree
3. From 2.60 to 3.39 Uncertain/ Not Applicable
4. From 3.40 to 4.19 Disagree
5. From 4.20 to 5.00 Strongly Disagree

Table 4.10: the main concepts of EVM techniques

The Concepts	N				
	Valid	**Missing**	**Mean**	**Std. Deviation**	**Attitude**
EVM Provides Early Warming Of Performance Problems	38	6	2.29	.984	Agree
EVM Assists The Project Team To Achieve Cost Objective	37	7	2.27	.838	Agree
EVM Improves Communication Among Team Members	38	6	2.55	.795	Agree
EVM Assists The Project Team To Achieve Schedule Objectives	37	7	2.32	.784	Agree
EVM Improves Project Scope Management	37	7	2.11	.809	Agree
EVM Is A Cost –Effective Tool For Performance Management	38	6	2.08	.784	Agree

Form the analysis carried out, the average meanlevel for the concept of (EVM Provides Early Warming of Performance Problems) got 2.29, which in agree category of the concepts of EVM techniques. It shows and agreed from the engineers that EVM plays main role in providing early warnings of performance issues, allowing for timely and appropriate adjustments. In addition, using EVM to provide early warning will lead to the Success of the construction project.

In addition, the concepts of (EVM Improves Communication among Team Members) got 2.55 average main levels and it was the higher comparing to the other concepts of EVM Techniques which means that it is one of the important concepts in the EVM Techniques Figure 4.8 shows the Main Concepts Of EVM Techniques it shows also that some engineer agreed that (EVM Improves Project Scope Management) and (EVM Is A Cost –Effective Tool For Performance Management) are concepts of EVM which they got 2.22 and 2.08 of average main level respectively .

