# APPLICATION OF EARNED VALUE MANAGEMENT (EVM) TECHNIQUE ON MEASURING THE PERFORMANCE OF INFRASTRUCTURE PROJECTS: A CASE STUDY OF MULAGO HOSPITAL CONSTRUCTION PROJECT

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## LIST OF ACRONYMS

| | |
|---|---|
| AC | Actual cost |
| ACWP | Actual cost Work Performed |
| AT | Actual Time |
| BAC | Budget at Completion |
| BCWS | Budget cost Work Schedule |
| BCWP | Budget cost Work Performed |
| CPI | Cost Performance Index |
| CR | Critical Ratio |
| CRB | Contractor Registration Board |
| CV | Cost Variance |
| EAC | Estimate Cost at Completion |
| EACt | Estimate Time at Completion |
| ERB | Engineer Registration Board |
| EV | Earned Value |
| EVA | Earned Value Analysis |
| EVM | Earned value Management |
| EVMS | Earned Value Management Technique |
| EVT | Earned value Technique |
| GDP | Gross Domestic Product |
| KPIs | Key performance indicators |

| | |
|---|---|
| NHC | National Housing Council |
| NASA | National Aeronautics and Space Administration |
| NDIA | National Defense Industrial Association |
| OBS | Organization Breakdown Structure |
| PMB | Performance Measurement Baseline |
| PV | Planned Value |
| PPRA | Public Procurement Regulation Act |
| PMBOK | Project Management Board of Knowledge |
| RC | Remaining Cost to Complete |
| RT | Remaining Time to Complete |
| SPI | Schedule Performance Index |
| SV | Schedule Variance |
| VAC | Variance at Completion |
| WBS | Work Breakdown Structure |

# CHAPTER ONE

# INTRODUCTION

## 1.1 Introduction

This study will examine the application of Earned Value Management (EVM) technique on to measuring the performance of construction of Specialised Maternal and Neonatal Health Care Unit Project (SMNHUP) in Mulago Hospital Kampala.

The construction industry serves as a fundamental pillar for the economic and social development of a country (Ballesteros-Pérez et al., 2010:66) and is usually reflected by its sensible contribution to the gross domestic product (GDP). In Uganda, the contributions of the construction sector to the GDP represented 7.5% in FY2014/15 (Uganda Bureau of statistics (UBOS, 2015:75). Considering the rapid growth of the construction sector in Uganda (grew by 5.3% in FY 2013/14 and by 2.7% in FY 2014/15 (UBOS, 2015:75)), more challenges are faced by construction industry in achieving better performance. Clients, Consultants and contractors have continuously focused their attention on better performance, thus adapting EVM in the Uganda Construction Industry.

Earned Value Management (EVM) is a technique of performance measurement focused on project physical, financial and time progress, indicating planned and actual performance, variations of them and forecasts on final project duration and cost (Alvarado et al., 2004:70). The technique is widely adopted by the construction industries of USA, UK, Australia and South Korea. However, its application as project control technique is not very common in Uganda.

This introductory chapter covers the background of the study, the statement of the problem, Objective of the study, the specific objectives, the research questions, hypotheses, Conceptual Framework, the significance of the study, the justification of the study and the scope of the study.

## 1.2 Background to the Study

### 1.2.1 Historical background

EVM originated late in the 1960s as a financial management tool to control defense acquisition projects. Project control specifications were defined by the US Department of Defense (DoD) to correct projects' deviations through cost and schedule accounting and reporting. During the 1980s the methodology emerged as a project management tool and was available also to other industries across the USA. In 1999, the PMI established its first College of Performance Management, today the premier professional organization for EVM research and project planning and control, and included the methodology in its standards (PMI, 2008). Consequently, the technique got across other countries and many industries.

The PMI provides an historic view on the evolution of this technique departing from the initial efforts with PERT/COST, but it was considered overly burdensome (not very adaptable) by contractors who were mandated to use it, and many variations of it began to proliferate among various procurement programs. In 1967, the DoD established a criterion-based approach, using a set of 35 criteria, called the Cost/Schedule Control Systems Criteria (C/SCSC). In 1970s and early 1980s, a subculture of C/SCSC analysis grew, but the technique was often ignored or even actively resisted by project managers in both government and industry. C/SCSC was often considered a financial control tool that could be delegated to analytical specialists (Fleming and Koppelman, 2010:5).

In the late 1980s and early 1990s, EVM emerged as a project management methodology to be understood and used by managers and executives, not just the EVM specialists. By 1989, EVM leadership was elevated as an essential element of program management and procurement. In 1991,

some defense projects and programs were cancelled because of performance problems detected by EVM (Marshall, 2006:288). This demonstrated how EVM mattered to successful projects, programs and portfolios.

### 1.2.2 Theoretical background

Indicators are essential management tools in monitoring and evaluating project activities, as they allow the achievement of goals to be monitored as well as advances and improvements in quality to be identified. To monitor the project is to compare the current with the planned situation, determining if the costs and the schedule are progressing according to plan, in order to take corrective action when needed (De Marco *et* Timur, 2013:70).The performance indicator in engineering projects is particularly important because it allows problems that may occur during the course of the project to be foreseen, enabling adjustments and corrections, as well as avoiding deviations from the plan. EVM (earned value management) is a powerful tool in managing scope, time and costs, allowing scheduled performance indices and costs to be achieved (Anbari, 2003:12). Alternately, the Earned Value Management Technique (EVM) emerged. Developed by the US Defense Department, this technique is widely used as tool of control and it is indicated by the Project Management Institute (PMI) as a standard tool for project performance measurement. The PMI provides an historic view on the evolution of this technique departing from the initial efforts with PERT/COST (1962, 1965, and Cost Schedule Planning and Control Specification - C/ SCSC (1967, 1996). Major advances are the integration of planning, control and definition of project scopes into a single tool (Fleming and Koppelman, 2010:8)

### 1.2.3 Conceptual background

EVM is a powerful quantitative technique for objectively monitoring the physical project progress. It enables measuring actual work performance and associated cost and time versus an agreed plan

(Project Management Institute, 2005).The earned value analysis gives early indications of project performance to highlight the need for eventual corrective action.

Any project with considerable cost overrun and schedule delay typically gets in trouble at its beginning, and unfortunately, project managers does not realize this problem until late in the project when their ability to recover the project to achieve its planned objectives diminishes (Alvarado et al., 2004:70). According to the PMI (2005), EVM has proven itself to be one of the most effective performance measurement and feedback tools for managing projects and enabling managers to close the loop in the plan-do check-act project management cycle (Project Management Institute, Practice Standard for Earned Value Management, 2005). The primary purpose of managing a construction project is to complete it on time and within the budget while conforming established requirements and specifications (Pewdum et al., 2009:544). To achieve that objective, substantial effort on managing the construction process must be provided and could not be done without an effective performance monitoring system. Performance measurement is a basic requirement for tracking cost, time, and quality of a construction project (Yang et al., 2010:269).The performance of a construction project can be judged by using different traditional approach like day to day monitoring, monthly or weekly management reports, performance reviews, key performance indicators, project audit reports etc. In these traditional approaches, usually there are two data sources, the budget (or planned) expenditures and the actual expenditures. The comparison of budget versus actual expenditures merely indicates what was planned to be spent versus what was actually spent at any given time (Mohd.Faris Khamidi, Waris Ali and Arazi Idrus, 2011:24). Accordingly, this approach does not count for the value of work accomplished thus ignoring a third dimension: the earned value (EV) of work (Fleming and Koppelman, 2003:55). What is missing

from most of these analyses is an understanding of how much work has been earned during the project execution and its integration with cost and time (Al-Jibouri, 2003:18)