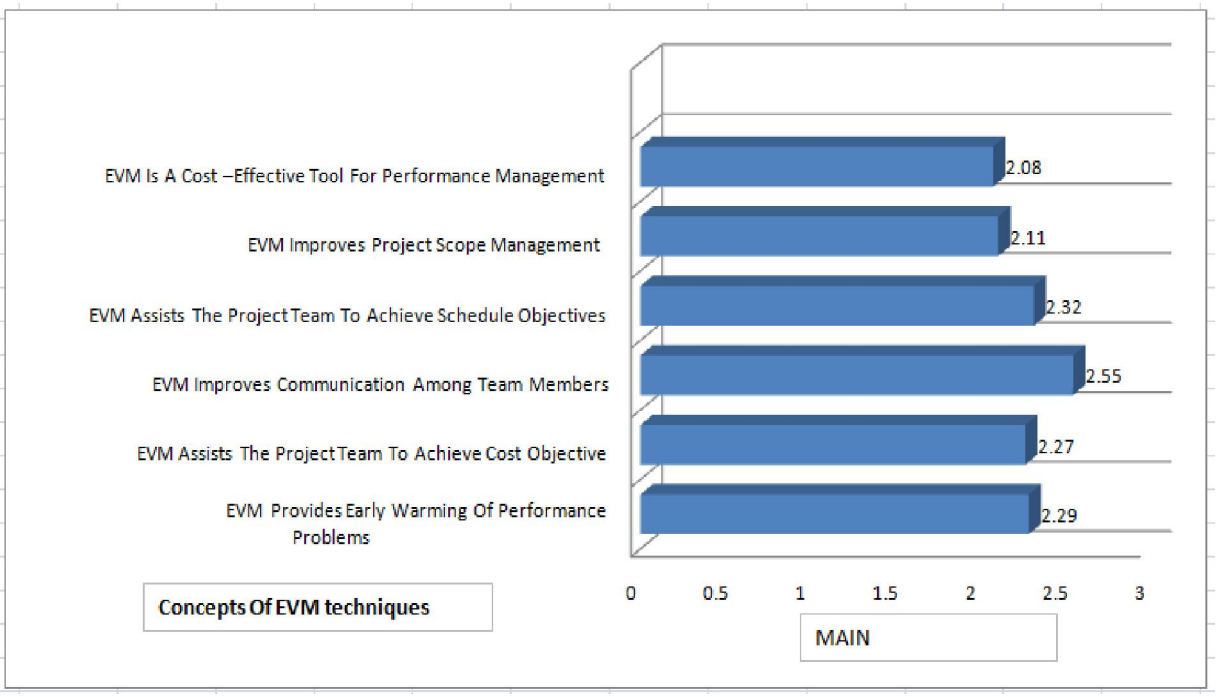


Figure 4.9: **Main Concepts of EVM Techniques**

4.4.7 Valuable Software used in Implementation Of EVM in construction project

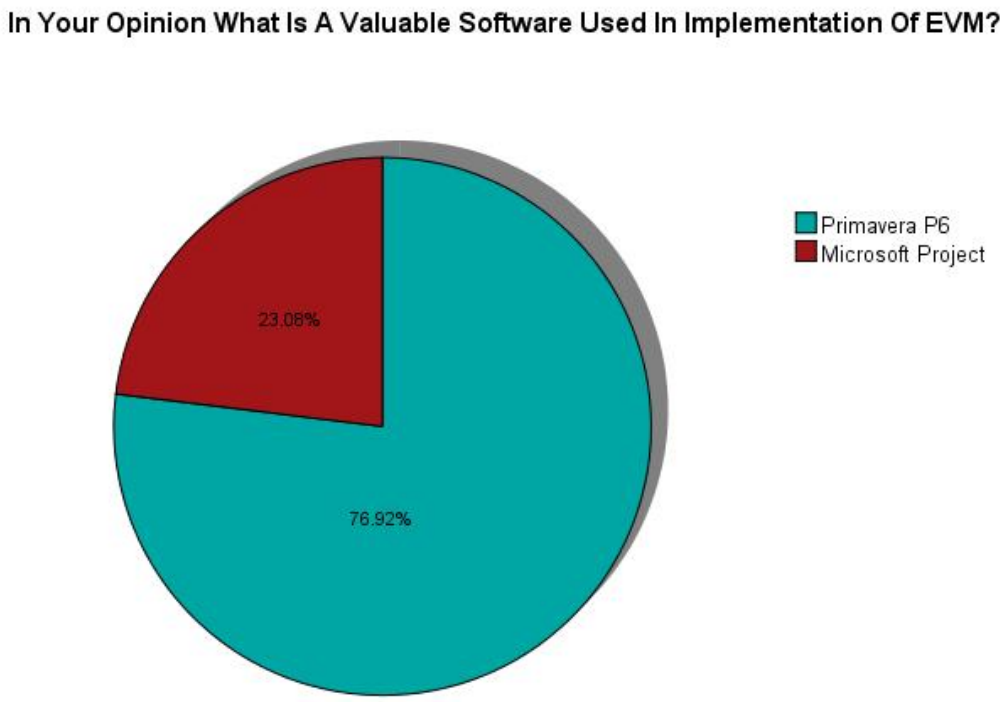


Figure 4.10 Valuable Software Used in Implementation of EVM in construction projects in Sudan

From Figure 4.9 above , almost 77% of the respondents believe that the Primavera is One of the most used programs in construction projects in Sudan .this is big as compare to 23% of the respondents believe that the Microsoft Projects that indicate that the engineer tend to use Primavera P6 in controlling , planning, managing, and executing construction projects

4.4.8 Advantages Of EVM in construction project

The main objective is to determine and rank the main Advantages of EVM techniques in managing construction projects as seen by respondents Based on the questionnaires collected, analysis has been done and the result is shown as table 4.11 and 4.10 Par Chart

Descriptive Statistics:

Weighted Mean Level:

1. From 1.00 to 1.79 Strongly agree
2. From 1.80 to 2.59 Agree
3. From 2.60 to 3.39 Uncertain/ Not Applicable
4. From 3.40 to 4.19 Disagree
5. From 4.20 to 5.00 Strongly Disagree

Table 4.11: the main Advantages of EVM techniques in managing construction projects

Advantages			
	Mean	**Std. Deviation**	**Attitude**
Reduce Overall Project Costs, Usually Well In Excess Of Their Fees.	2.29	.867	Agree
Enhance Quality Control To Reduce Potential For Defects And Poor Workmanship	2.38	.907	Agree
Provides An Early Warning Of Performance Problem	2.18	.730	Agree
Uncover Any Time And Cost Deviations From The Plan	2.36	.931	Agree
Forecasting Project Cost At Completion	2.38	.794	Agree
Support Decision Making	2.13	.704	Agree

Form the analysis carried out, the majority of respondents are agreed on 6 main Advantages of EVM techniques in managing construction projects:

- Reduce Overall Project Costs, Usually Well In Excess Of Their Fees.
- Enhance Quality Control To Reduce Potential For Defects And Poor Workmanship
- Provides An Early Warning Of Performance Problem
- Uncover Any Time And Cost Deviations From The Plan
- Forecasting Project Cost At Completion
- Support Decision Making

Based on the survey done, the majority of respondents are agreed on the above Advantages of EVM techniques in managing construction projects Provides An Early Warning Of Performance Problem was the most Advantages has more than 50% of respondents believed and agreed that this advantage provides progress information that can be compared to the planned budget and actual cost to provide additional insight into project status.

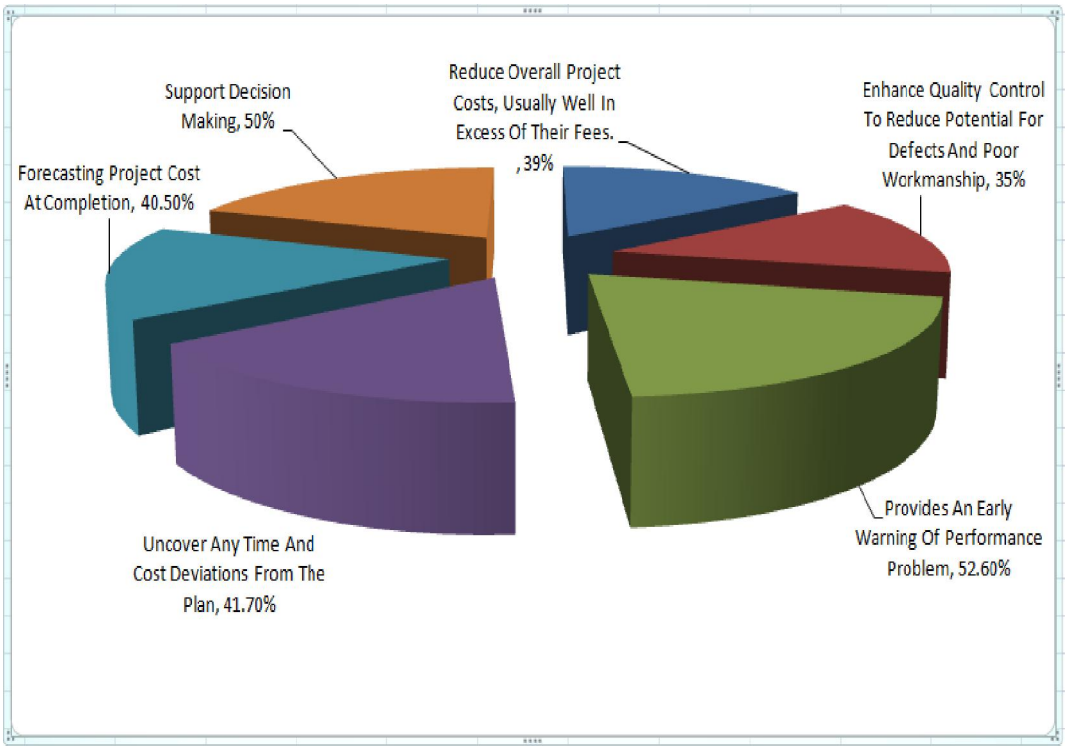


Figure 4.11: **the main Advantages of EVM techniques**

CHAPTER 5: CONCLUSION AND RECOMMENDATIONS

5.1 Introduction

This chapter concludes the study by the discussion of the results of the data analysis done in Chapter 4. This study is basically aimed to investigate the applicability of Earned Value technique in analyzing and controlling the performance of construction projects in Sudan and main factors of successful construction project.