### 1.2.4 Contextual background

EVM focus on forecasting final costs and project duration, what is deemed crucial to alert managers and enforce their reaction to overcome delays and costs overruns. EVM addresses value from the perspective of the developer or building company, only indirectly generating views of final value that are of interest for final data clients. The uniqueness of the method is that it provides accurate cost performance and progress measurement for project monitoring and control (Demarco, 2013:71). However, even in face of this supposedly overwhelming easy of adaptation to project management needs, critics were able to find information domains that are not covered by this tool: such domains might inhibit the provision of data on project progress status that are useful for practioners of different current of thoughts in planning. Kim and Ballard (2000) analyzed the applications of EVM technique in the construction industry from the perspective of workflow. They concluded that the EVM is an inappropriate tool to monitor workflow, a cornerstone conceptual basis of lean construction. Furthermore, EVM addresses value from the perspective of the developer or building company, only indirectly generating views of final value that are of interest for final client.

Research in Uganda indicates that work programs, reports, project budget and inspection of works, among others, are the techniques used to manage project cost. In Nigeria, it was noted that project budget was the most frequently used tool followed by monitoring of labour and material cost respectively.

What differs between these countries is the weighting attached for each strategy. For instance, in Uganda work programs are weighted high, while this same factor has a very low frequency in

Zimbabwe. Figure 1 below summarizes contractor cost management strategies. The identified strategies are discussed in the subsequent sections.


**Figure 1: Cost Management Strategies on Building Projects**

The strategies employed by contractors to manage cost are summarized in Figure 1 as follows: cost reports (31.8%); cost estimating and budgeting (36.4%), variance analysis (54.5%); resources management (59.1%), cost value reconciliation (CVR) (31.8%) and cash flow analysis and work programs (18.2%), and other factors, for example, project meetings (13.6%). Cost estimating and budgeting, variance analysis and cost value reconciliation are mostly used by contractors in category A and B, while resources management and variance analysis are used by contractors in all the three categories. However, contractors in category C did not show much use of cost reports, cost estimates and budgets, and cost value reconciliation

### 1.3 Statement of the Problem

The inability to complete projects on time and within budget continues to be a chronic problem worldwide and is worsening (Ahmed et al., 2002:414). Azhar and Farouqui (2008:507) observe that

the trend of cost overrun is common worldwide and that it is more severe in developing countries. If this problem is not addressed, the project beneficiaries are deprived of the benefits that would have accrued from timely completion of the project and sometimes there could be complete abandonment of important projects (Sambasivan and Soon, 2007:517), this restrains the economic growth and failure in realizing the intended benefits of the country. The delays and cost overrun are attributed to poor Project management, inaccurate estimation, inappropriate construction method and delayed payments (Muhwezi, Acai & Otim, 2014:19)

There is strong evidence of inconsistent performance of Ugandan construction projects both by international firms and local construction contractors (LCC) and the trend is growing rapidly. Projects are reportedly failing across all the key performance measures of cost, time and quality (Muhwezi, Acai & Otim, 2014:13) and the dramatic shift in the capacity and volume of the Ugandan construction sector over the last decade warrants a systematic analysis of an appropriate performance measurement technique within the industry. For instance, it took 56 months to complete Mapeera House on Kampala road instead of the original 13 months, representing a total delay period of 43 months (tripling the construction period); the current church house project under construction was expected to be completed within 18 months from the date of commencement of works (April 2011), but by May 2013, the works had already taken 25 months and was yet to be completed (Muhwezi, Acai & Otim, 2014:13).

### 1.4 Objective of the Study

The study will aim at assessing the applicability of EVM Technique on measuring the performance of infrastructure projects in the Uganda construction industry.

### 1.5 Specific objectives

The Following Objectives will guide the Study,

1. To assess the relationship between EVM technique and performance of a project in Kampala
2. To examine the factors that enhances the application of EVM on a construction project in Kampala
3. To identify the factors that hinders the usage and application of EVM
4. To investigate the standard practices of EVM Technique in measuring performance of a construction project in Kampala

### 1.6 Research Questions

1. What is the relationship between earned value management (EVM) technique and performance of an infrastructure project in Uganda?
2. What are the factors that will hinder the effective of application of Earned Value Management Technique (EVMS) in Uganda Construction Industry?
3. What are the factors that hinder the usage and application of EVM in the Uganda construction industry?
4. What are the Standard Practices of EVM Technique in measuring performance of a construction project in Kampala?

### 1.7 Hypothesis of the Study

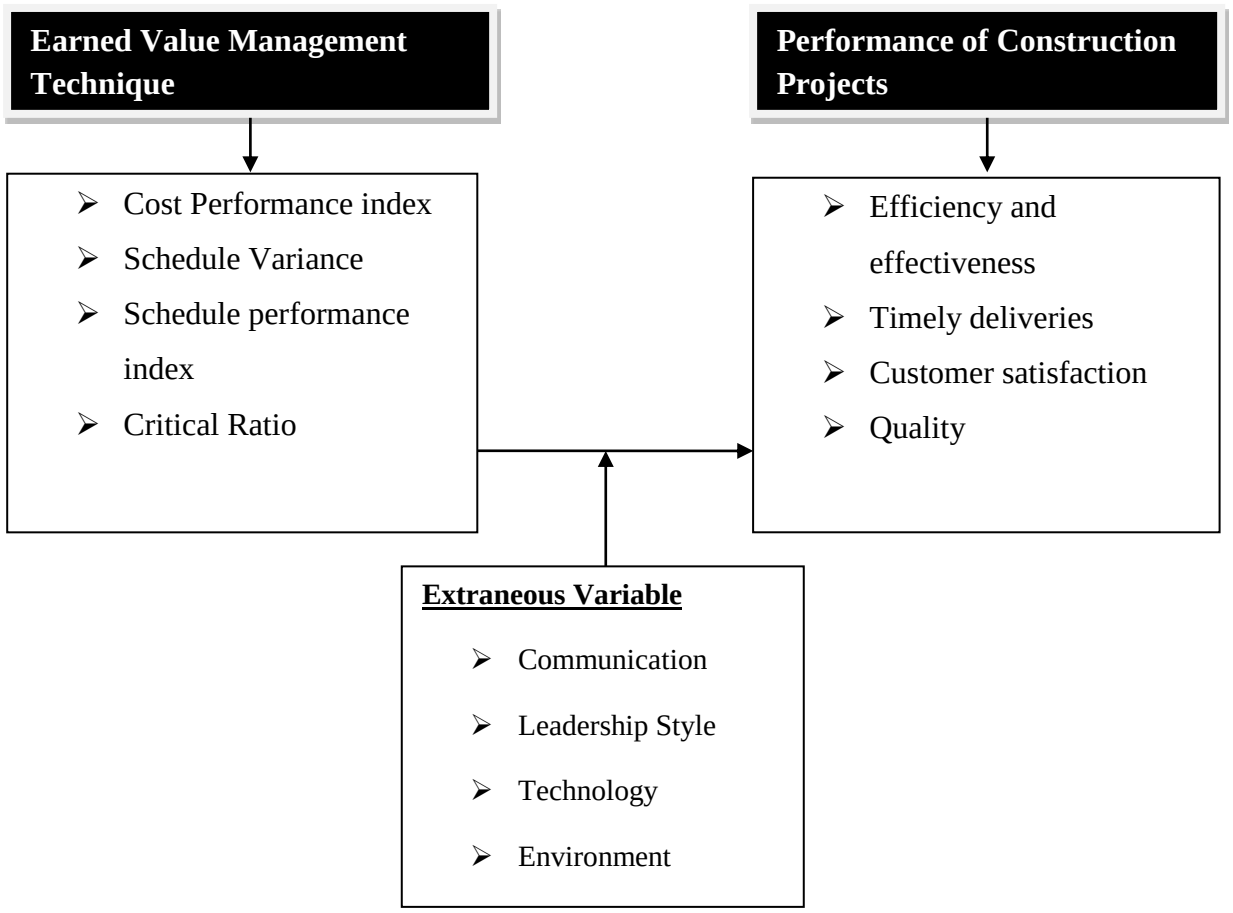
The following are the investigative assumptions which will guide the study. These hypotheses will help to answer the research questions and guide the next steps of the research.