5.2 Summary and the Analysis

In general , this thesis is conducting an exploratory study on the applicability of Earned Value technique in analyzing and controlling the performance of construction projects in Sudan and also determine the contractor's performance in completing projects based on the level of cost available to them during the construction process. This was discussed thoroughly in the literature review.

In order to achieve the target of this study , four main objectives have been outlined and are set to be analyzed since Earned Value management is a very wide topic , hence in order to achieve the target of the analysis , these objectives were developed so that analysis can be done without being diverted to other area or topics . apart from that, the method of analysis that being carried out in this study shows that it fulfills the requirement required by the objective analysis n general there were two main method used in this study in order to gather all the information required for the purpose of the analysis . The first being the literature review where the data collected were obtained from external sources such as books, journals, internet , newspapers and magazines . Through the literature review, the information pertaining Earned Value Management (EVM) as well as the contributing factors towards its development is acquired.

The second method is the questionnaire types where it was distributed only to those engineers and contractors who have been working in construction industry in Sudan. When all data the data is acquired, the arrangement and analysis is done by using software called Statistical Package for Social Science (SPSS) which can easily analyzes the data in orderly manner. The results of the factors which have the most influencing contributions are identified in Chapter 4

5.3 Conclusions

5.3.1 Research objectives

Objective (1): To identify the element of a successful construction projects

Quality, time, cost and client satisfaction are the most recognized success factors for construction projects, although safety was considered in some literatures as one of project success factors but profound analysis confirms that safety is ultimately a work environment, culture and attitude of industry human resources. Quality is the main concern for construction stakeholders; contractors should not compromise quality as it builds contractor reliability in the market. Client satisfaction is important to sustain business, maintain reasonable market share and build strategic relationship with clients, balancing different success factors is the key to reach overall project success and the most important Element is Managing COST, TIME AND QUALITY

Objective (2): To identify the level of understanding of using Earned Value technique (EV) in construction project in Sudan.

The results show that the level of understanding of EVM is good Among Engineers in construction industry in Sudan. Through the study of the literature review as well survey through the questionnaires the research has concluded 10 Steps to Understanding
Earned Value Management:

1. The Foundation - Deconstructing the project Statement of Work (SOW) into discrete, measurable components to develop the Work Breakdown Structure (WBS) and the activities/tasks that are required to execute the work (Vertical Integration)
2. Determine the effort and resources required to perform the work (Estimate)
3. Develop a resource loaded schedule of the time it takes to execute the work (Horizontal Integration)
4. Define a methodology to measure activity/task completion (EV Methods)
5. Price the effort and resources to create a project budget (Budgeted Cost of Work Scheduled)
6. Collect actual cost by period against the WBS below the level required for reporting (Actual Cost of Work Performed)
7. Calculate the activity/task completion percentage (using methodology established n step 4)
8. Multiply the activity/task completion percentage against the budget at completion to determine the amount accomplished in terms of budget dollars (Earned Value or Budgeted Cost of Work Performed)
9. Subtract the Budgeted Cost from the Earned Value to obtain the Schedule Variance. Subtract the Actual Cost from the Earned Value to obtain the Cost Variance (Variance Analysis)
10. Using the actual cost, variance information, and the work remaining to complete the activity/task, calculates a new estimate at complete (EAC).

Objective (3): To identify the frequency of using Earned Value technique (EV) in construction project in Sudan.

The results shows that most of the engineers working in construction industry are rarely implement EVM in construction Industry in Sudan. through the study of the literature review as well survey through the questionnaires Some of the reasons of lack of using EVM in construction industry in Sudan have been identified :

- Lack of Management Support
- Inability to Find Qualified Resources
- Difficulty Integrating Cost, Resource and Schedule Data
- Inconsistent Application of EVM Across the Enterprise
- It Takes Too Long to Manually Produce Reports

Objective (4): To identify the importance of using project management in analyzing and controlling the performance of construction projects in Sudan.