H1: There is a positive relationship between EVM Techniques and performance of a construction project.

H2: There is a positive effect of EVM Technique on performance of an infrastructure project.

### 1.8 Conceptual Framework

This is a scheme of variables which indicates the relationships among the variables in order to achieve the set objectives. The study shall focus on two dimensions namely Cost factors and time factors (Enshassi et al., 2012:65) and the performance shall be measured in terms of time performance, Cost Performance, risk control and client Satisfaction (Qiang et al., 2015). The variables defined here are the dependent and independent variables. Variables within each group are interrelated and intra-related. A variable in one group can influence a variable in the others, and vice versa. Figure 2 below illustrates the relationship between variables.




**Source:** Adapted with modification from Enshassi, Abdul-Aziz, & Abushaban(2012) and Qiang, Wen, Jiang, & Yuan (2015)

### 1.9 Effects of cost factors on performance

There are various dimensions of cost that contribute to the overall project performance which have been noted out by different scholar's world-wide in the construction industry.

Bubshait and Al-Juwairah (2002:30) evaluated 42 main factors influencing the construction cost in Saudi Arabia and among the main factors were material cost, incorrect planning, inexperience in managing contracts, and poor financial control on-site. Similarly, Chan and Park (2005:295) investigated factors that contribute to project costs in the Singapore construction industry and concluded that contractor's specialized skills, and public-administered contracts have significant effects on costs. Other factors include the contractor's technical expertise and financial management ability, as well as the owner's level of construction familiarity.

Nyariki (2014) evaluated success indicators of building construction projects in Nairobi Kenya and concluded that comprehensive briefing by the client was highest on the hierarchy followed by delivery of project within the budget, meeting safety requirements, fast communication and decision making process topped the list.

### 1.10 Effects of time factors on performance

There are various dimensions of time that contribute to the overall project performance which have been noted out by different scholar's world-wide in the construction industry.

Memon, Rahman, Aziz, & Abdullah (2013:6) carried out a study using structural equation modelling to assess the effects of the resource related factors on project cost in the Southern part of peninsular Malaysia, issues of late delivery of equipment's, delayed payments to supplier/subcontractor, delay in progress payment by owner and late delivery of materials were ascertained. The findings concur with earlier results obtained by (Memon, Abdul, Rahman, & Azis, 2010:41) while identifying the significant causes of construction cost in Mara large

projects.

In a study by Enshassi et al. (2012:65) to analyze factors affecting the performance of construction projects in the Gaza strip, the time factors considered in the analysis were; site preparation time, planned time for project construction, percentage of instructions delivered late, time needed to implement variation orders, time needed to rectify defects, average delay in claim approval, average delay in payment from owner to contractor, availability of resources as planned through project duration, average delay because of closures and materials shortage. The average delay because of closures and materials shortage and the availability of resources as planned through project duration were identified as the most significant factors.

Babalola, Oluwatuyi, Akinloye and Aiyewalehinmi (2015:57) carried out a study to identify the factors influencing the performance of construction projects in Akure, Nigeria and among the issues noted were; insufficient supply of materials, motivating skills of the project team leader, quality control of materials, consultants commitment to ensure construction work is done according to specification, project team leaders experience, technical skill of the project team leader, overall management actions, and economic environment.

In Trinidad and Tobago, Hicksona et al. (2014:4) established factors which included: the lack of labour supervision, unrealistic scheduling and expectation of labour performance, shortage of experienced labour, construction manager's lack of leadership skills, skill set of labourers, delay in responding to requests for information, payment delay, communication problems between site management and labour, rain and late arrival, early quitting, and frequent unscheduled breaks, to be the factors affecting construction labour productivity hence poor overall project performance.

### 1.11 Significance of the Study

- This information will be useful to academicians and researchers for carrying out further research in the field.
- The information will also help the construction parties, policy makers, Government and all other stakeholders who could use the findings to make improvement within the industry and also make good decision making.
- The study will also help the student to learn from it hence completing his studies.

### 1.12 Justification of the study

Cost and schedule overruns are one of the most common problems faced during project execution and if this problem is not addressed, it may lead project delays, cash flow problems and this may end up affecting the Quality of the project. In order to solve these problems, a substantial effort on managing the construction process must be provided and could not be done without an effective performance monitoring Tool.

### 1.13 Scope of the study

#### 1.13.1 Content Scope

The study will focus on EVM Technique as the independent variable and project performance as the dependent variable. The independent variable will have Four Variables which include: Cost Performance Index, Schedule Variance, Schedule performance index and the critical ratio; while the dependent variable will be based on four major indicators which include: timely delivery, effectiveness and efficiency, quality of work and customer satisfaction. The variables were considered since they would be used to examine the relationship between EVM technique and performance in the infrastructure project in Mulago

### 1.13.2 Geographical Scope

The study will be carried out within Kampala city and focused on mainly on a building project (Construction of SMNHUP) under the administration of Mulago Hospital. Kampala City is one of the growing cities with a high level of infrastructure development including roads that connect to different parts of the country.

### 1.13.3 Time Scope

The literature content included will be from 2010 to 2015 because during this period, Kampala City experienced major developments in the building construction sector where some projects were completed while others were unsuccessful up to date, which has caused great loss to the private clients and the government at large.

## 1.14 Operational Definitions

**EVM**: This is a technique to control the time and cost performance of a project and to predict the final project duration and cost.

**Construction**: this is the process of constructing infrastructure which includes buildings, roads and Bridges.

**Project**: Planned set of interrelated tasks to be executed over a fixed period and within certain cost and other limitations.

**Performance**: is the measure of the building project in terms of time, cost, and quality

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 Introduction

This chapter presents review of relevant existing literature on the applicability of EVM technique on measuring the performance of a construction project. The Chapter will also focus on the manner in which the concept of EVM technique has been applied into project management. This chapter is sequentially arranged from the Theoretical review, Conceptual review, EVM Performance analysis and Forecasting, an outline of knowledge gaps addressed by this study and finally Synthesis of the literature review.

## 2.2 Theoretical Framework

A theory is a system that explains phenomena by stating constructs and the laws that interrelate these constructs to each other (Mugenda and Mugenda, 2003:5). The research will be conducted basing on the theory of Goal setting which was proposed by Edwin Locke in 1968, with focus on the area of performance measurement. Goal refers to future valued outcomes (Locke & Latham 2006:265). While measuring performance, according to the theory of Goal Setting, there are five basic principles that allow goal setting to perform better. These include: charity, challenge, commitment, feedback, and task complexity (Locke & Latham 2006:265)

Charity refers to a clear and measureable goal that can be achieved within specific timeline and within goal setting. In case of the construction industry, the charity is the CPI which is the ratio of the value of the work achieved to date, to the actual cost of achieving those results. The CPI identifies the work efficiency to date.

Challenge refers to the goals being able to achieve decent level of difficulty, motivating the individual and organization to strive for positive goal achievements. In the construction of

infrastructures, this is related to Schedule variance which compares the value of the work achieved to date with the planned value of achieving those results.

Feedback provides information on the progress towards achieving goals. In building projects, this relates to the Schedule performance index (SPI) which is the ratio of the value of the work achieved to date, to the actual cost of achieving those results. SPI identifies the time efficiency to date.

Task Complexity makes the achieving of goals easier by laying down process and steps. In building projects, the critical ratio is a performance factor that act as an indicator to predict cost at Completion. According to this theory, the goal setting can be applied in all places where effective results are desired through efficient goal setting.

### 2.3 Project Management

PMBOK (2004:171) addresses EVM in its Chapter 7 on Project Cost Management. The section on Cost Control identifies five tools and techniques: Cost Change Control System; Performance Measurement Analysis; Forecasting; Project Performance Reviews; Project Management Software; and Variance Management. Since all of those techniques are directly or indirectly related to earned value methods, PMBOK actually devotes nearly 19 of its 21 Cost Control pages to EVM.

#### 2.3.1 Construction Project Management

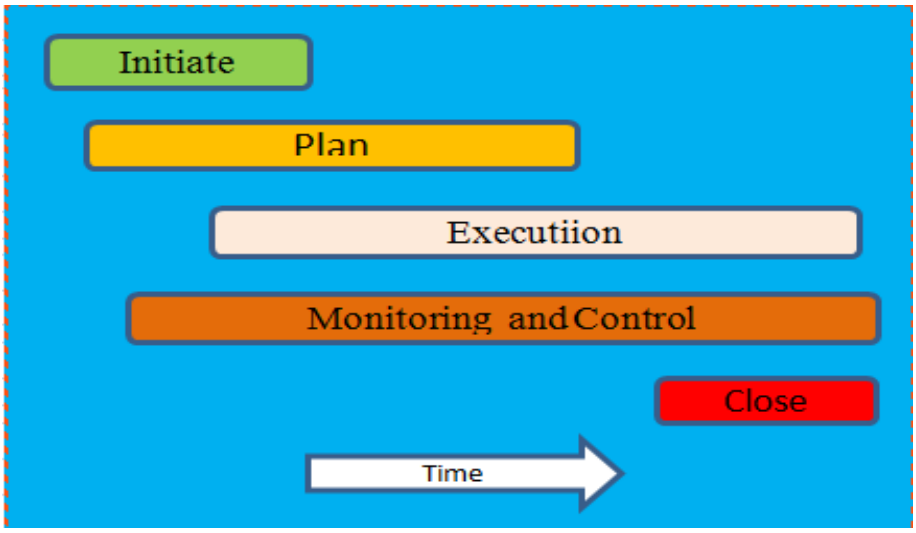
According to Gower (2007:22), the purpose of project management is to "foresee or predict as many of the dangers and problems as possible and to plan, organize and control activities so that projects are completed successfully in spite of all the risks". This need plan early before resources committed there is need of organization to have management technique, and the process must continue until all work is finished. Earned value management technique to an organization may be able to help the organization. Kerzner (2009:67), state that "the project manager must control company project resources within time, cost, and performance and Most companies have six resources those are

Money, Manpower, Equipment, Facilities, Materials and technology" . Heagney (2012:5) argue that the role of the project manager is to help the team get the work completed.

### 2.3.1.1 Construction Project Management Process

According to Project PMBOK, (2008:27-28) ; Williams (2008:144-145) and Bower, (2007) in order to meet the requirement of the project, project management process is accomplished through the following sequential and intergraded project phases, Initiating , Planning, Executing, Monitoring and Controlling and close out. The projects Manager Role to deliver the project while balancing the requirement of the project scope schedule and budget PMBOK, (2008).

Figure 1: Construction project management process




***Source: Bower, 2008***

### 2.4.2 The Trend of Construction Project Management

Projects and project management are not new concepts. The whole time history, the records of projects of different magnitudes have been creatively undertaken on generations. Projects Management earliest time to 1900 were generally managed by the creative architects and engineers themselves. There was no standard professional for project management, people study by working

practices at site, the job done with only commonsense (Gower, 2007:10). However there are few skilled and generous person like French Engineer Henry Fayol (1841 – 1925), Fayol on his observation state that every manager can perform on five management functions those are "planning, organizing, commanding, coordinating and controlling", The second pilot Henry Gantt (1861 - 1919) was an American engineer, He is famous for developing the Gantt chart and still in use in today as tool in a project manager's toolkit (Seymour and Hussein, 2014:233-240). Flow line scheduling in the 1930s was used to schedule the construction of the Empire State Building in record time. In 1956 Kelly and Walker had developing "Activity-on-Arrow "a method of critical path scheduling. In 1957-1958 US air force developed CPM/PERT, both focuses to deliver the project on time and cost, time as the key variable , and In 1969 Dr Martin Barnes (UK) described the 'iron triangle' of time, cost and scope for performance of project (Weaver, 2007:49).

The major professional bodies were established from 1960 to 1979. First project management Association is Institute of Project Management Associations (IPMA), in 1965, and four years later in 1969 Project Management Institute (PMI) were established which is primarily based in the U.S. now is commonly known as the publisher of The Project Management Body of Knowledge (PMBOK). In 1975 Project, Resource, Organization, Management and Planning Technique (PROMPT) was developed by a British company called Simpact Techniques Ltd. and 1979 PROMPTII was adopted by the UK Central Computer and Telecommunications Agency (CCTA) (Weaver, 2007:66).

The present day Construction Project management is considered as separate branches form others industrial like IT. There is wider and welcome acceptance that managing company changes as projects can bring faster and better results and more interest on project risk. Well-regarded

professional qualifications awarded by universities, follow the appropriate training and can demonstrate competence (Gower, 2013:41).

### 2.4.3 Issues facing the construction Industry

Olden times show the construction projects above had performed by the slave, unlimited timelines and cost the current construction projects facing with the several challenges (Muir, 2005). One of the factors make project failure is "the project sponsor dictate the project manager" to finish the project by certain time, budget and get a magnitude of scope while achieving a specified performance level (Heagney, 2012:48). Other issues are Clarity of the Project Objectives and stake holder agreement, Complexity of the project, Technological, Legal Issues, Political Pressures and Government regulation and Cultural, Ecological (Heagney, 2012:33).

### 2.4.4 Global contribution of the construction industry

"The construction industry is the largest industry in the world", it's integrates political, Economic and social (Elbeltagi, 2009). Construction sector and construction activities are considered to be one of the major sources of economic growth .It can be regarded as a mechanism of generating the employment to millions of unskilled, semi-skilled and skilled work force. It supplements the foreign exchange earnings derived from trade in construction material and engineering service the activities of the industry have great significance to the achievement of national socio-economic (Rangelova, 2015:17).