Through the study of the literature review as well survey through the questionnaires the research has concluded and Identifying the important of using project management in analyzing and controlling the performance of construction projects in Sudan in three main points:

- Analyzing and controlling help Relates time-phased budgets to specific tasks to requirements contained in a statement of work.
- Analyzing and controlling help provides accurate, reliable, and timely data.
- Analyzing and controlling help Measures project progress and performance with related costs, schedule, and technical accomplishments.

5.3.2 EVM implementation on construction industry.

The basic outcomes of proper EVA are better managerial control on project success and company strategic goals, therefore accurate economic decisions and overall industry improvement. For centuries, the construction industry has played an essential role in the socio-economic development of all communities. EVM implementation at project level has a positive feedback to company strategic decisions and market share; earlier decisions have the greatest impact on cost savings.

The main conclusion is that EVA can provide an important contribution to the cost management of construction projects. EVA allowed scope change management to keep the final budget of the project within check by providing alternatives to decide in what activities to reduce scope or reduce specifications/ performance to save money in order to fit cost overruns in other activities. Another interesting contribution is the perception that the Schedule Performance Index (SPI) is NOT a "time" performance index - it is really a "progress" performance index related only to physical progress. The SPI index deals with the variables planned values (PV) and earned values (EV) expressed in costs, in the vertical axis, but the time is the horizontal axis. Project managers can measure delays on the horizontal axis. We suggest changing the name from the Schedule Performance Index to the Progress Performance Index. It is related to progress, not time.

The Work Breakdown Structure (WBS) is called the "soul" of the management process. It is very important to define a suitable structure for control and the accounting. The work packages must have clear responsibilities and criteria for measurements. It is important to balance greater or smaller packages in order to get better results in the process. Greater or smaller packages do not directly mean better or worse results, regarding precision and effectiveness. Good judgment is necessary to define the level of control and the amount of results to deal with.

The main contribution of the EVA process was the motivation of the project manager and his staff concerning the cost management and the goal to finish the project on budget. The EVA process provided more perception about the costs and their related elements of scope, contracts, performance, suppliers, risks, procurement, communications, quality, people and negotiations. The EVA process provided clearer information about scope issues because the scope was better modeled through the WBS and appropriate account packages. EVA provides the means for integrated management of schedule, progress and cost based on 3 variables: Planned Value (PV), Earned Value (EV) and Actual Costs (AC), as well as the related indexes Schedule Performance Index (SPI) and Cost Performance Index (CPI). EVA inspires the participants to pay more attention to costs and progress, motivates the participants to discuss the cost elements with more intensity and optimize the costs resulting in a project that was finished on time and on budget.

The benefits of EVM in construction industry in Sudan

The main benefits of EVA identified in construction industry: integrated cost, progressed time management, better vision of the project in terms of scope and procurement, early alert to problems, forcibility of project deviation trends, reduced time to perceive and understand problems and solutions, support for negotiations and the decision making process, and the motivation of people to implement the project control process.

10 Steps to Successfully Implement EVM in Construction in Sudan

The findings of the case study have led to the following recommended steps for the successful implementation of EVA:

1. Obtain top level organization commitment with EVA
2. Education and training of the people in the project in EVA
3. Scope well defined, detailed and identified, with proper WBS and packages
4. Schedule and budget organized according to the WBS
5. Clear Project Responsibility Tables, with clear responsibility descriptions
6. Clear flowchart of activities and relationship with the main participants
7. Cost/Schedule Control System with database and data collection procedures
8. Suitable reports related to EVA, well planned, analyzed and distributed
9. Procedures to consistency analysis and validation of information
10. Lessons Learned - continuous improvement process

5.3.3 Hypothesis

The answers to the question proposed by the research and the evaluations of the formulated hypothesis can be reached by using qualitative research, including field observation, informal interviews and document analysis from questionnaires studded.

- IS There a lacking of using adequate methods (Earned value management (EVM))) of analyzing and controlling the performance of construction projects in Sudan?