European countries except German economic grow was slow in 2012 due to fallen badly construction output, with a slight grows in 2013 and 2014. In 2010, US the construction industry contributed $511.6 billion (3.5%) to the total Gross Domestic Product (GDP). The whole economic of UK decline in 2012, 2008 and 2009 due to fallen badly the Output in the construction sector. United kingdom (UK) in 2014 the construction industry graded is highest donate £103 billion in

economic output equal to 6.5% of the total income, and 2015 offering 2.1 million jobs equal to 6.2% of the total (Rangelova, 2015:17). Australia in 2011 real GDP grew by 2.7%, the economic development in Austria slowed down considerably in 2012 growth amounted to merely 0.8% expected to pick up during the second half of 2013 (Rhodes, 2015).

### 2.5 Construction Performance Measure using Earned Value Technique

Kerzner recognises the value of EVM as a risk monitoring tool. Specifically, "it provides a basis to determine if risk handling actions are achieving their forecasted results." (Kerzner, 2003:686). EVM allows the performance and progress of a project to be assessed at a single point in time, usually repeated on a regular basis such as weekly or monthly. Projects are composed of many activities (sometimes hundreds or thousands) with differing durations and start times. Therefore at any point during the project some activities have been completed, some are underway, and some have not been commenced. The only possible exception arises when a project is divided into separate phases that do not overlap, and the point of EV assessment happens to coincide with the period of inactivity between those phases. At that instant, it would be possible for no activities or work to be in progress.

#### 2.5.1 Key Parameters of EVM

For implementing EVM, 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.

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.

Summarized, EVM makes use of **three key parameters**:

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

### 2.5.2 EVM Performance analysis and Forecasting

EVM relies on three key variables which represent fundamentals of its analysis: budgeted cost of work scheduled (BCWS), budgeted cost of work performed (BCWP), which is also referred to as EV, and actual cost of work performed (ACWP). The fourth data point is the budget at completion (BAC): it represents the total BCWS for the project. The four data points are used for deriving variances of actual versus budgeted performance and associated indices, and for forecasting a project's cost and time at completion. The PMB is the standard against which the project actual cost (ACWP) and progress (BCWP) is compared from start to finish.

The key practice of EVM includes two steps: first, establishing a performance measurement baseline (PMB) and, second, measuring and analyzing a project's performance against the PMB. Steps to effectively build a PMB includes decomposition of work scope to a manageable level, assigning responsibilities, developing a time-phased budget for each work task, and maintaining PMB integrity throughout the project. Performance measurement and analysis comprises recording

resource usage during the project execution, objectively measuring the actual physical work progress, analyzing and forecasting cost/schedule performance, reporting performance problems, and taking corrective actions (PMI, 2011). Performance management works best when the physical progress of work is objectively planned and measured. The techniques used in EVM to achieve this goal are Earned Value measurement techniques (sometimes called earning and crediting methods) (Project Management Institute, 2005:65)

The difference between a PMB and the actual status is measured by using two variances revised continuously throughout the project life. The variances give precise monetary values of positive or negative status and represent the difference between the current status of the project and its Baseline, in monetary terms (Pieter Buyse & Tim Vandenbussche, 2010:35)

Cost variance (CV) is a measure of the budgetary conformance of ACWP and is used to follow up the project budget. A negative (positive) value points out that more (less) has been spent for the executed activities than what was originally planned: CV = BCWP – ACWP; While schedule variance (SV) is an indicator that provides PMs with a value that represents whether the project is on schedule or not. SV is the difference between BCWP and BCWS. Positive values of these variances indicate under budget and ahead of schedule, respectively, while negative – over budget and behind schedule, respectively.

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

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

Indices, instead, do not give a precise monetary value of a project actual status, but are used as indicators of actual performance. They are merely ratio expressions of CV and SV such as the Cost Performance Index (CPI = BCWP/ACWP) indicating how efficiently a project team is using its resources, and the Schedule Performance Index (SPI = BCWP/BCWS) indicating how efficiently

the team is using its time. In the above formulae, 1.00 indicates that performance is on target; more than 1.00 indicates excellent, and less than 1.00 indicates inefficient performance. Overall, both the variances and indices are measures of past behaviour and, if no corrective actions are undertaken, are used to predict the project final cost and time (CII, 2004). See the figure below.

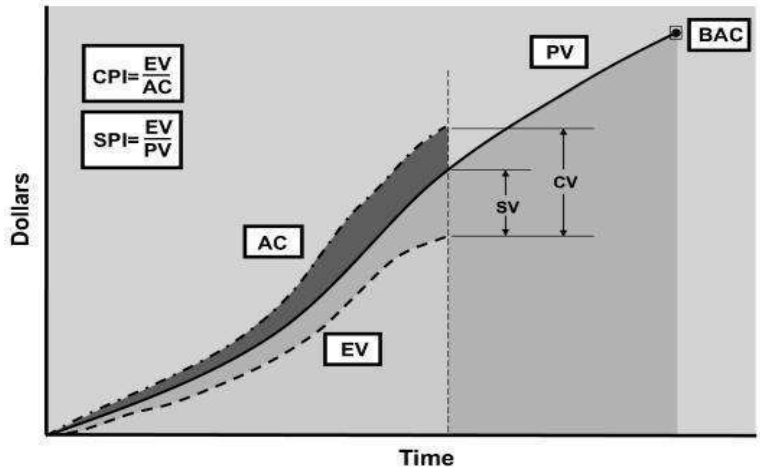



*Figure 1: Earned Value Basics (Source: Lipke W., 2012, p.2)*

Despite a vast methodological literature, few studies have been targeted to investigate the EVM practice in Uganda so that there is a shortage of recorded applications in European construction projects and the availability of reported best practices and case studies in both scholarly and trade literature is limited (Buyse and Vandenbussche, 2006:25; Marshall, 2008:). An overview of all EVM key parameters, performance measures and forecasting indicators can be summarized in figure 8, which was found in the book "Measuring Time" by Vanhoucke (2010)

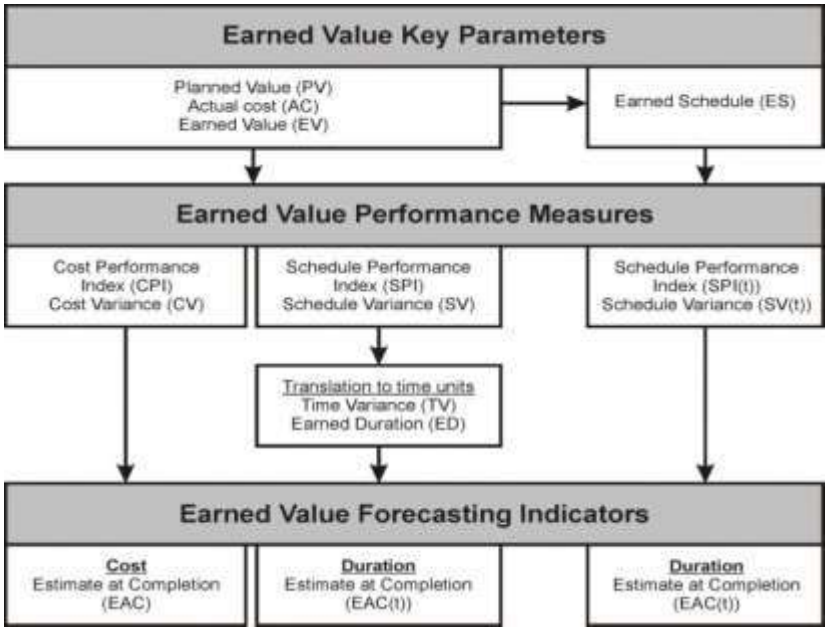



*Figure 8: Overview EVM metrics (Source: Vanhoucke Mario, 2010, p.3)*

### 2.5.3 Cost forecasting

Here the focus lies on predicting the final cost of the project. This final cost will be referred to as the Estimate at Completion (EAC). The EAC consists of the Actual Cost (AC), the cost that has been spent so far and an estimate of the cost of the remaining work (Estimate to Completion, ETC). In some literature, ETC is also referred to as Planned Cost of Work Remaining (PCWR) (Pieter Buyse & Tim Vandenbussche, 2010). It can be calculated as follows:

$$\text{ETC} = \frac{(\text{BAC} - \text{EV})}{\text{Performance Factor}}$$

Several different formulas exist to calculate the EAC, depending on the performance factor that is used to calculate the ETC. In general eight commonly used forecasting formulas are accepted by project managers (see table 1)

| | |
|---|---|
| $EAC_1 = AC + (BAC - EV)$ | $EAC_5 = AC + \frac{BAC - EV}{CR}$ |
| $EAC_2 = AC + \frac{(BAC - EV)}{CPI}$ | $EAC_6 = AC + \frac{BAC - EV}{CR(t)}$ |
| $EAC_3 = AC + \frac{(BAC - EV)}{SPI}$ | $EAC_7 = AC + \frac{BAC - EV}{wt1 * SPI + wt2 * CPI}$ |
| $EAC_4 = AC + \frac{BAC - EV}{SPI(t)}$ | $EAC_8 = AC + \frac{BAC - EV}{wt1 * SPI(t) + wt2 * CPI}$ |

*Table 1: EAC formulas*

$EAC_1$ assumes a discount factor that is equal to one. This means that to estimate the remaining cost of the project, no project performance measure is taken into account. The remaining cost is assumed to equal the planned cost for the remaining work. The most commonly used formula for cost forecasting is EAC2. In this formula the CPI is used as a discount factor for estimating the Remaining cost. EAC3 and EAC4 on the other hand are used in cases where the duration has a huge impact on the final cost of the project (Pieter Buyse & Tim Vandenbussche, 2010).

### 2.5.4 Duration forecasting

EVM has also been used for more than forty years to predict the final duration of projects. This is done analogue to forecasting the EAC. The oldest method calculated the Independent Estimate At Completion (IEAC(t)). This estimate exists of the time that has already elapsed (Actual Time, AT) and the duration of what the remaining work is estimated to take (Estimate To Complete, ETC(t)). The time that is expected to complete the project is calculated by adjusting the work remaining (Estimate To Complete, ETC) for the work rate that is expected on the remaining of the project. ETC (t) is also referred to as Planned Duration of Work Remaining (PDWR) and can be calculated as follows:

$$\text{ETC (t)} = \frac{(BAC - EV)}{\text{work rate}}$$

## 2.6 Empirical Literature

### The level of applicability of EVM Technique in measuring performance of a construction projects

Many studies about the applicability of the Earned Value Analysis have been made. Thamhain (1998) tried to evaluate the popularity of different practices of project management. Surveys were made with 400 professionals who work with projects (managers, directors, people in charge) in 180 projects in Fortune-1000 companies. They were asked about the popularity and value of different techniques of performance evaluation. As a result, he could see that the Earned Value Analysis is used by 41% of people who work with projects. It is more used than critical path method, QFD (quality function deployment) and Crashing, among others. The Earned Value Analysis is almost as popular as the net PERT/CPM.

(Wideman, 1999:5) states that a project of great importance requires a unit of planning and control that has professionals capable of collecting the information and making the Analysis of Added Value, turning its applicability justifiable.

Christensen (1998:373) states, in his studies about the applicability of Added Value in govern organizations in the United States, that the implementation of Earned Value requires a cultural change, which demands time and effort. This means to make sure that policies and knowledge are taught by the organization and by the project in order to quicken the work of the ones involved.

The Earned Value Analysis enables a supplementary value to the project because it offers a premature visibility of its results, in other words, it is possible to determine a tendency of costs and deadlines of the project in a certain phase of it, when there is still a possibility of implementation of corrective actions.

On the contrary, West & Mcelroy (2001) agree that the Earned Value Analysis is an adequate tool for the generation of reports of work done, and not a managerial tool, since the control in real time of the project, using all parameters of analysis becomes unviable: “the Earned Value Analysis shows to the project team the performance obtained until then, and not the future forecast of the project.”

Wideman (1999) supports that the technique is conceptually attractive, however it requires great efforts in its maintenance, therefore it needs a qualified team to understand and provide reliable information. He also states that many project managers don’t consider the analysis an appropriate cost-benefit ratio.

From those opposite points of view, we may imply that the Earned Value Analysis is a group of powerful intrinsic characteristics, wide and varied, like payment projection and forecasting. However, it is bound to find great difficulty in either data collection or in the low speed of information generation.

Terrel et al (2008) states that, in order to make the Earned Value Analysis effectively implemented, it is necessary to have the information about the resources clearly defined. A failure in obtaining these data, motivate the creation of inaccurate performance measurement baseline (PMB), distant from the real scenario.

**The possible barriers, benefits and standard practices of EVM Technique in measuring performance of a construction projects**

Fleming & Koppelman (2009) found that difficulty in applying EVM is about an adequate work breakdown structure (WBS). If the work is subdivided in small packages of work, it will represent a high cost of control and a lot of paperwork. On the other hand, a badly stratified subdivision may represent an inaccuracy of data, concerning real costs and deadlines.

This confirmation may be proved in the low application of the Earned Value Analysis in technology and marketing areas, where the creative work is the variant in a scope previously defined, making its application limited and directly related to the stability of a defined scope, according to Peterson & Oliver (2001). They state that, the more short-term projects grow, with reduced team and a generically defined scope, the more the Earned Value Analysis, according to Instruction 5000. 2R (DOD, 1997) and by ANSI/EIA 748, is not viable, due to inaccurate projections, consequence of a badly defined scope and to high costs noticed by the entrepreneurs.

Kerzner (1998) considers EVA a relevant maturity differential in project management. Managing costs using EVA is referred to as “managing with open eyes” because the manager can clearly see what was planned, what was performed and the actual costs. This is a powerful tool in the decision making process. In the day-to-day activities of the project manager, EVA provides “alarm” signals and facilitates decisions that keep the project on time and on budget.

Vagas (2014) found that EVM inspires the participants on the project 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

# CHAPTER THREE

# METHODOLOGY

## 3.1 Introduction

This chapter presents the methodology that will be adopted during the study. It describes and discusses; the research design, sample size and selection, the data collection methods used and their corresponding data collection instruments, data management and analysis procedure as well as steps that will be taken to ensure validity and reliability during the study and measurement of variables.