- Yes. it has been found that there are lacking of using adequate methods (Earned value management (EVM))) of analyzing and controlling the performance of construction projects in Sudan

Hypothesis 1 - company in Sudan has a perception about the importance of using the EVM for project performance.

Analyzing the result regarding to the important of using EVM, it has been confirmed in the analysis of the questionnaires, survey and interviews Engineers understand the principles of EVM but there is lack of knowledge of EVM in top management in Sudanese companies that is the main reason of leaking in using the EVM in project performance.

Hypothesis 2 – EVM applied in construction project in Sudan
According to the information in figure 4.9, the company applies EVM Rarely in Managing projects the reason was lack of knowledge of EVM in top management in Sudanese companies.

Hypothesis 3 - there is a good Understanding of EVM among engineers in Construction industry in Sudan.

Relate to understanding the important of EVM the analysis of the results in Graph 4.7 show that most of the engineers who are working in construction industry understood the important of EVM this is due to Focus on management principles in universities and institutes but it has not been applied practically universities and institutes in Sudan.

Hypothesis 4 - Management tools is a best Description of Earned Value Management.

Analyzing the result regarding to Managing tools the analysis of the results from table 4.8 show that Management tools is a best Description of Earned Value Management.

Hypothesis 5 -primavera p6 is Valuable Software used in Implementation of EVM in construction project in Sudan.

Analyzing the result regarding to using primavera p6 in Implementation Of EVM and According to the information shows in figure 4.10 confirmed that -primavera is Valuable Software in Implementation Of EVM in construction project in Sudan the result shows almost 77% believe that primavera is one of the most used programs in Sudan compare to Microsoft project .

5.4 Recommendations

Several suggestion have been made in order to improve the Implementation of EVM in construction projects in Sudan

1. Direct & Indirect Education

   As with most processes, education always makes the acceptance go more easily, so it is no surprise that there were quite a few suggestions associated with education.

   - Focus on development of management curriculum in universities
   - Training students fresh graduates in management-related projects
   - Development of scientific and practical fellowship with international companies in the field of construction management.
   - Focus on planning department in the companies and organizations and continued development of the planning department.
   - Local contractors are advice to have the basic knowledge of construction management especially in EVM.

2. Executive Training

   This follows on the previous recommendations by stating that the executives of the company need to be trained in basic EV principles and in the company best practices. Another supplement to the training is a peer visit from another company who has had success with EVM, or simply have the executive attend an IPM Conference to see what is happening and who is performing.

3. The information and data of study

   The information and data of study could be collected through interviewing with selected local contractors in order to have a more reliable and trustable data.

5.5 Recommendations For Future Researches

The followings are several recommendations that can be considered for future work:

1. More studies about the relations between the projects resources and project baseline and their effect on Planned Value (PV), Earned Value (EV) and Actual Costs (AC)..
2. More studies in predicting the final cost for projects using Earned value management (EVM)
3. More studies in using Earned value management (EVM) to prediction of final duration for the schedule component of projects
4. Study the effect of good Project Procurement Management on Planned Value (PV), Earned Value (EV) and Actual Costs (AC) and Earned value management (EVM)

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APPENDICES

Appendix (1)

- QUESTIONNAIRE

Sudan University of Science and Technology

QUESTIONNAIRE

GENERAL INFORMATION

Name:……..

-Type of work: (Select only one.)

□ Common

□ Privet

□ other: ……. State.

-Age:……..

-How long have you served the construction industry?

(Select only one.)

□□□□□Below 5 years

□□□□□5 – 10 years

□□□□□11 – 15 years

□□□□□16 – 20 years

□□□□□Above 20 years

- **Degree Honor:**

(Select only one.)

□□□□□High diploma

□□□□□Bachelor

□□□□□Master Degree

□□□□□Dr. Degree

SECTION A

1. Which organization do you represent?

(Select only one.)

□□□Developer/Client
□□□Architectural firm
□□□General Building Contractor
□□□Consultant Firm
□□□Government Agency
□□□Others:_____(state)

2. What is the type of project your company usually deals with?

(Select only one.)