## 3.2 Research Design

According to Sekaran (2003:117), a research design shows the details of the study in relation to purpose of the study, types of investigation, and the extent of researcher interference, measurement and measures, unit of analysis, sampling design, Data collection method and data analysis, are integral to research design. The study design will adopt a mixed method approach. Both quantitative and qualitative research methods will be used to explain the phenomenon. Even though, the domination of one method cannot be avoided, the other will perform as supportive method (Creswell, 2014:119). The design will be descriptive and analytical in nature. For qualitative data, the study will adopt the field research method where the researcher will go to the field take extensive field notes which will be subsequently coded and analyzed in a variety of ways (Sekaran & Bougie, 2010)

### 3.2.1 Survey Research Design

Survey Research design is a valuable tool for assessing opinions and trend, often its low cost, easy accessible information and the data can be collected more than one cases at single point in time for collective both qualitative and quantitative data of two or more variable (Magigi, 2015:67).

The use of this tool is in line with objective two, three and four of the study. The data will be collected by sending the structured open ended and closed questions to the respondent

Follow up semi-structured interviews with senior project managers, Engineers, Architects and Quantity Surveyors in the Uganda construction industry intend to further investigate the readiness of the professionals aiming to identify potential barriers and enablers as well as potential scenarios of the most optimum but realistic way to adapt EVM in the Uganda construction sector and this is in line with all the objective of the study.

### 3.2.2 Case Study

Case study is the field in depth study, is best method for testing weather the models, formula can be applies to the phenomena and give accuracy results (Magigi, 2015:54). The selected ongoing project will take as sample for case study. The information will be gathered from a tender document, bill of quantities, contract documents, progress report and abstract sheets in support of provides necessary data for project cost and scheduling activities which will use to make suggestion toward the application of EVMS. This design is in line with objective one.

## 3.3 Study Population

The targeted population of this study will involve a parent population of 175 respondents. These are assumed to have the relevant information in relation to the study variables. The study population

will comprise of 40 Project managers of the building construction projects, Engineers (55), Architects (40) and Quantity Surveyors (40).

**Table 3.1: Target population**

| S/N | STUDY GROUP | STUDY POPULATION |
|---|---|---|
| 01 | Project Managers from construction firms | 40 |
| 02 | Engineers from the Engineers Registration Board (ERB) | 55 |
| 03 | Architects from the Architect Registration Board (ARB) | 40 |
| 04 | Quantity surveyors from the Surveyors Registration Board(SRB) | 40 |
| | **Total** | **175** |

**Source: Primary data, 2017**

### 3.4 Sample Design

Sampling is the process of selecting a sufficient number of elements from the population, so that a study of the sample and an understanding of its properties or characteristics would make it possible for us to generalize such properties or characteristics to the population elements (Sekaran, 2003: 266). The study sample will be comprised of 156 respondents and this is based on Krejcie and Morgan (1970) table.

**Table 3.2: Sample size**

| S/N | Category | No. of Respondent | Sample Size (S) | Cumulative Sample Size | Percentage (%) |
|---|---|---|---|---|---|
| 1 | Project Managers | 40 | 36 | 36 | 23 |
| 2 | Engineers | 55 | 48 | 84 | 31 |
| 3 | Architects | 40 | 36 | 120 | 23 |

| | | | | | |
|---|---|---|---|---|---|
| 4 | Quantity surveyors | 40 | 36 | 156 | 23 |
| | Totals | 175 | 156 | 396 | 100 |

**Source:** ***Researcher's Primary Data, 2017***

### 3.5 Sampling Techniques and Procedure

Simple random sampling will be used on the different construction firms and purposively select the projects managers from those construction firms since they are expected to have knowledge on EVM technique and performance of infrastructure project in Kampala City. In addition, purposive sampling will be used to obtain desired information from selected respondents. These will include the Engineers, Architects and Quantity Surveyors from their respective professional bodies. These key informants will be purposively sampled because they are believed to have technical and specialized knowledge about the topic under investigation by virtue of the offices that they held.

### 3.6 Data collection Methods

#### 3.6.1 Questionnaire Survey Method

The study will use the questionnaire method to collect data. The questionnaire will be used to gather responses quantitatively from the Project Managers, Engineers, Architects and Quantity Surveyor. The questionnaire will be structured to contain questions that address the variables in the conceptual framework. Such data can best be tapped on a closed ended questionnaire which allows easy generation of frequencies and percentages as suggested by Amin (2005:50).

#### 3.6.2 Interview Method

The study will employ interview method. Interviews in this study will help the researcher obtain more information from the project managers, Architect, Engineers and Quantity Surveyor on the topic under investigation. This method will also offer the researcher an opportunity to adapt

questions, clarify the questions by using the appropriate language, clear doubts and establish rapport and probe for more information (Sekaran, 2003:225).

### 3.7 Data Collection Instruments

The instruments used in this study will be questionnaire, interview guide and document review

#### 3.7.1 Self-Administered Questionnaire

The study will employ a questionnaire as a tool of data collection. The questionnaires will be closed ended. Closed ended questions will be developed to help respondents make quick decisions; in addition, closed ended questions will help the researcher to code the information easily for subsequent analysis and narrow down the error gap while analyzing data as observed by Sekaran (2003:236).

#### 3.7.2 Interview Guide

An unstructured interview guide will be used as a tool for collecting in-depth information from the key informants. The guide will have list questions which will be explored in the course of conducting the interviews. The guide will be drawn with the questions soliciting for the perception of the key informants regarding the application of EVM to the measurement of performance within the construction firms in Kampala.

### 3.8 Validity and Reliability of the Research Instruments

#### 3.8.1 Validity

To ensure validity, the questionnaire will be developed and given to three expert judges to score the relevance of each question in providing answers to the study. After which a content validity index C.V.I will be computed using the formula; number of items declared valid/number of items in the questionnaire. A CVI of above 70% will be acceptable (Amin, 2005)

### 3.8.2 Reliability

A pre-test will be done on 10 of the respondents who will not be part of the final study. Data will be coded and entered into the computer. Cronbach's Alpha Reliability Coefficients will be generated using the statistical package for social scientists (SPSS) computer program to estimate the reliability of the questionnaire. The Cronbach's alpha reliability coefficient of above 0.7 will be acceptable (Sekaran, 2003:311).

## 3.9 Research procedure

I will obtain a letter of introduction from UTAMU which will be presented to the authorities at the construction firms. A self-administered questionnaire will be used to collect information from the above mentioned respondents. I will then purposively select officials from ERB who will be interviewed. After data collection, data will be analyzed; a report will be written and submitted to UTAMU for review and defense.

## 3.10 Data Analysis

### 3.10.1 Analysis of quantitative Data

The statistical package which will be used for analysis of data in this study is the SPSS version 16.0. Descriptive statistics namely frequency counts, percentages will be used to analyze the respondents' demographic characteristics and the mean and standard deviation will be used to analyze the respondents' opinions on the application of EVM to the measurement of construction project success.

### 3.10.2 Analysis of qualitative data

Qualitative data will be analyzed using content analysis. Responses from key informants will be grouped into recurrent issues. The recurrent issues which will emerge in relation to each guiding

questions will be presented in the results, with selected direct quotations from participants offered as illustrations.

### 3.11 Measurement of variables

Data on the respondent's views and opinions about EVM will be obtained using scaled variables from a self-developed questionnaire. A five point-Likert scale of a= strongly disagree, b= disagree, c= not sure, d= agree and e= strongly agree will be used to tap respondents perception on the study variables.

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## APPENDIX I: QUESTIONNAIRE

**Research Title:** "Application of Earned Value Management (EVM) Technique on an Infrastructure Projects: A Case Study of Mulago Hospital".

Dear Respondent,

I am a student of Uganda Technology and Management University, Kampala pursuing a Masters in Monitoring and Evaluation. This questionnaire is intended to help the researcher get information on the relationship between EVM Technique and performance of construction of a construction project in Kampala - Uganda. The purpose of this study is purely academic and the information given will be treated with the highest degree of confidence. You have been selected as a key respondent for this study. Kindly, complete the questionnaire to enable the researcher complete the study. Please tick the answer which represents your opinion on the subject.

I appreciate your participation in this effort.

Thank you,

Mukiibi Henry

**Section A: BACKGROUND INFORMATION**

Please tick or circle the appropriate number

| **1** | **AGE (Years)** | | | | |
|---|---|---|---|---|---|
| | Less than 25 years | 26 – 35 years | 36 – 45 years | 46 -55 years | 56yrs and above |
| | 1 | 2 | 3 | 4 | 5 |

| **2** | **SEX** | |
|---|---|---|
| | Female | Male |
| | 1 | 2 |

| 3 | **TITLE** | | | | |
|---|---|---|---|---|---|
| | Project Manager | Architect | Engineer | Quantity Surveyor | Others, specify |
| | 1 | 2 | 3 | 4 | 5 |

| 4 | **EDUCATION QUALIFICATION** | | | | | |
|---|---|---|---|---|---|---|
| | PhD | Masters | Bachelors | Diploma | Certificate | Others (Specify) |
| | 1 | 2 | 3 | 4 | 5 | 6 |

| 5 | **DURATION OF SERVICE** | | | |
|---|---|---|---|---|
| | Less than 5 years | 5 – 10 years | 11 – 16 years | 17 years and above |
| | 1 | 2 | 3 | 4 |

From questions 1 – 10, tick or circle the number that best indicates your opinion on the question using the following scales

1. How do you track Project Costs/Progress? (Multiple choice)
    a. Critical path method
    b. PERT method
    c. EVM: Earned Value Management Tool
    d. Others

And if others, please specify below

2. How knowledgeable are you about EVM?
    a. Expert
    b. Knowledgeable
    c. Familiar
    d. Slightly familiar
    e. Not familiar
3. How often do you use EVM techniques?
    a. Always
    b. Frequently
    c. Occasionally
    d. Rarely
    e. Never
4. What is your opinion of the value of EVM?
    a. Extremely valuable
    b. Useful for most projects
    c. Suitable for some projects
    d. Not worth the effort

5. If EVM is used in your organization, identify one of more of the following reasons:
    a. Required by client
    b. Required by project sponsors
    c. Used voluntarily by project managers
    d. Used on a trial basis, or occasionally
    e. Not certain of reason why it is used

6. How much do you agree that EV, as a new estimate value on top of Plan Value and Actual Cost, is necessary in cost estimate systems?
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree

7. How much do you agree that your organization is able to provide up-to-date information of project cost and schedule in time?
    a. Strongly agree
    b. Agree
    c. Neutral
    d. Disagree
    e. Strongly disagree
8. If EVM is not used in your organization, identify one or more of these reasons:
    a. **Not requested:** Senior management or clients do not require EVM reports
    b. **Not successful:** Earned value techniques were tried in the past, and rejected
    c. **No training:** Project managers are untrained in the application of EVM
    d. **Too complex:** Earned value procedures seem too complicated
    e. **No budget:** Project budgets are not required by management or clients
    f. **No schedule:** Project schedules are not required by management or clients
    g. **Partial costs:** Project budgets do not cover the cost of all project resources or costs
    h. **Not sure:** Uncertain, or other reasons

9. Which elements do you think are the major barriers of company to practice efficient and effective cost management and Earned Value Management?
    a. Change of construction policy or code
    b. Current situation of construction process
    c. Labour rates
    d. Usage of construction equipment
    e. Usage of new materials
    f. Various material price
    g. High level of technology

Which Technique do you recommend to measure performance on a construction project and why?

**……**

**……**

**Thank you for your participation!**

## APPENDIX II: FOCUS GROUP GUIDE

"Application of Earned Value Management (EVM) Technique on Measuring the Performance of Infrastructure Projects: A Case Study of Mulago Hospital Construction Project"

**INTRODUCTION:**

The purpose of the interview is to gather key information from the project managers, Architects, Engineers and Quantity Surveyors about the application of Earned Value Management (EVM) Technique to Measuring the Performance of a Construction Project in Kampala-Uganda

1. What are the existing performance measuring techniques used on the construction projects?
2. How effective and efficient are they in measuring performance of a construction project
3. What are the possible barriers of EVM Technique in measuring performance of a construction project in Kampala?
4. What are the likely recommendations with regard to the above challenges?
5. What are the possible benefits of EVM Technique in measuring performance of a construction project in Kampala?
6. What are the standard practices of EVM Technique in measuring performance of a construction project in Kampala?
7. What is the relationship between earned value management (EVM) technique and the performance of a construction project in Kampala Uganda?
8. What perception do professionals have on the EVM Technique in measuring performance of a construction project in Kampala?
9. Any general comment with regard to the application of EVM Technique on measuring the performance of construction projects in Kampala city?

**Thank you!!**

## APENDICES III: KREJCIE & MORGAN TABLE

Table 3.1

*Table for Determining Sample Size of a Known Population*

| N | S | N | S | N | S | N | S | N | S |
|---|---|---|---|---|---|---|---|---|---|
| 10 | 10 | 100 | 80 | 280 | 162 | 800 | 260 | 2800 | 338 |
| 15 | 14 | 110 | 86 | 290 | 165 | 850 | 265 | 3000 | 341 |
| 20 | 19 | 120 | 92 | 300 | 169 | 900 | 269 | 3500 | 346 |
| 25 | 24 | 130 | 97 | 320 | 175 | 950 | 274 | 4000 | 351 |
| 30 | 28 | 140 | 103 | 340 | 181 | 1000 | 278 | 4500 | 354 |
| 35 | 32 | 150 | 108 | 360 | 186 | 1100 | 285 | 5000 | 357 |
| 40 | 36 | 160 | 113 | 380 | 191 | 1200 | 291 | 6000 | 361 |
| 45 | 40 | 170 | 118 | 400 | 196 | 1300 | 297 | 7000 | 364 |
| 50 | 44 | 180 | 123 | 420 | 201 | 1400 | 302 | 8000 | 367 |
| 55 | 48 | 190 | 127 | 440 | 205 | 1500 | 306 | 9000 | 368 |
| 60 | 52 | 200 | 132 | 460 | 210 | 1600 | 310 | 10000 | 370 |
| 65 | 56 | 210 | 136 | 480 | 214 | 1700 | 313 | 15000 | 375 |
| 70 | 59 | 220 | 140 | 500 | 217 | 1800 | 317 | 20000 | 377 |
| 75 | 63 | 230 | 144 | 550 | 226 | 1900 | 320 | 30000 | 379 |
| 80 | 66 | 240 | 148 | 600 | 234 | 2000 | 322 | 40000 | 380 |
| 85 | 70 | 250 | 152 | 650 | 242 | 2200 | 327 | 50000 | 381 |
| 90 | 73 | 260 | 155 | 700 | 248 | 2400 | 331 | 75000 | 382 |
| 95 | 76 | 270 | 159 | 750 | 254 | 2600 | 335 | 1000000 | 384 |

*Note: N is Population Size; S is Sample Size* *Source: Krejcie & Morgan, 1970*