□□□□□Government sector

□□□□□Private sector

□□□□□Both

3. What is the size of your company ?

(Select only one.)

□□□□□Small (5 million SDG)

□□□□□Medium (15 million SDG)

□□□□□Large (50 - 200 million SDG)

□□□□□Mega (more than 200 million SDG)

4. Who is involved in planning and monitoring projects in your organization?

(Select only one.)

□□□□□Planner engineer

□□□□□General Manager

□□□□□Project manager

□□□□□Site engineer

5. What is your profession in construction industry?

(Select only one.)

□□□□□Architect

□□□□□Project Manager

□□□□□Engineer

□□□□□Quantity Surveyor

□□□Others:_____(state)

SECTION B

6. In your opinion, rank the following elements that were considered in developing the success of a construction projects.

The Elements	strongly agree	agree	uncertain/ not applicable	disagree	strongly disagree
1. Within the allocated time period	☐	☐	☐	☐	☐
2. Within the budgeted cost	☐	☐	☐	☐	☐
3. At the proper performance or specification level	☐	☐	☐	☐	☐
4. With acceptance by the customer or user	☐	☐	☐	☐	☐
5. With minimum or mutually agreed upon scope changes	☐	☐	☐	☐	☐
6. Without disturbing the main work flow of the organization	☐	☐	☐	☐	☐
7. Effective communication process	☐	☐	☐	☐	☐
8. Without changing the company culture	☐	☐	☐	☐	☐

SECTION C

EVM (Earned Value Management)

7. Using the options provided below, please assess your knowledge about EVM techniques:

(Select only one.)

□□□□□Poor

□□□□□Fair

□□□□□Good

□□□□□Very good

□□□□□Excellent

8. In your opinion, the (EVM)could be considered as:-

(Select only one.)

□□□□□Reporting Tool Only

□□□□□Reporting Tool with (some) Management Uses

□□□□□Equal Parts Reporting and Management Tool

□□□□□Management Tool with (some) reporting Uses

□□□□□Management Tool Only

9. How do you implementEVM in your projects?

(Select only one.)

□□□□□Least frequent

□□□□□less frequent

□□□□□Moderate

□□□□□Frequent

□□□□□Most frequent

10. In your opinion, rank the following concepts that were considered in developing EVM.

The concepts	strongly agree	agree	uncertain/ not applicable	disagree	strongly disagree
1. EVM provides early warming of performance problems	☐	☐	☐	☐	☐
2. EVM assists the project team to achieve cost objective	☐	☐	☐	☐	☐
3. EVM improves communication among team members	☐	☐	☐	☐	☐
4. EVM assists the project team to achieve schedule objectives	☐	☐	☐	☐	☐
5. EVM improves project scope management	☐	☐	☐	☐	☐
6. EVM is a cost –effective tool for performance management	☐	☐	☐	☐	☐

11. In your company, the most used tools and technique that used in implementing project is:

(Select only one.)

□□□□□Primavera p6

□□□□□Microsoft project

□□□□□Others: ----------(-state).

12. Throughout your experience can you rank the use of (EVM)in the construction industry in Sudan.

(Select only one.)

□□□□□Never

□□□□□Rarely

□□□□□Sometimes

□□□□□Most of the time

□□□□□Always

13. In your opinion what is the best way to apply EVM in construction industry (Select only one.)

□□□□□assign planner engineer to each project.

□□□□□Develop the management skills of project managers.

□□□□□Others: ----------(state)

14. In your opinion, rank the following advantages behind analyzing and controlling the performance of construction project

Advantages	strongly agree	agree	uncertain/ not applicable	disagree	strongly disagree
1. Reduce overall project costs, usually well in excess of their fees.	☐	☐	☐	☐	☐
2. Enhance quality control to reduce potential for defects and poor workmanship	☐	☐	☐	☐	☐
3. Provides an early warning of performance problem	☐	☐	☐	☐	☐
4. Uncover any time and cost deviations from the plan	☐	☐	☐	☐	☐
5. Forecasting project cost at completion	☐	☐	☐	☐	☐
6. Support decision making	☐	☐	☐	☐	☐